Manual for the Creation of Blue Carbon Projects in Europe and the Mediterranean

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CO-FUNDER

Manual for the Creation of Blue Carbon Projects in Europe and the Mediterranean

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LIST OF ACRONYMS

AAU	Assigned Amount Unit
AFOLU	Agriculture, Forestry and Other Land Use
CAR	Corrective Action Request
CCB	Climate, Community & Biodiversity Standard
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CL	Clarification Request
CO_2	Carbon Dioxide
CaCO3	Calcium Carbonate
CH_4	Methane
DOE	Designated Operational Entity
EIA	Environmental Impact Assessment
ERU	Emission Reduction Unit
ESR	Effort Sharing Regulation
ET	Emission Trading
EU	European Union
EU-ETS	European Union Emission Trading Scheme
GHG	Greenhouse Gas
GS	Gold Standard
GS4GG	Gold Standard for the Global Goals
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
ITMO	Internationally Transferred Mitigation Outcomes
JI	Joint Implementation
KP	Kyoto Protocol
LULUCF	Land use, land-use change, and forestry
$MtCO_2$	Megatonnes of carbon dioxide equivalent units
N_2O	Nitrous Oxide
NbS	Nature-based Solutions
NDC	National Determined Contributions
PA	Paris Agreement
PIN	Project Idea Note
PDD	Project Design Document
PP	Project Proponent
QA/QC	Quality assurance and quality control
REDD	Reduction of Emissions from Deforestation and forest Degradation
RMU	Removal unit
t	Tonne
tCO_2	Tonne of carbon dioxide
tCO_2e	Tonnes of carbon dioxide equivalent
UNFCCC	United Nation Framework Convention on Climate Change
VCS	Verified Carbon Standard
VER	Voluntary (or Verified) emission reduction unit
VVB	Validation and Verification Body

PREFACE

Climate change is one of the most important threats to humanity and it will increasingly challenge the way we manage our development. Stabilising the climate system, as envisaged under the Paris Agreement, demands mitigation and adaptation measures to reduce climate-change impacts and increase the resilience of essential ecosystem services. In the marine environment, the degradation and loss of coastal habitats, particularly ecosystems capturing carbon, is resulting in an unprecedented loss of biodiversity and ecosystem services. Additionally, pressure on public funding is leading organisations to seek innovative approaches to tackle these challenges and find ways to finance such initiatives and identify opportunities for public-private sector collaboration.

In this context, nature-based solutions for climate change adaptation and mitigation are gaining traction as a *no-regrets option*. Blue carbon is the carbon stored in coastal and marine ecosystems. Coastal ecosystems composed of mangroves, salt marshes and seagrass meadows, such as the *Posidonia oceanica* meadows in the Mediterranean, represent significant carbon sinks. Indeed, they sequester carbon in its organic form and store it for thousands of years. Moreover, coastal "blue carbon" ecosystems provide a wide range of ecosystem services that underpin coastal livelihoods and support adaptation to climate change. However, despite the importance of the ecosystem services provided, these habitats are disappearing at an alarming rate.

For all the above, there is a need for a range of incentives and mechanisms to be used to ensure both the reduction of impacts with more sustainable practices and the achievement of conservation goals for these ecosystems. Involvement and leverage from the private sector are crucial to address these challenges.

This manual arises from an interest in financing restoration and conservation efforts at European and Mediterranean levels through the sale of blue carbon offset credits. It intends to provide knowledge-based guidance for developing project-based interventions using the carbon finance mechanisms to improve seagrass and coastal wetland conditions for climate change mitigation and adaptation. Complementary to this, it can be used for other interventions such as addressing how to robustly quantify blue carbon stocks to identify gains and losses and inform national greenhouse gas inventories.

The main target audience for this manual is the range of potential project proponents interested in applying blue carbon values through the development of initiatives to mitigate climate change and support coastal ecosystem management. Among them, relevant ministries and agencies; coastal management practitioners; professionals studying carbon emissions, restoration works or climate change footprints; civil society organisations; researchers; and private sector representatives who may be looking for opportunities to strengthen their corporate social responsibility initiatives.

The manual draws from a number of existing methodologies such as *Coastal Blue Carbon: methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrass meadows* developed by the International Blue Carbon Initiative and the works developed by the EU LIFE BlueNatura project.

The manual presents methodological steps to identify, assess, set up, implement, and organise a blue carbon project on the ground – including how to optimise effort allocation in obtaining data from the field and obtain robust estimates within the boundaries of blue carbon projects. It also articulates essential elements for restoration implementation, particularly for mitigation purposes, describing additional resources that project developers can use to understand further management actions that are effective in enhancing this value. Case examples from different regions are used to illustrate concepts, approaches and interventions taken.

To enhance capacity on how to structure projects to be funded through carbon finance, the manual provides an overview and detailed information on carbon financing mechanisms and tools with (i) background information on carbon markets, baseline-and-credit mechanisms, carbon certification standards, commercialisation of carbon credits, and existing blue carbon projects; (ii) tools to assess blue carbon project eligibility/feasibility, including methodological assessment, costs and revenue streams, ownership and rights, and additional considerations; (iii) detailed explanation of the carbon project certification process from the drafting of a project idea note to the issuance of carbon credits; and (iv) consideration of double counting and host country commitments to international treaties.

This work has been developed in the context of the EU LIFE BlueNatura-funded effort with co-financing from Cepsa, MAVA and Red Eléctrica Foundation to enhance understanding within public and private organisations of the different standards and initiatives for blue carbon. Our approach is to facilitate stakeholders to track the progress in the various venues that promote volunteer standards and create the foundations for results-based payments. As these efforts and methodologies available for calculating and verifying carbon credits by restoration and conservation are still in their early stages in Europe and the Mediterranean, individual projects will necessarily conform to unique national settings and priorities, including ecological, social, and political/legal conditions, geographical context, availability of funding, and other factors. Final recommendations provide some indications for the future of these standards and mechanisms.

CHAPTER 1:

NATURAL CARBON SINKS: BLUE CARBON ECOSYSTEMS IN CLIMATE CHANGE MITIGATION


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NATURAL CARBON SINKS: BLUE CARBON ECOSYSTEMS IN CLIMATE CHANGE MITIGATION

The emission of greenhouse gases, including carbon dioxide (CO_2), has been the main cause of climate change and global warming since the mid-20th century. Today, the joint action of anthropogenic activities such as fossil fuel burning, deforestation, and cement production are elevating CO_2 levels in the atmosphere from a concentration of approximately 280 parts per million (ppm) as observed at pre-industrial times to above 400 ppm. Total fossil CO_2 emissions are now 62% higher than emissions at the time international climate negotiations began in 1990 and present projections predict a sharp increase on these concentrations, reaching up to 535-983 ppm in the atmosphere by the end of the 21st century (Fig. 1) [1]. Likewise, the concentrations of other greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O), which are highly linked to activities such as agricultural production, have increased dramatically since pre-industrial levels [1]. Continuing greenhouse gas emissions at or above current rates would cause a further increase in global temperatures and rapid dangerous climate change impacts.

A large part of the released atmospheric carbon is gradually captured, stored and mobilised in the ocean through biological, physical, and chemical natural processes [1] (Fig. 2). Concurrently to the increase of atmospheric levels, seas and oceans have increased the amount of CO_2 they absorb [2] and this consequently has driven up marine surface temperatures and is causing a decline in ocean pH (also known as ocean acidification) [3, 4].

Once in the ocean, carbon is partly taken up by photosynthetic organisms such as plankton, marine vegetated benthic communities and calciferous organisms and thereafter in part stored in oceanic sediments. This uptake and storing of CO_2 into a long-term reservoir, as well as the organic carbon that is exported from the

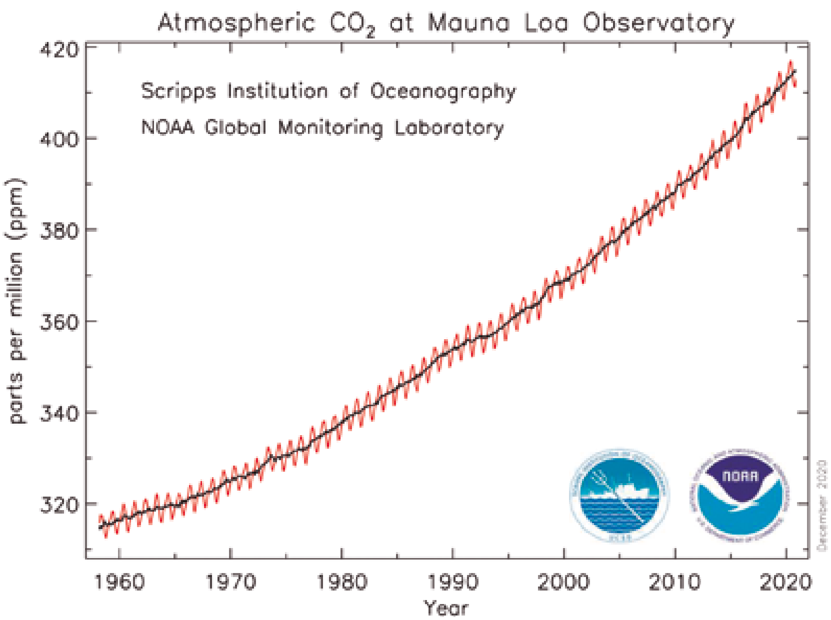


Figure 1: Global fossil CO_2 emissions recorded at Mauna Loa, Hawaii (Source: NOAA). The projected emissions decline for 2021-2050 will depend on the continued trajectory of the pandemic and government responses to address it over that time and after.

coastal waters to offshore areas and buried in ocean sediments, constitutes the **natural carbon store in deep ocean sediments.** Current estimates report that the marine process is responsible for at least 55% of world's biological carbon fixation, 197.64-215.94 Gt CO_2 year^{-1} from a total of 406.26-428.22 Gt CO_2 year^{-1}, and supports up to 71% of carbon storage in oceanic sediments [5–7].

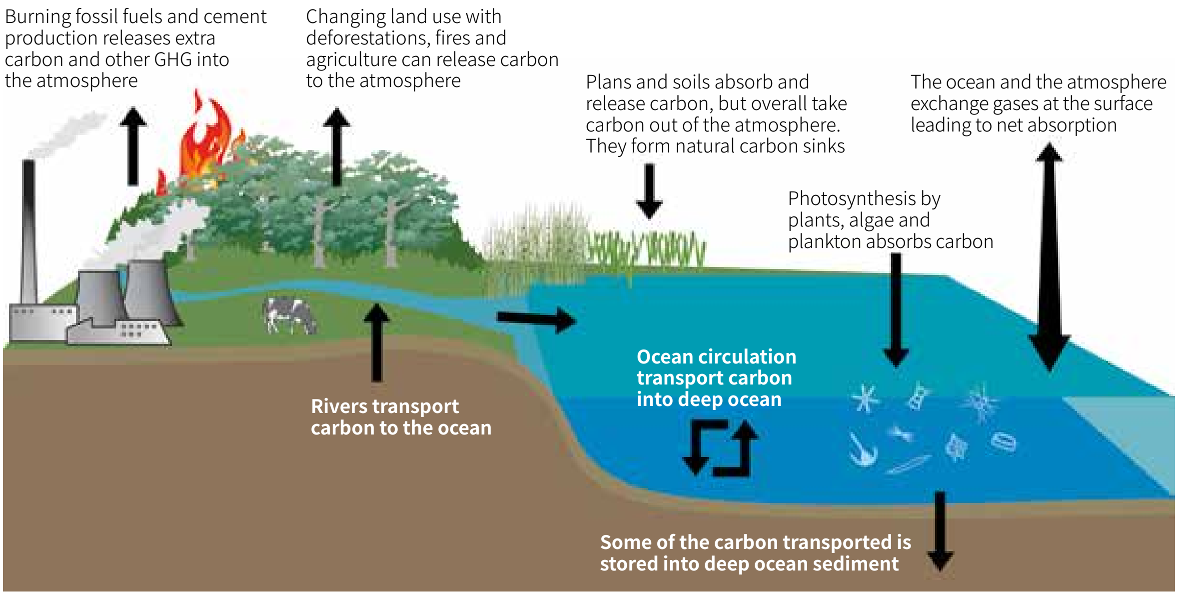
Key coastal ecosystems dominated by higher plants —such as mangroves, salt marshes and seagrasses— have outsized carbon burial rates compared to terrestrial ecosystems with important long-term carbon storage [4]. They are known as **coastal blue carbon ecosystems** or **coastal blue carbon habitats** because their capacity to sequester and store carbon as organic matter [8-11] (Fig. 3). Maintaining and enhancing these sinks is an emerging priority in climate change mitigation [12-14].

In addition to this capacity, coastal blue carbon ecosystems provide a wide range of ecosystem services that underpin coastal livelihoods and support adaptation to climate change, including habitat and food chain support for many species including commercial fishes, nutrient recycling, shoreline stabilisation, storm protection, and flood attenuation [15, 16]. By reducing the impact of incoming waves and stabilising sediments, they provide coastal protection and erosion control for adjacent shorelines [17, 18].

Additionally, blue carbon ecosystems as seagrasses provide a source of carbonate sand to beaches, sinks excess of nutrients and inorganic and organic pollutants and act as natural filters reducing turbidity and improving water quality.

The unique structure of many of the species that form these coastal ecosystems, can also significantly raise the seafloor with the accumulation of material produced within the ecosystem (e.g. leaf litter) and material imported from land via rivers or deeper areas, supporting natural coastline protection against sea level rise [19].

Figure 2: Diagram showing sinks and sources of the carbon cycle. IUCN.
Diagram symbols courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science.



WHAT IS BLUE CARBON?

Coastal blue carbon is the organic carbon stored in ecosystems from the coastal or near-coastal zone, especially mangroves, seagrasses and salt marshes [4, 6, 9, 20]. This carbon can remain stored in these ecosystems over the short term (months to decades) as biomass or over millenary time scales in the soils underneath [21]. **Oceanic blue carbon,** on the other hand, includes carbon stored in the deep ocean's water and sediments through the actions of marine life such as phytoplankton and other open ocean biota as well as chemical processes.

Here we focus on coastal blue carbon due to its relevance as a tool for conservation of coastal vegetated ecosystems.

Most of the carbon in these ecosystems is retained within their substrates, within their living biomass above ground (leaves, stems, branches) and below ground (roots), and within their non-living biomass (e.g. leaf litter and dead wood). In coastal marshes and seagrasses, the largest carbon pool from all these compartments is stored in the soils (>98%) [22, 23]. Here, the soil (organic) carbon pool is composed of both autochthonous carbon stabilised within the ecosystem itself (e.g. as organic matter through photosynthesis) and allochthonous carbon that has been imported (e.g. from land via freshwater inputs, or the ocean; [24]).

In seagrass meadows and mangrove plants, there is also a significant pool of particulate inorganic carbon in the form of calcium carbonate ($CaCO_3$) that accumulates in the sediment, derived from the shells of different organisms inhabiting the meadows and mostly from sources external to the habitat [25]. Hence, $CaCO_3$ burial is a fundamental process supporting the role of blue carbon ecosystems in climate change adaptation, contributing to their capacity to rapidly accrete sediments and to seabed elevation and therefore buffering sea-level rise.

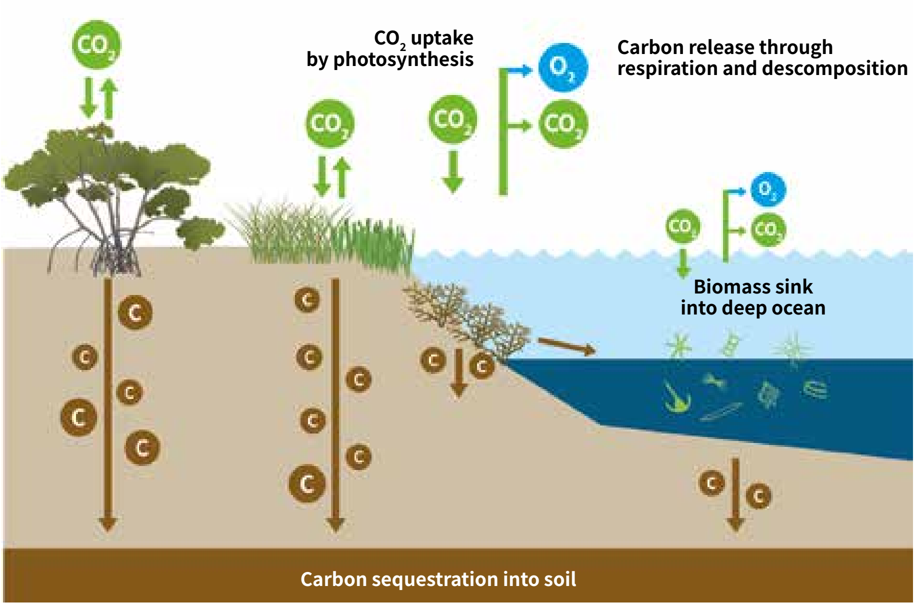
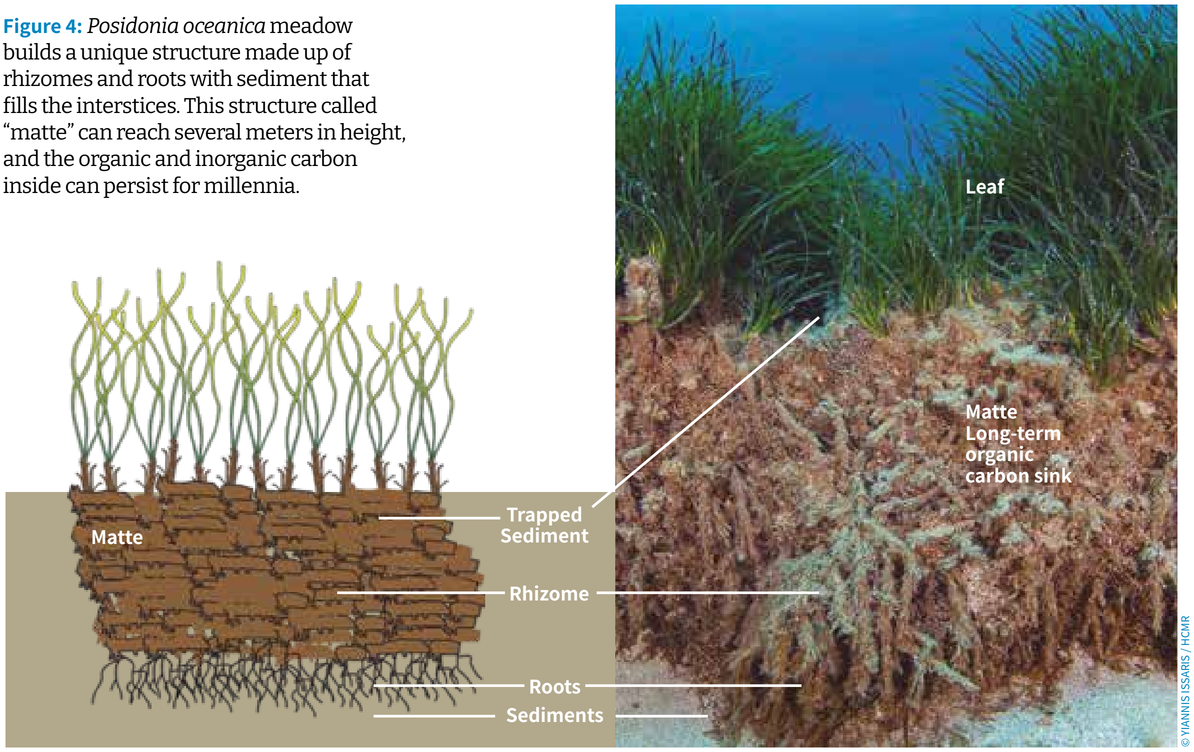


Figure 3: Graphic illustration of carbon uptake of blue carbon ecosystems via photosynthesis and subsequent long-term sequestration into biomass and soil, or respiration. Adapted from: Howard *et al.,* 2017, Frontiers in Ecology and the Environment.

Figure 4: *Posidonia oceanica* meadow builds a unique structure made up of rhizomes and roots with sediment that fills the interstices. This structure called "matte" can reach several meters in height, and the organic and inorganic carbon inside can persist for millennia.



Coastal blue carbon is the organic carbon stored by coastal ecosystems such as wetlands including marshes, mangroves and seagrasses, representing a large pool of this natural carbon that is sequestrated and stored over thousands of years in these environments.

Recent research also highlights the contribution that other key components of marine ecosystems such as **marine forests of macroalgae** have in carbon sequestration [4, 6, 9, 20]. New research in the last couple of years suggested that up to 30% of net primary productivity of kelp growth may be exported to the deep sea for deposition and long-term sequestration, putting this ecosystem and methods such as regenerative ocean farming or kelp reforestation in the blue carbon field [13].

All plants remove carbon from the atmosphere, converting it to plant tissue through photosynthesis. Living plant tissue (or standing stock) has generally a short turnover time (months to decades) but carbon stored in the soils can remain there for centuries. This is especially true in the case of the organic soil formed by the matte complex of roots and rhizomes buried in sediment beneath the seagrass meadows of *Posidonia oceanica* (Fig. 4). It can be several metres thick resulting from thousands of years of growth and sediment deposition, serves as an important blue carbon store in the Mediterranean Sea [26, 27].

The importance of blue carbon ecosystems for long-term carbon sequestration is particularly significant when compared to terrestrial ecosystems. On a per area basis, global estimates indicate that these coastal ecosystems are more efficient carbon sinks than most terrestrial forests [4, 24] (Fig. 5). For just the top metre of soil, carbon storage has been estimated at approximately 250 t C ha^{-1} for salt marshes, 280 t C ha^{-1} for mangroves, and 140 t C ha^{-1} for seagrass meadows [10].

There is substantial variability in the sequestration potential of blue carbon habitats. The effectiveness may be partly due to their high primary productivity

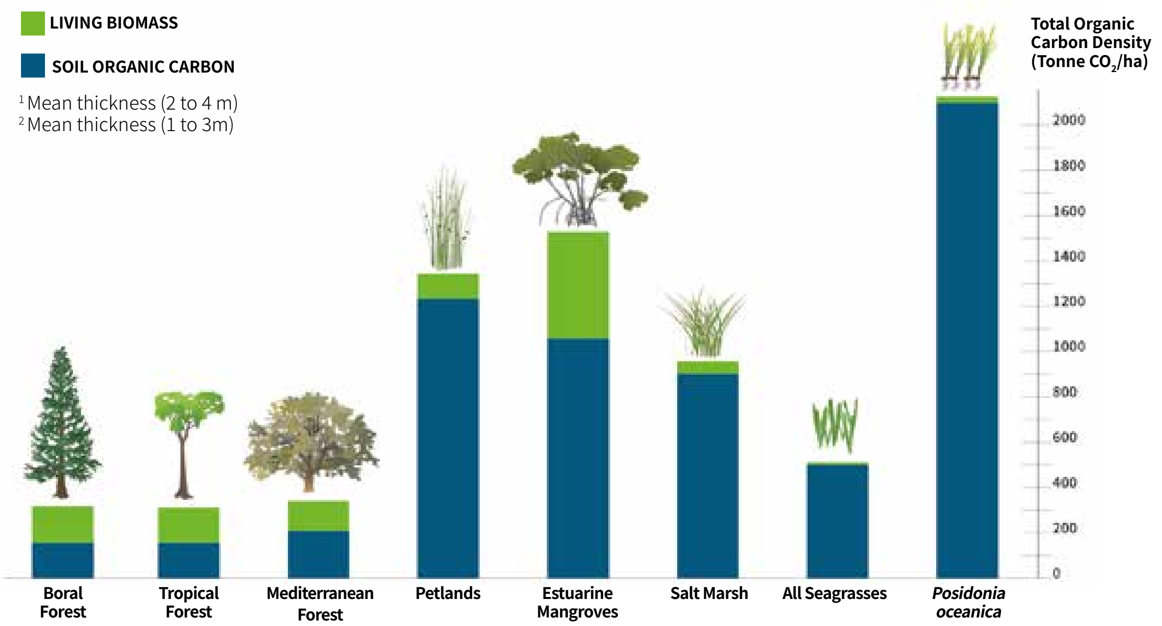


Figure 5: Comparison of soil C_{org} storage in the top metre of the soil with total ecosystem C_{org} storage for major ecosystem types. Here, the seagrass *Posidonia oceanica* is a unique seagrass in terms of the quantity of organic carbon that can be stored in its sediments and matte. Soil Data: Top meter sediment [12, 111, 112, 113].

and their success in storing carbon and nutrients in anoxic solis [21, 28]. Contrary to terrestrial habitats, carbon sequestered in the below-ground in mangroves, salt marshes and seagrass meadows, can remain accumulated through centuries to millennia for the most persistent plant species [29, 30]. Furthermore, the saline conditions of coastal wetland soils have the advantage of potentially emitting only negligible amounts of other greenhouse gases such as methane (CH_4) and dinitrogen oxide (N_2O) [31] (although there are exceptions), which are substantially more potent greenhouse gases than CO_2. For these reasons, there is growing interest in managing, protecting, and restoring blue carbon habitats as part of local and global climate change mitigation policies.

Globally, the estimated average rate of carbon sequestration in salt marshes and mangroves is respectively 242.2 and 210 g C m^{-2} yr^{-1}, which is the equivalent [1] of 880.1 and 770 g CO_2 m^{-1} yr^{-1} [32, 33].

For seagrass meadows estimates ranged between 1.8 and 177.8 g C m^{-2} yr^{-1} or 6.6 and 651.9 g CO_2 m^{-2} yr^{-1} (median: 206.1 g CO_2 m^{-2} yr^{-1}) [21].

This indicates that the economic potential of restoring these ecosystems lies more in the effect of protecting the carbon stock than in the annual rate of CO_2 sequestration.

Many factors influence the exact amount of carbon that can be taken up by blue carbon ecosystems. Among them are habitat type, plant species composition, location, water depth and nutrient supply. Location influences, for example, the type and abundance of sediments and climatic conditions [35]. Estuarine systems often have a higher availability of fine sediments, nutrients and materials that can be incorporated into coastal wetland sediments compared to open coastal systems. Likewise, the accumulation of carbon in seagrass meadows is promoted

[1] Conversion factor for carbon: 1 tonne of carbon (C) equals 11/3 = 3.66666667 tons of carbon dioxide (CO_2)

in shallow and sheltered environments with low energy and turbidity, and with low-to-mid nutrient inputs [36].

The carbon stock also differs among habitats composed of different species, depending on their characteristics and the environmental conditions in which they grow. For instance, the highest stocks have been observed in continuous and high density seagrass meadows composed of large and persistent plant species with complex canopies (e.g. *Posidonia spp*. and *Thalassia spp.),* or by small and coloniser species (e.g. *Halophila spp.* and *Halodule spp.)* [36].

Anthropogenic conversion and degradation of blue carbon ecosystems can lead to major emissions because much of the carbon stored in the soils is released back into the atmosphere and the sea [10, 37], shifting the habitats from net sinks to sources of carbon.

"The loss and degradation of blue carbon ecosystems can release stored carbon back into the atmosphere, increasing CO_2 emissions and contributing to global warming" [10].

Some of the exported carbon may remain sequestered at deep ocean sites, and some is deposited along the coastline as wrack on beaches, marshes, and on tidal flats.

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IMPORTANCE OF CONSERVING EUROPEAN AND MEDITERRANEAN BLUE CARBON ECOSYSTEMS

Coastal blue carbon ecosystems in Europe and the Mediterranean basin encompass mostly salt marshes and seagrass beds [38, 39]. They sequester carbon slowly over time, building stocks of soil carbon that may be thousands of years old, below a cover of living biomass. **These stocks of carbon are "protected emissions", as long as neither the sediments nor soil moisture conditions are impacted.**

Recent research and publications suggest that other marine habitats (e.g. coastal and shelf habitats with soft sediments, macroalgae forests) might have a significant role as carbon stores, until now less quantified [8, 9, 40].

Seagrass meadows

Seagrass is a globally distributed group of marine flowering plants that form extensive meadows in shallow waters. They typically occur from the lower salt marsh limit to the sublittoral zone.

Along the coast of the Mediterranean Sea, there are several species of seagrasses: *Posidonia oceanica, Cymodocea nodosa, Zostera marina and Z. noltii,* as well as the non-native seagrass *Halophila stipulacea.* The latter is most commonly found on the Eastern and South Mediterranean shores. Recently, another non-native seagrass species, *Halophila decipiens,* also known from the Atlantic waters of the Canary Islands, has been reported for the first time in the Saronikos Gulf (Greece). Further studies will provide information on the permanence of the species in the region [41].

Among all the seagrasses, the endemic Mediterranean *Posidonia oceanica* is the most abundant and widespread, being also the most efficient in retrieving and storing CO_2 from the atmosphere [22]. In the Atlantic European waters, *Zostera marina* is the most dominant. In terms of their CO_2 sequestration and storing capacity, few studies have provided information across species and geographical range (examples in Table 1).

Posidonia oceanica seagrass meadows, one of the most extensive coastal carbon sinks in the Mediterranean.

Most notably, **the organic carbon stored by *Posidonia oceanica* alone, has been estimated at between 1 and 4,100 t CO_2 ha^{-1}** [39].

Large losses of seagrass habitats across Europe and the Mediterranean have occurred in the past, largely attributable to anthropogenic impacts, mainly reduction of water quality (pollution and eutrophication from sewage or aquaculture), mechanical erosion (by trawling and anchoring), and indirect changes that cause burial of meadows by the construction of new coastal defences, marinas or other infrastructure [42, 43].

More recently, losses have been attributed to extreme events such as storms and marine heat waves. Acidification and hypoxia (low or depleted oxygen in water bodies) could also affect the stability of these blue carbon ecosystems, or some ecosystem services, although these are generally believed to be of relatively lower impact [44].

"Based on the global estimate of seagrass and saltmarsh coverage in Europe of 3 million hectares, initial estimations indicated that the Blue Carbon stock made by these habitats could represent as much as 1.5–4% of existing global one from coastal vegetated habitats" [4, 40].

Table 1. Carbon and CO_2 stock (t C ha^{-1} at 1 m and tCO_2 ha^{-1}) and sequestration rates (t C ha^{-1} yr^{-1} and tCO_2 ha^{-1} yr^{-1}) to the soil among different temperate habitats and species. Values are means and standard errors. *At the first 30 cm. **At the first 10 cm.

Habitat type	Dominated species and conservation condition	Location	Average C stock (t C ha^{-1}) at 1m	Average CO_2 stock (tCO_2 ha^{-1}) at 1m	C Sequestration rate (t C ha^{-1} yr^{-1})	C Sequestration rate in CO_2 (tCO_2 ha^{-1} yr^{-1})	References
 Seagrasses	*Posidonia oceanica*	Andalusia	222.51 – 1,106.83	814.4 – 4,051	0.38 – 0.85	1.4 – 3.1	[22]
		Crete Island	51	186.66	—	—	[45]
	Posidonia oceanica death mat	Andalusia	200.96 – 290.82	735.5 – 1,064.4	0	0	[22]
	Zostera marina	Northern Hemisphere	23.1 – 351.7	84.55 – 1,287.22	—	—	[46]
		Canada Pacific coast	13.42 ± 4.82	49.11 ± 17.64	0.029 – 0.396	0.11 – 1.45	[47]
	Cymodocea nodosa	Canary Islands	86.20 ± 19.06*	315.49 ± 69.76*	—	—	[48]
		Crete Island	21	76.86	0.065	0.24	[45]
		Andalusia	21.74 – 28.47	79.6 - 104.2	0.03 ± 0.06	0.1 ± 0.2	[22]
	Halophila stipulacea	Crete Island and Red Sea	35	128.1	0.148	0.54	[45]
		Limassol (Cyprus), West Crete (Greece)	5 ± 1**	18.35 ± 3.67**	0.074 – 0.283	0.27 – 1.04	[115]
 Salt marshes	High	Andalusia	78.36 – 134.64	286.8 – 492.8	0.18 – 0.24	0.66 – 0.89	[32]
	Medium	Andalusia	46.7 – 156.56	171 – 573	0.54 – 1.125	1.98 – 4.58	[32]
	Low	Andalusia	59.29 – 63.47	217 – 232.3	0.1 – 0.13	0.38 – 0.49	[32]
	—	Netherlands	328 – 393	1,200 – 1,438	0.18 – 17.3	0.65 – 63.31	[49]
	—	Denmark	210 – 270.5	770 – 990	—	—	[50]
	—	Rhone Delta, France	731	2,677	—	—	[50]

At healthy salt marshes in Andalusia (South Spain)

Organic cabon stocks in Andalusian saltmarshes has been accumulating during the last century at an average rate of 38-458 g CO_2 m^{-2} yr^{-1} while in *Posidonia oceanica* seagrass meadows at a rate of 140-130 g CO_2 m^{-2} yr^{-1}. The total global carbon burial by salt marshes and seagrass meadows in Andalusia is estimated to be 61,000 tCO_2 yr^{-1} [22, 32].

Salt marshes

Coastal wetlands with salt marshes are important coastal ecosystems frequently fringing the interior of estuaries and bays and low-energy inter-tidal zones. Atlantic European salt marshes are characterised by natural grasslands developed on sands and clays subject to tidal fluctuation along more sheltered stretches of the Atlantic European coast, from north of mid-Portugal, and around the North Sea [51]. Further south, more characteristic Mediterranean salt marshes can be found in sheltered shores and extending around the south coast of Portugal and the Mediterranean basin, where commonly they experience minimal tidal influences [52] (Fig. 6).

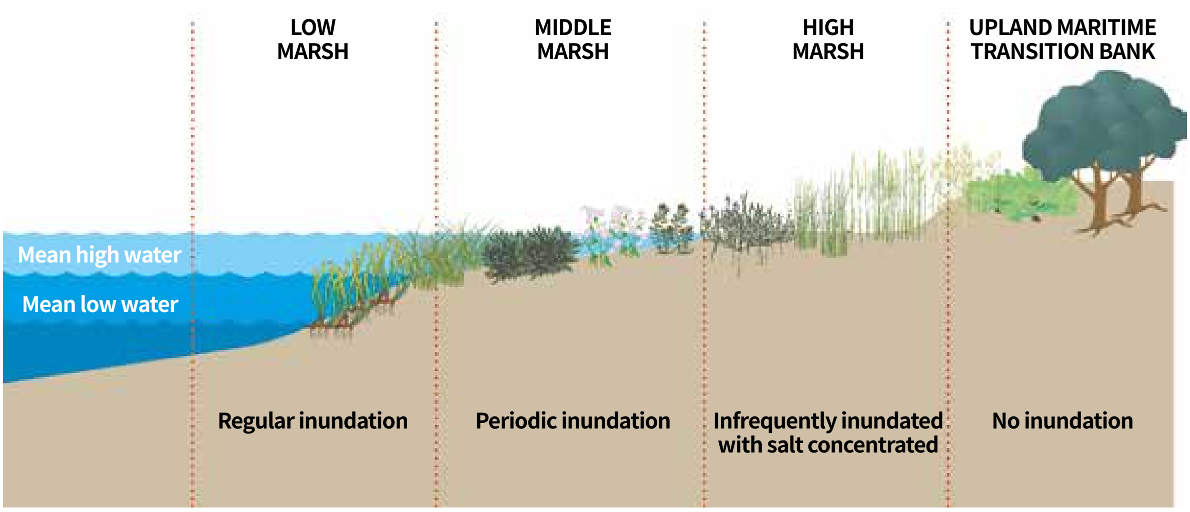
Over the last decade diverse studies have provided estimates of the carbon storing and sink capacity in some of these wetlands (Table 1). Salt marshes appear to be highly efficient in carbon burial, but studies on carbon accumulation in salt marshes in the Mediterranean and European region lag behind other ecosystems. Firstly, data on salt marsh extent and carbon stock are patchy and large areas of salt marsh habitats across the region have never been mapped. Some global estimates indicate that salt marshes rank among the most effective ecosystems in carbon sequestration with an average of 242.2 g C m^{-2} yr^{-1} (888 g CO_2 m^{-2} yr^{-1}) [53] while long-term carbon sequestrations rates in soils of European salt marshes are on average 151 g C m^{-2} yr^{-1} (554 g CO_2 m^{-2} yr^{-1}) and six times greater than carbon sequestration in peatlands 26.6 g C m^{-2} yr^{-1} (91.7 g CO_2 m^{-2} yr^{-1}) [54].

However, salt marshes also critically suffer from losses due to dredging, filling, draining and construction and are particularly threatened by sea-level rise as a result of "coastal squeeze". European habitat assessments in 2017 [55] estimated a reduction of an average 13% in the area covered by these habitats in the Mediterranean over the last 50 years with also a quality decline across the whole territory (affecting 23–30% of the habitat with 51% severity). Furthermore, the 2018 *Mediterranean Wetlands Outlook report*[2] clearly highlights the negative long-term trends worsening the condition of wetlands and threatening their future.

Atlantic salt marshes in Europe have also undergone a reduction in the surface area occupied of about 26% during the last 50 years, while large parts (>60%) of the remaining area have been affected, with relatively high severity (58%). Confirmation of this trend was also provided in the EC Science to policy report, recently published [56], concluding that of all terrestrial, freshwater and marine ecosystems in Europe, wetlands are in the worst condition of all.

Salt marshes are highly sensitive to sea-level rise, particularly where coastal constructions and steep slopes limit landward migration and/or insufficient sediment is delivered to support their accretion. Reduced supply of coastal sediment and modification of water hydrodynamics are also frequent drivers of decline for these ecosystems. Their degradation due to climate change and other pressures, can lead to the release of the massive carbon stocks that these ecosystems have stored over millennia [10].

Figure 6: Classification schemes of five vegetation zones in salt marshes along the vertical gradient in seawater exposure (inundation frequency) [57]. IUCN. Diagram symbols courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science.



[2] https://tourduvalat.org/en/actions/les-zones-humides-mediterraneennes-enjeux-et-perspectives-2-solutions-pour-des-zones-humides-mediterraneennes-durables/

CHAPTER 2:

POLICIES AND NEW MECHANISMS FOR CARBON MANAGEMENT

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POLICIES AND NEW MECHANISMS FOR CARBON MANAGEMENT

The decision by 195 countries to adopt the **Paris Agreement** at the 21st Conference of the Parties (COP) on 12 December 2015 marked a historic turning point to climate change efforts, committing nations to limit the global temperature rise to well below 2 °C, while pursing efforts to limit to 1.5 °C^[3]. As such, it charted a new course where countries have adopted emissions reduction targets by transitioning towards a low-carbon economy using innovation in the technology, energy, finance, and conservation sectors[4].

Unlike the Kyoto Protocol adopted nearly two decades earlier, the current Paris Agreement do not only focus on mitigation but also on finance and adaptation. Moreover, it formally recognised the important role marine ecosystems play in regulating the climate and absorbing anthropogenic CO_2 emissions [58].

As part of the Paris Agreement, the Contracting Parties are committed to regularly submit revised **National Determined Contributions (NDCs)** every five years, indicating their national strategies for climate action, and to submit reviewed pledges that are intended to continually increase their ambitions (Art 4.3 and 4.9 of the Paris Agreement). Here the countries are requested to include information on the scope and coverage of their mitigation and adaptation efforts, as well as on methodological approaches, including those for estimating and accounting for anthropogenic greenhouse gas emissions and removals (e.g. 2013 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands). Parties can develop their NDC mitigation actions and priorities based on a portfolio of measures including nature-based solutions. This offers the opportunity for countries to consider nature-based solutions beyond what was originally submitted, including blue carbon as an opportunity to target the emissions gap [58].

Blue carbon mitigation contributions have been included by a few countries in their past contributions (previously referred to as INDCs), from a wide range of activities encompassing ocean carbon storage and the protection, replantation, or management of mangroves, salt marshes, seagrass beds, or other marine ecosystems. Still, given the significant carbon sink capacities of these ecosystems, significant opportunities exist to further expand the carbon mitigation potential of blue carbon ecosystems with management actions and report these efforts under this mechanism [58, 59].

"The climate mitigation opportunity of blue carbon ecosystems. [...] If coastal wetlands were restored to their 1990 extent, it would have the potential to increase annual carbon sequestration by 160 Mt CO_2 yr^{-1} which is the equivalent to offsetting the burning of 77.4 million tonnes of coal" [58].

Recognising the value of blue carbon ecosystems in climate change efforts has been further highlighted in the Intergovernmental Panel on Climate Change (IPCC) Special Report on *the ocean and cryosphere in a changing climate*[5], released in 2019. Among the major adaptation measures proposed, the report includes restoring terrestrial and marine habitats and improving the management of coastal blue carbon ecosystems. Conservation of intact blue carbon ecosystems such as wetlands and seagrasses is seen as one of the effective management measures to minimise detrimental change in greenhouse gas emissions

[3] The Paris Agreement | UNFCCC
[4] The Agreement entered into force on 4 November 2016.
[5] https://www.ipcc.ch/srocc/

and to protect existing ecosystem services. In parallel, restoration of coastal ecosystems, specifically tidal salt marshes, seagrass meadows and mangrove forests, are mentioned as examples proving the potential of nature-based solutions for climate mitigation and adaptation (Fig. 7).

Developing these types of measures would not only help reduce the emissions that are warming and acidifying the ocean; they would create new jobs, enhance coastal resilience, boost food security, and improve air quality and human health.

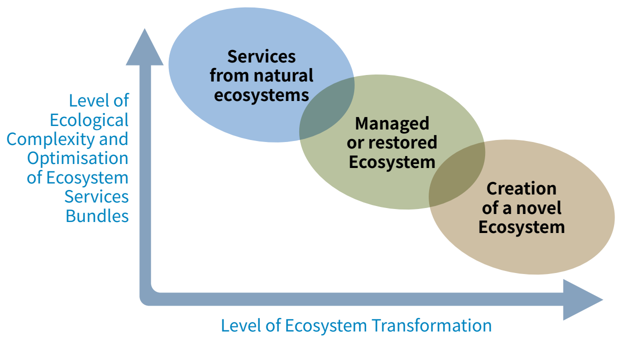


Figure 7: IUCN Global Standard of NBS.The relationship between ecological complexity and ecosystem services optimisation, and the level of engineering ecosystems. (Adapted from Balian, Eggermont & Le Roux (2014)).

"Restoration of vegetated coastal ecosystems, such as mangroves, tidal marshes and seagrass meadows (coastal 'blue carbon' ecosystems), could provide climate change mitigation through increased carbon uptake and storage of around 0.5% of current global emissions annually (medium confidence). Improved protection and management can reduce carbon emissions from these ecosystems. Together, these actions also have multiple other benefits, such as providing storm protection, improving water quality, and benefiting biodiversity and fisheries (high confidence). Improving the quantification of carbon storage and greenhouse gas fluxes of these coastal ecosystems will reduce current uncertainties around measurement, reporting and verification (high confidence) [60].

European Policies

At EU level, to suppport the European Union member countries reach the 2030 climate and energy targets, a new **Regulation mechanism on the Governance of the Energy Union** (Regulation (EU) 2018/1999) has been set up with common rules for planning, reporting and monitoring. The Regulation aims to ensure that EU planning and reporting are synchronised with the ambition cycles under the Paris Agreement. Additionally, it includes elements to track progress in the implementation of EU climate legislation, such as the **Effort Sharing Regulation** and the **LULUCF Regulation** (land use, land-use change and forestry sectors). The regulation also lays down a monitoring mechanism for greenhouse gas emissions and other climate information, so EU counties are able to comply with its reporting obligations under the UNFCCC and the Paris Agreement.

In line with these efforts, and along with the Aichi targets for biodiversity, in May 2020 the European Commission adopted the **Biodiversity Strategy** as one of the most heavy-hitting frameworks under the **umbrella European Green Deal.** This ambitious multilateral framework sets a series of biodiversity goals with new measures to be achieved by 2030, including restoration investments and conservation measures in protected areas for improving weakened and deteriorated ecosystems such as carbon sinks.

These efforts will contribute to the road map of biodiversity conservation and climate mitigation/ adaptation policies at national and EU levels (e.g. goals for LULUCF Regulation on wetlands by 2026) as well as to the European Climate Pact for the 2030 Climate Targets that propose to raise the 2030 greenhouse gas emission reduction target, including emissions and removals, to at least 55% compared to 1990.

THE CARBON MARKETS BACKGROUND AND PRINCIPLES

Carbon markets are one of the tools to tackle the climate change mitigation and were initially created to allow allowance and reductions (or emissions reductions measures as tonnes of carbon dioxide equivalent, CO_2e) from projects to be exchanged from one entity to another.

There are two main carbon market mechanisms: **cap and trade schemes** (or emissions trading systems, ETS) and **baseline-and-credit mechanisms,** which are commonly called **offsetting mechanisms.** These two forms of market do not work in the same way, and do not have the same objective. Below, we describe how different carbon markets function and the main offsetting mechanisms in the world, in order to highlight their link to blue carbon and targets when it comes to climate ambition. Some of the present schemes are under revision as part of the current discussions of the Paris Agreement operationalisation.

2.1. Carbon trading mechanisms under international treaties

Terminology for greenhouse gas (GHG) emission units can be confusing. Carbon assets can be split into two main categories:

- **Carbon emission units:** these are units materialised by an institution in the context of a cap-and-trade mechanism. Each unit does not per se represent an emission reduction but a right to release GHG, each equivalent to a tonne of carbon dioxide (tCO_2e), into the atmosphere. Depending on the jurisdiction they are often interchangeably called allowances, quotas or amounts. This is notably the case for the Kyoto Protocol's Assigned Amount Units and the European Union Allowances of the EU Emission Trading Scheme (EU-ETS).

- **Carbon emission reduction units,** also call "removal units": these are materialised by an authority or an independent not-for-profit organisation in the context of a baseline-and-credit mechanism. These units represent a range of GHG emissions, expressed in carbon dioxide equivalent (also tCO_2e), reduced, avoided or sequestrated in carbon sinks in comparison to a hypothetical baseline scenario. Often called carbon credits, these are issued for projects having demonstrated their emission reduction are additional, real, verifiable, measurable, unique and permanent. Depending on the certification standards or organisations concerned, they are often interchangeably called carbon credits, carbon offsets, carbon certificates or removal units. This is notably the case for Certified Emission Reductions from the UNFCCC's Clean Development Mechanism, Verified Carbon Units from the VCS, and Plan Vivo's Certificates.

The role carbon certification standards play is central to a baseline-and-credit mechanism

Carbon certification standards set the rules under which projects can be granted carbon credits. One of the core elements of this approach is the definition of a **hypothetical baseline scenario.** This could be defined as the most likely scenario in the absence of the project taking place. Once the most likely scenario is established, the GHG emissions related

to this scenario are calculated and compared to those induced by the project.
The difference of emissions between the baseline and the project scenarios are those reduced, avoided or sequestrated by the project.

In order to ensure the environmental integrity of carbon credits and guarantee they represent emission reduction/avoidance/sequestration that would not have occurred without the proposed project/activities, carbon certification standards have established a broad range of rules projects need to follow and criteria they need to meet.
The first carbon certification standards, which emerged from Kyoto Protocol, were the Clean Development Mechanism and the Joint Implementation. Their rules cover:

- Certification stages and processes,
- The development and approval of GHG accounting and monitoring methodologies,
- Various rules on project start dates, scales, ownership of emission reductions, safeguards, etc.,
- Environmental assessment and stakeholder consultation requirements,
- Host country approval requirements, and
- The accreditation of auditing companies allowed to validate and verify projects and emission reductions.

The sections that follow provide an overview of the characteristics of the compliance and voluntary carbon markets and the role baseline-and-credit mechanisms play in these.

Figure 8: Overview of interactions between compliance and volunteer carbon markets including previous under the Kyoto Protocol (KP) and new ones under development with the Paris Agreement (PA). Adapted from NewClimate Institute; Lambert Schneider.

Compliance carbon markets

The carbon markets are mechanisms originally designed under the Kyoto Protocol (1997) and operationalised through the Marrakesh Accords (2001) to help Parties of the United Nations Framework Convention on Climate Change (UNFCCC) to meet their emission reduction requirements in a cost-effective manner.

The Kyoto Protocol defines three flexibility mechanisms:

- Clean development mechanism (CDM)
- Joint implementation (JI)
- Emissions trading (ET)

The CDM and the JI are baseline-and-credit mechanisms while ET is a market-based mechanism, often taking the form of cap-and-trade scheme.

Since they refer to mechanisms designed to help Parties to meet their regulatory requirements, these mechanisms form part of what is called the compliance carbon markets (Fig. 8). A compliance carbon market imposes emission reduction targets and instruments to be used by organisations within specific geographical and sectoral boundaries.

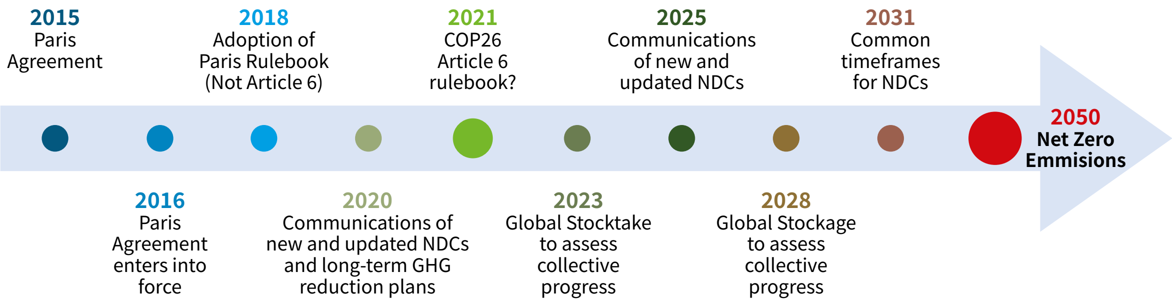
The mechanisms were scheduled to finish at the end of 2020 when the Paris Agreement was to enter into force. At the date this manual was drafted, and given that Article 6 (international cooperation mechanisms) of the Paris treaty remains to be fully developed, discussions were held with regard to extending the operation of the CDM with respect to registration and renewal of crediting periods of project activities and programmes of activities with a crediting period starting on or after 1 January 2021, and issuance of certified emission reductions related to emission reductions or removals achieved on or after 1 January 2021[6].

Carbon markets under the Paris Agreement

Under the Paris Agreement, most countries around the world have adopted climate targets and two new carbon markets have been established to replace the three Kyoto markets. These markets are covered in large part by **Article 6 of the agreement,** and negotiators have been discussing the detailed rules of these mechanisms since 2016 (Fig. 9). At present, no agreement has been found and rules are still to be fully developed, even though the treaty entered into force in January 2021.

Article 6 is split into two different market mechanisms: Article 6.2 and Article 6.4 (the latter is sometimes called the Sustainable Development Mechanism, or SDM).

Figure 9: Overview of the implementation process for the Paris Agreement, including the NDC updating cycle.



[6] https://unfccc.int/news/the-cdm-executive-board-considers-cdm-beyond-2020

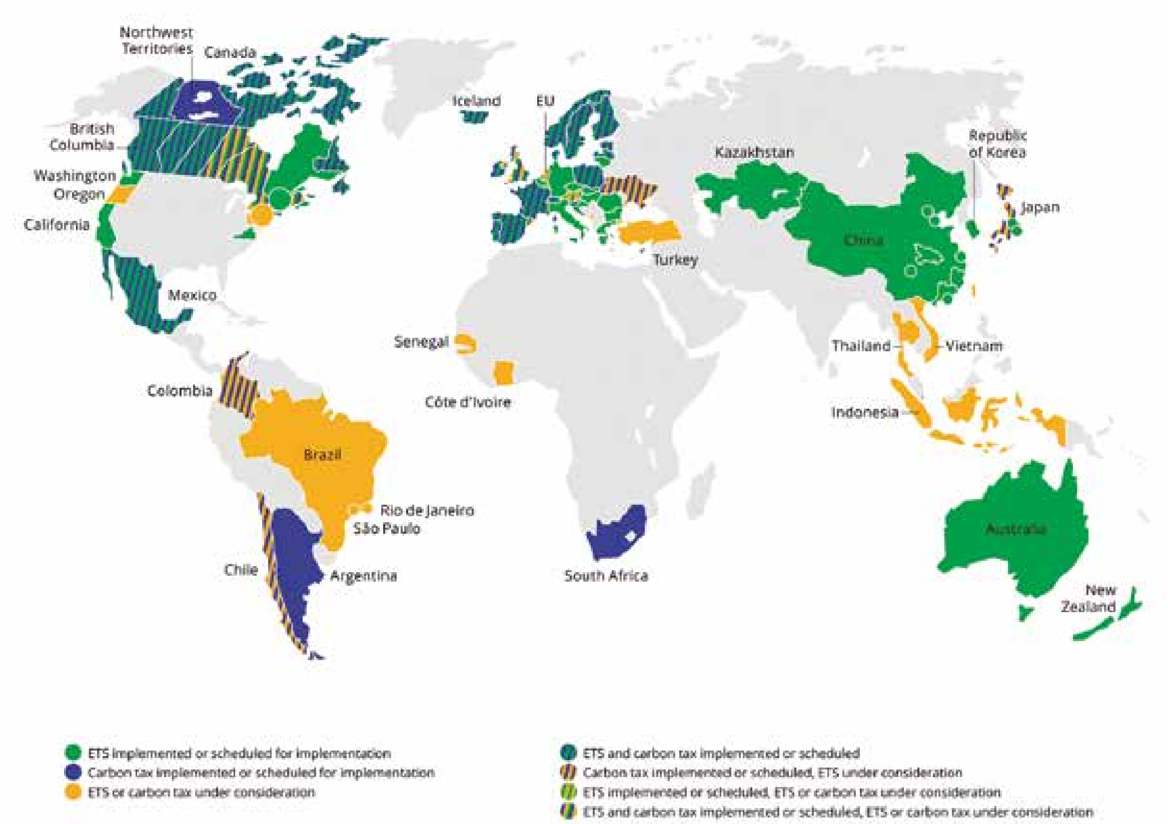
• **Article 6.2.** Sets up a carbon market that allows countries to sell any extra emission reductions they have achieved compared to their target. These extra credits would be called Internationally Transferred Mitigation Outcomes (ITMOs).

• **Article 6.4.** A different system, Article 6.4 resembles much more the Clean Development Mechanism (CDM), except that it will not be restricted to projects implemented in developing countries. Under this market, it is expected that project developers will reduce emissions through specific actions in a country and sell these emission reductions to another country/company/person. This process requires more "governance", i.e. more control from a body tasked with establishing detailed rules and verifying that projects and credits comply with certain criteria.

Emissions trading

Parties with commitments under the Paris Agreement accepted targets for limiting or reducing emissions. These targets were expressed as levels of allowed emissions, or assigned amounts, over the commitment periods. The allowed emissions were divided into assigned amount units (AAUs). Emissions trading, as set out in Article 17 of the Kyoto Protocol, was allowing countries that have emission units to spare, emissions permitted

Figure 10: Carbon pricing initiatives implemented, scheduled for implementation and under consideration (ETS and carbon tax) in 2020. Source: State and Trends of Carbon Pricing.



The large circles represent cooperation initiatives on carbon pricing between subnational jurisdictions. The small circles represent carbon pricing initiatives in cities.

Note: Carbon pricing initiatives are considered "scheduled for implementation" once they have been formally adopted through legislation and have an official, planned start date. Carbon pricing initiatives are considered "under consideration" if the government has announced its intention to work towards the implementation of a carbon pricing initiative and this has been formally confirmed by official government sources. The carbon pricing initiatives have been classified in ETSs and carbon taxes according to how they operate technically. ETS not only refers to cap-and-trade systems, but also baseline-and-credit systems as seen in British Columbia and baseline-and-offset systems as seen in Australia. The authors recognize that other classifications are possible.

to them but not 'used', to sell this excess capacity to countries that are over their targets (Fig. 11).

To cascade down the national level commitments, emissions trading schemes were established as climate policy instruments at national and regional levels. Under such schemes, governments set emissions obligations to be reached by the participating entities. The EU-ETS is the largest in operation.

At present, 31 emission trading systems (ETSs) existed at least in regional, national and subnational jurisdictions[7]. The figure 10 provides an overview of the status and nature of these schemes.

The European Union Emissions Trading Scheme

As part of the European Green Deal, the Commission proposed in September 2020 to raise the 2030 GHG emission reduction target, including emissions and removals, to at least 55% compared to 1990.

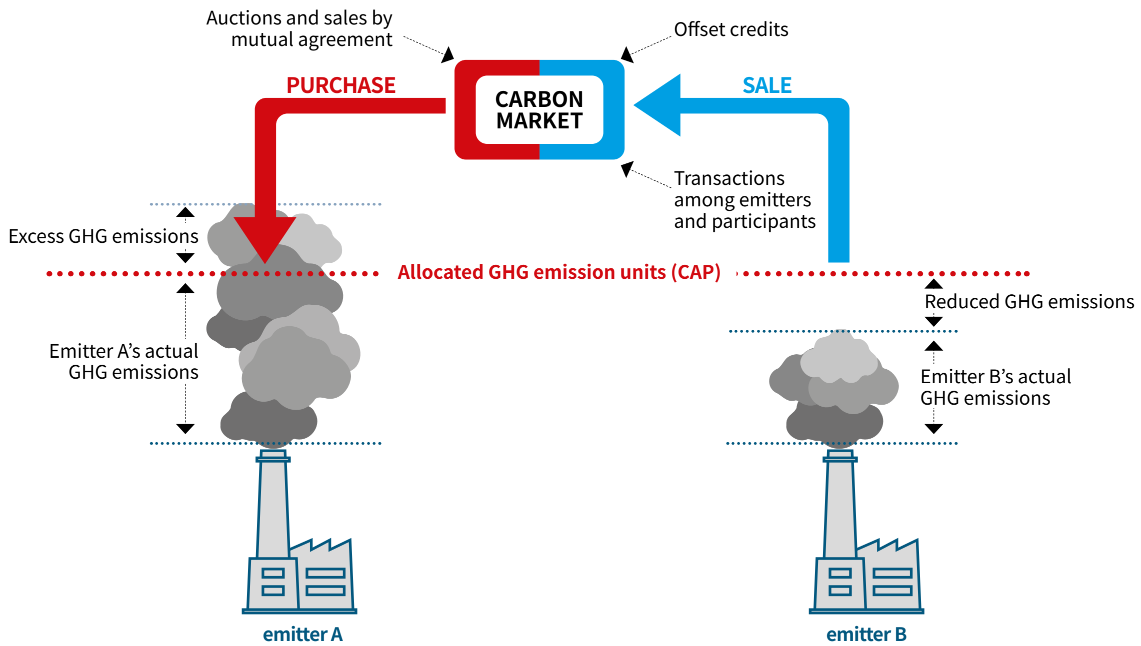
The 2030 EU climate and energy framework now includes EU-wide targets and policy objectives for the period from 2021 to 2030. Besides key targets on renewable energy and energy efficiency, a 40% reduction of GHG should be implemented by EU-ETS, the Effort Sharing Regulation with Member States' emissions reduction targets, and the land use, land use change and forestry (LUCLUCF) Regulation.

The EU-ETS is a cornerstone of the EU's policy to combat climate change and is a key tool for reducing GHG emissions cost-effectively. It is the world's first major carbon market and remains the largest one.

The EU-ETS operates in 31 countries (all 28 EU countries plus Iceland, Liechtenstein and Norway), and limits emissions from more than 11,000 heavy energy-using installations (power stations and industrial plants) and airlines operating between these countries. It covers around 45% of the EU's GHG emissions.

With this new 2030 target, climate legislation will now be updated with a view to implementing the proposed "at least 55% net greenhouse gas emissions reduction target".

Figure 11: Emissions trading system based on allocated GHG emission units. To reach the Paris agreement target by 2050 and more ambitious targets, this limit of GHG emissions will need to be reduced over time through different actions to reduce emitter's emissions in all economic sectors.



[7] Source: State and Trends of Carbon Pricing (WB, 2020)

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2.2. Carbon trading mechanism not covered by the Paris Agreement

The Carbon Offsetting and Reduction Scheme for International Aviation

In parallel to the UNFCCC's carbon markets, another UN agency, the International Civil Aviation Organisation (ICAO) has been developing its own mechanism. In 2016, member countries of ICAO agreed to establish the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), a carbon market specifically designed for airlines[8].

The objective of this market is to compensate the growth in emissions from international flights above 2020 levels. Reference emission levels were taken from 2019- 2020, and anything emitted above this threshold will in the future have to be avoided or compensated by airlines through the purchase of carbon offsets. As in paragraph 9 of the Assembly Resolution, the CORSIA is implemented in phases, starting with participation of States on a voluntary basis until 2026, followed by participation of all States except the States exempted from offsetting requirements.

Countries meeting through ICAO decided which offset credits would be eligible for CORSIA, based on recommendations from an expert group (the Technical Advisory Body) under the auspices of the ICAO Council. The Council has accepted offsetting could be done through the purchase and cancellation of emissions units arising from different sources of emissions reductions, achieved through projects certified to a broad range of certification standards (Fig. 12). **The Verified Carbon Standard (VCS)** (see Voluntary Carbon Markets) has been accepted as one of the programmes that has been deemed eligible to supply emission reduction units for compliance under the CORSIA. Most project types under the VCS programme are eligible, including those using the **Methodology for Tidal Wetland and Seagrass Restoration and the REDD+ Methodology Framework.**

[8] https://www.icao.int/environmental-protection/pages/a39_corsia_faq2.aspx

2.3 Voluntary carbon markets

Voluntary carbon markets have developed on the back of the major compliance carbon markets. The main differences with the compliance carbon markets are listed below:

Nature of participants

Participants of most major compliance markets are carbon-intensive industries. This is notably the case for electricity producers, ceramic, glass, iron and steel manufacturers, as well as airlines. They all are heavy users of energy.

Participants of the voluntary carbon markets are organisations of all types (private companies, NGOs, government agencies or international organisations). They are usually organisations not participating in any compliance market but willing to reduce and offset their emissions on a voluntary basis. Large banks, insurance companies and law firms have been among the first to be active on these markets.

Certification standards

Within compliance carbon markets allowing baseline-and-credit mechanisms, an authority defines the project certification standards allowed for compliance. These usually fit into a very restrictive list of allowed standards. For example, the EU-ETS only allows carbon credits from the CDM and the JI, both endorsed by the UNFCCC. Voluntary carbon markets are unregulated and for this reason are much more flexible around certification standards. While most carbon credits are coming from projects certified to credible standards, a much more diverse range of certification standards is being used. The CDM is being used, as well as the Verified Carbon Standard, the Gold Standard, Plan Vivo, the American Carbon Registry and the Climate Action Reserve. Voluntary standards have initially been developed to offer faster and less resource-intensive certification schemes for emissions reduction projects. They are all modelled on the principles and sometimes the rules of the CDM.

Volumes and value

The volume traded and exchanged on compliance and voluntary carbon markets also set them apart. In 2019, about 70 million carbon offsets were used on the voluntary carbon markets. Since the voluntary carbon markets are less transparent, little trading volume data is available, but since the credits rarely change hands more than three times (being traded twice), this amounted to a trading volume of up to 104 million carbon offsets. In the same year, as many as 9 billion allowances were traded[9] on the EU-ETS. This made the voluntary carbon markets 86 times smaller than the EU-ETS on its own.

Buyers' motivations

The only reason organisations are active on the compliance markets is to meet the requirements of jurisdictional legislation.

In contrast, the range and diversity of organisations active on the voluntary carbon markets is reflected in the diversity of motivations when buying carbon offsets. Around a third of them state that they acquire carbon offsets because of a sense of responsibility, 22% of them for brand building, 13% for market differentiation, 9% for employee engagement and others for pre-compliance, internalising carbon cost or risk-mitigation purposes[10].

[9] Source: State of the EU ETS Report (ERCST, Wegener Center, BloombergNEF and Ecoact, 2020)
[10] Source: Business Leadership on Climate Action, Drivers and Benefits of Offsetting (ICROA, 2017)


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Volunteers planting young mangrove trees in Phuket island (Thailand) as example of potential blue carbon project.

Buyers' preferences

Driven by the need to comply at the lowest cost possible, buyers on the compliance carbon market usually optimise their strategy to buy carbon allowances or offsets at the lowest price possible. A marginal proportion are also keen to buy carbon offsets from projects in specific locations or to have a small portion of carbon offsets with more social impacts.

In contrast, organisations active on the voluntary carbon markets are looking for carbon offsets that fit their organisations' priorities, match their budget, and offer social and environmental benefits beyond the emissions reductions (e.g. poverty alleviation, biodiversity conservation, etc.)[11]

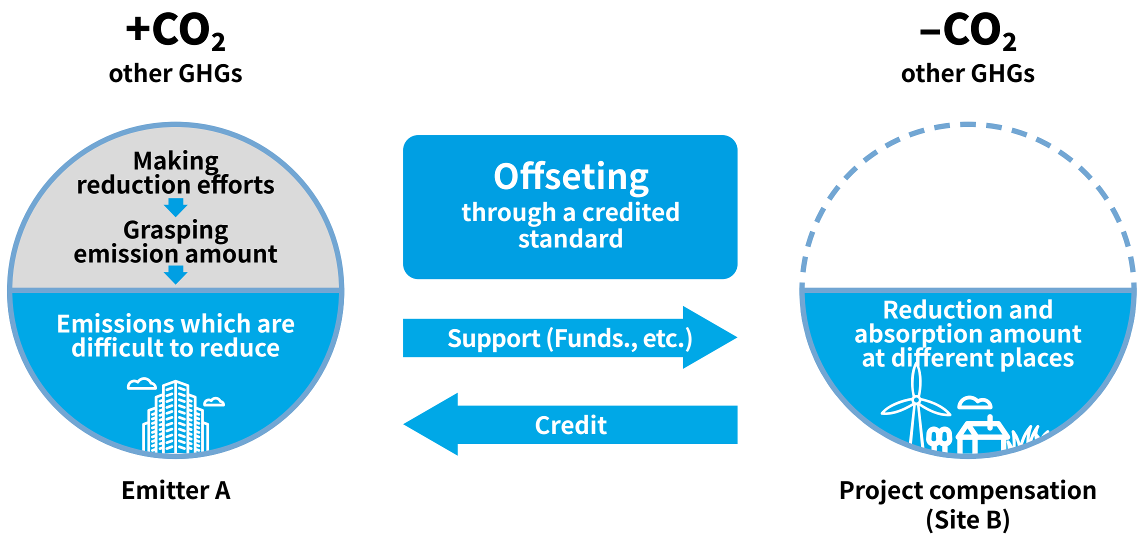
Prices

Compliance carbon markets offer transparent marketplaces and price levels. Therefore, there is a unique price for each type of GHG emission unit. On the EU-ETS, the carbon allowances (e.g. European Union Allowances) have been fluctuating between €8 and €30 while carbon credits (e.g. Certified Emission Reductions) have been fluctuating between €0.15 and €25 over the years.

Voluntary carbon markets have been developing on the back of the compliance carbon markets to offer smaller scale projects by lowering transaction costs. As a result, numerous small-scale and charismatic projects have been emerging from these. On these markets, carbon credits are less perceived as a commodity and underlying projects matter more. Prices range from €0.35 to around €60 and there can be as many prices are there are transactions or projects.

[11] Source: State of Voluntary Carbon Market 2016 (Forest Trends, 2016)

Figure 12: Carbon offsetting allows to balance out climate impacts (e.g. from business) after reduction efforts and compensate for the emissions produce by reducing CO_2 (and other GHG) elsewhere.



Pricing drivers

The prices of the various GHG emission units on compliance carbon markets are multiple and depend on the structure of the markets themselves. Some of the most common drivers are energy prices, weather, issuance and limits of carbon reduction units, production levels and economic outputs, and inter-linked policies (e.g. energy efficiency).

On the voluntary carbon markets, each transaction is carried out over-the-counter and prices are dependent on the buyers' willingness to pay, the sellers' willingness to accept, and the offer and demand balance.

European domestic offset initiatives

Certified carbon projects in Europe have been enabled through the Kyoto Protocol's Joint Implementation (JI) until the enter of the Paris Agreement. The issuance of emission reduction units was allowed in sectors not covered under the national inventory of host countries and whenever host country governments were willing to cancel their own Assigned Amount Units for corresponding adjustments. Under this mechanism, 231 projects were registered (excluding Russia and Ukraine). **In the European Union countries of the Mediterranean region (i.e. Spain, France, Italy and Greece), only 20 projects were registered** (17 in France and three in Spain) and none of them in relation to ocean ecosystems.

Over the past few years, initiatives around domestic carbon offsets have taken place notably in Austria, Belgium, France, Germany, the Netherlands, Switzerland, the United Kingdom and Spain. This increase of interest has been emerging from organisations' desire to offset their emissions with local projects, rather than projects located in developing countries with which they have no links. However, the demand cannot currently be met by the supply, notably due to issues around double counting and the actual price of carbon credits.

The United Kingdom has developed the *Woodland Carbon Code* and the *Peatland Carbon Code;* France has developed the *Label bas-carbone;* Germany has used the *MooreFutures;* Switzerland has used *Swiss attestations;* and Spain set up *Proyectos de absorción de* CO_2[12] .

Since 2020, the development of a mangrove-related methodology had been under development under the French *Label bas-carbone,* which will allow companies wishing to offset their CO_2 emissions to finance future projects under the label of the Ministry of Ecological and Inclusive Transition. Future mechanisms for other blue carbon habitats could be supported and emerge in the coming years.

The Spanish voluntary carbon offsetting scheme (Spanish registry of carbon footprint, compensation and absorption projects) only includes certain afforestation/reforestation projects and is of modest size, counting 63 projects with an (ex-ante) volume approximately 200,000 tCO_2e. Another Spanish initiative that facilitates the acquisition of carbon credits is the *Fondo de Carbono para una Economía Sostenible* (FES-CO_2), which sees the government acquiring verified emission reductions from domestic climate projects through the Spanish carbon fund in order to promote private actions to reduce emissions in non-ETS sectors.

In Spain, the Valencian Voluntary Carbon Market and the Andalusian Emissions Offset System have been emerging and present an interesting potential for domestic carbon projects to retail carbon credits.

Forum for discussing with EU Member States and stakeholders on the role of these coastal and marine ecosystems for climate mitigation and adaptation. Organised by IUCN and European Parliament Intergroup on “Climate Change, Biodiversity, and Sustainable Development”. 2018.

[12] Source: https://www.miteco.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/organizaciones-proyectos.aspx

Andalusian Emissions Offset System

The Andalusian Emissions Offset System *(Sistema Andaluz de Compensación de Emisiones*–SACE)[13] developed under the regional climate change law (Law 8/2018, article 50; Decree 2/2020) is a voluntary initiative that provides private companies with the opportunity to actively participate in climate change mitigation. Under this initiative, companies commit to:

- Audit their GHG emissions;
- Reduce these; and
- Offset their remaining emissions.

The offsetting planned under the SACE is to be carried out through projects of afforestation, reforestation, and conservation of existing forests, coastal ecosystems, seagrass meadows and wetlands, as well as those conserving or increasing the organic matter content of the soil in the fields of forestry or agriculture. This mechanism creates the possibility of offsetting CO_2 emissions through the execution of these types of projects, including for the first time **blue carbon projects.** Emissions sequestrated are called Absorption Units (UDAs). Offsetting projects are planned to be developed within the framework of the Andalusian Forest Plan and will have to protect the biodiversity of the Andalusian Forest Heritage, involve sustainable forest management and conserve protected natural areas. The Department of Environment and Territorial Planning is expected to approve a catalogue of offset projects, which will include projects that meet the necessary requirements on eligibility, additionality, safeguards, and sustainability, according to the Andalusian Plan, as well as a description of their characteristics and location. In addition, the UDAs certified by the Department of Environment and Territorial Planning will not be included in the national inventory, avoiding double counting.

The regulatory development of the SACE, still pending approval, will provide the conditions for the registration of carbon offset projects under the registry. This is expected to establish general norms for offsetting projects, such as the requirements of the applied standard, and incorporate a project management plan that guarantees, at least during the established period of permanence, the success of the actions and the permanence of the carbon stock generated. Moreover, carbon offset projects under this registry should ensure the maintenance of the carbon stock during the minimum period of permanence of the defined project and present information periodically during the life cycle on the status of the project, in such a way as to allow the calculation and certification of the UDAs. As part of these new mechanisms, new blue carbon standards are also under development[14].

The special issue of double counting

Since European countries account for most of their GHG emissions within their national GHG inventory, any emission reduction happening within the geographical and sectoral boundary of their inventory would be accounted for at the national level. Any third-party entity developing a project reducing GHG emissions within the scope of the host country national inventory would only be able to claim these reductions if it had been deducted from the national inventory. For this reason, carbon project development in European countries are generally not claimed to be used by an organisation to offset its own emissions.

[13] http://www.juntadeandalucia.es/medioambiente/site/pacc/
[14] http://life-bluenatura.eu/en/home/

2.4. Structuring principles

The UNFCCC has set principles to be met by GHG emission reductions materialised as carbon credits. These principles have been applied by all existing carbon standards. Each emission reduction needs to be:

- **Additional:** the revenue from the sale of carbon credits is a determining factor in the implementation of the project. The survival of the project depends, to some extent, on the project developer's ability to sell these carbon credits. In other words, this implies that the project could not have emerged had it not been financially supported by an offset scheme. This concept is known as 'additionality';

- **Real:** the emission reductions must have actually happened. There must be an emission reduction underlying each carbon offsets which corresponds to the outcome of the implemented project;

- **Measurable and Verifiable:** emission reductions can be calculated with scientific rigour and be monitored and audited. To do this, there must be calculation and monitoring methodologies that are appropriate to the context and technology concerned;

- **Permanent:** the emissions which have been reduced or avoided must last over time and must not be released back into the atmosphere by the project in question at a later date;

- **Be unique:** each carbon credit must correspond to a single tonne CO2e. This also means that procedures to avoid double-counting must be put in place.

These principles are reflected in the requirements of the various voluntary carbon standards.

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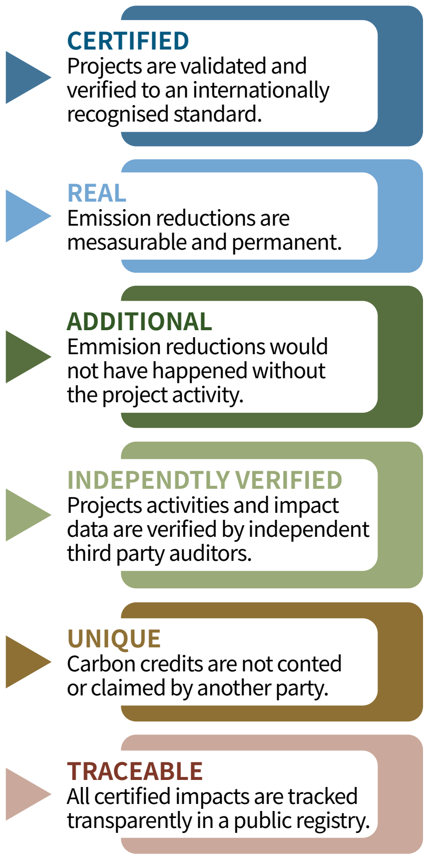


2.5. International Voluntary Carbon Standards

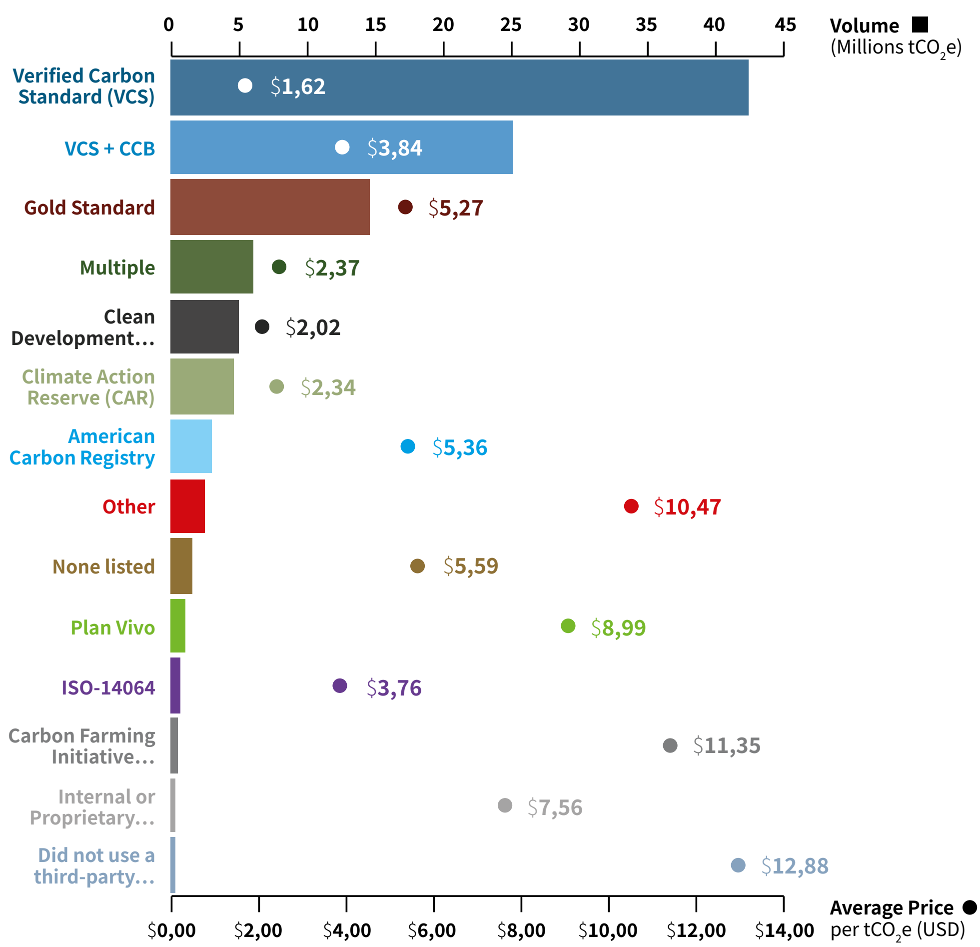
Carbon credits sold on the voluntary carbon markets are mostly issued by seven certification standards, as is illustrated in Fig. 13.

These standards are as follows:

- The **Verified Carbon Standard** (VCS) was launched in 2005 by the Climate Group, IETA and the World Economic Forum (with WBCSD joining later), representing private interest groups. In 2018, Verra became the organisation owning and managing the VCS. Over time it has become the favoured standard for renewable energy and land-use-related activities, notably for the Reduction of Emissions from Deforestation and forest Degradation (REDD) programme. While most CDM and CAR methodologies can be used under the VCS, Verra has developed 42 proprietary methodologies.

- The **Gold Standard** (GS) was launched in 2003 by WWF, SouthSouthNorth and Helio International. Initially launched as a co-benefit certification standard for the CDM, it was reshaped in 2006

Figure 13: Market share of carbon market standards in 2019[15]**.**



[15] Source: State of Voluntary Carbon Market 2019 (Ecosystem Market Place. Forest trends).

to deliver its own carbon credits and align on the Millennium Development Goals. It has developed more than 20 proprietary methodologies and is the favoured standard for community-oriented projects. It has developed partnerships with Fairtrade International and the Forest Stewardship Council and is supported by a broad network of NGOs. In 2017 the GS Foundation aligned its rules and principles with the Sustainable Development Goals and launched the Gold Standard for the Global Goals (GS4GG). Recently, GS has launched a new framework methodology for carbon credit assurance (for soils) with different activity models and the possibility for multiple credible approaches to be used to calculate sequestration.

- The **Clean Development Mechanism** is the reference carbon standard developed by the UNFCCC. While initially intended for the compliance carbon markets, the carbon credits it delivers are also used on the voluntary carbon markets. The UNFCCC has developed more than 200 methodologies.

- The **Climate Action Reserve** was created in 2001 as the California Climate Action Registry. Although it was initially to encourage voluntary actions throughout the USA, it is very actively used under the California cap-and-trade scheme. It has developed more than 20 methodologies (called protocols) focusing particularly on the USA and Mexico. This standard has a more standardised and higher-level approach to additionality and focuses on coal mine methane, livestock, forestry, landfill gas and agriculture.

- **ISO-14064-2** was published in 2006 by the International Organization for Standardization (ISO). It specifies principles and requirements and provides guidance at the project level for quantification, monitoring and reporting of activities intended to cause GHG emission reductions or removal enhancements. It includes requirements for planning a GHG project, identifying and selecting GHG sources, sinks and reservoirs relevant to the project, and baseline scenario, monitoring, quantifying, documenting and reporting GHG project performance and managing data quality. ISO does not deliver or materialise carbon credits on a registry like most other standards and is now mostly used in specific countries (e.g. Canada).

- The **American Carbon Registry** (ACR) was launched in 1996 under the Environmental Resources Trust by Environmental Defense Fund, an NGO advocating for market-based solutions. In 2007, the newly branded ACR was launched, mostly focusing on US-based projects and based on ISO 14064.

- The **Plan Vivo Standard** is a scheme for rural smallholders and communities dependent on natural resources for livelihoods. It was developed by the Edinburgh Centre for Carbon Management in partnership with El Colegio de la Frontera Sur (ECOSUR), the University of Edinburgh and other local organisations. While Plan Vivo originated in 1994, in 2008 a fully-fledged version of the standard was articulated under the Plan Vivo Foundation. Eligible activities (for generating Plan Vivo certificates) are afforestation and agroforestry, forest conservation, restoration and avoided deforestation. Plan Vivo projects are community-led: communities decide which land-use activities (e.g. woodlots, agroforestry, forest conservation) will best address threats to local ecosystems and are of interest and value to them.

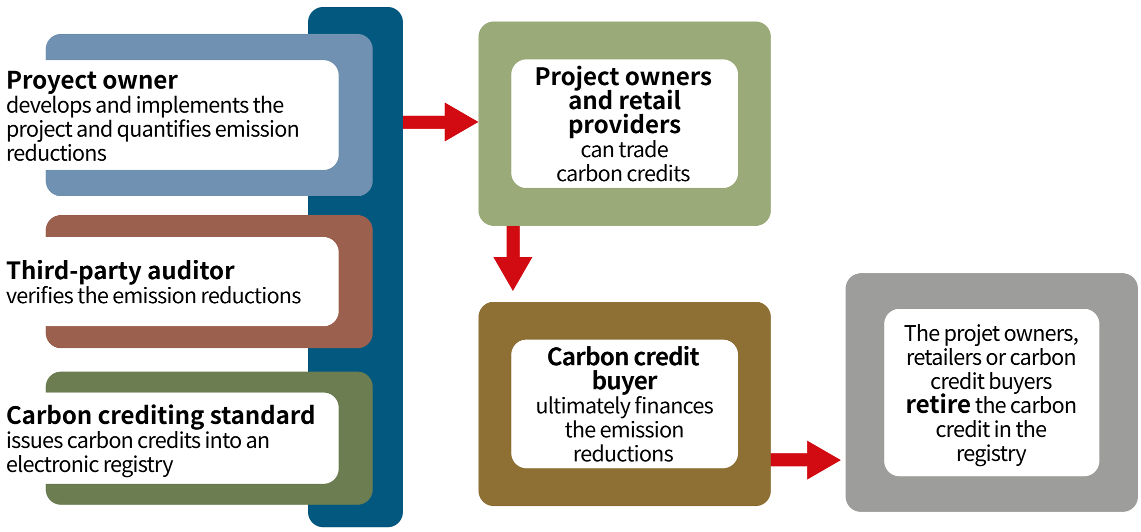
Besides these carbon certification bodies issuing carbon credits, a few additional standards are also relevant for the carbon markets. They are commonly called co-benefits standards and have established a set of requirements for carbon projects to meet in relation to social, human, biodiversity, adaptation and financial benefits. The two most used are as follows:

- The **Climate, Community & Biodiversity (CCB) Standards** were launched in 2005 by several NGOs including CARE, the Nature Conservancy and the Rainforest Alliance. The standards do not certify emission reductions but foster the integration of best-practice and multiple-benefit approaches into project design and implementation. The CCB Standards intend to (i) identify projects that simultaneously address climate change, support local communities and smallholders, and conserve biodiversity; (ii) promote excellence and innovation in project design and implementation; and (iii) mitigate risk for investors and offset buyers and increase funding opportunities for project developers. The CCB Standards can be applied to any land-management project, including projects that reduce GHG emissions from deforestation and forest degradation or from avoided degradation of other ecosystems.

- The **SOCIALCARBON Standard** was launched in 2000 by the Ecologica Institute, a Brazilian NGO that certifies carbon reduction projects for their contributions to sustainable development. Six aspects of project sustainability are individually measured using the SOCIALCARBON hexagon: carbon and biodiversity as well as social, financial, human and natural components. Projects set up ISO-like management plans with the objective to keep improving on these components, throughout the project lifetime.

Both these standards are mostly applied in combination with the VCS. While the CCB Standards are adapted for land-use projects, the SOCIALCARBON standard is usually applied to fuel switch and renewable energy projects.

Figure 14: Overview of a standard voluntary carbon cycle.
Adapted from New Climate Institute; Lambert Schneider.



COMMERCIALISATION OF VER/ITMOs

There are two main types of transaction on the carbon markets: Forward Sales and Spot Sales.

Forward Sales

This type of sale can correspond to the selling of:

- Ex-ante (non-issued) emission reductions before they occur; or
- Ex-post (issued) emission reductions to be delivered months or years after they have been issued and contracted.

Forward sales are the most complex as a broad range of terms need to be negotiated. Clauses should cover:

- Quantities to be purchased/sold (e.g. fixed vs variable amounts, firm commitment vs options to buy/sell);
- Price(s) to be paid (e.g. fixed vs indexed on quantities or another benchmark);
- Payment terms (e.g. payment in advance vs payment upon delivery);
- Delivery, and remedies to deal with the seller not being able to deliver the assets, or if the amount delivered is larger or smaller than expected;
- Allocation of costs to the various parties (e.g. cost of registration, or issuance);
- Registries and cancellation (e.g. has the buyer their own registry or do the credits need to be cancelled on their behalf and how);

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- Termination conditions;
- Governing law and resolution, especially if the buyer and the seller are not based in the same country;
- Taxes included and excluded;
- Invoicing requirements;
- Exclusivity or first right of refusal for the project or the next batch of credits to be issued;
- Requirements for the seller not to market the sold credits to another buyer;
- Marketing content requirements from the buyer; and
- Conditions for site visits.

Spot Sales

The common practice is for (i) the seller to deliver the carbon credits onto the buyer registry and then for the buyer to pay for the carbon credits delivered (Fig. 14). Alternatives include the opposite, where (ii) the buyer will pay first, and the seller will deliver afterwards or (iii) the use of an escrow account where the buyer will pay for the carbon credits on an account that will be blocked until he has received the carbon credits.

Depending on the transaction option chosen, the risk will be with the buyer (option ii) or the seller (option i) and contracts will need to address this risk. The contract will at least need to consider:

- Quantities to be purchased/sold;
- Price(s) to be paid;
- Payment terms (e.g. delays of payments);
- Registries and cancellation (e.g. has the buyer their own registry or do the credits need to be cancelled on their behalf and how);
- Termination conditions;
- Governing law and resolution, especially if the buyer and the seller are not based in the same country;
- Taxes included and excluded;
- Invoicing requirements;
- Exclusivity or first right of refusal for the project or the next batch of credits to be issued;
- Marketing content requirements from the buyer; and
- Conditions for site visits.

CHAPTER 3:

ASSESSING CARBON PROJECT ELIGIBILITY/FEASIBILITY

ASSESSING CARBON PROJECT ELIGIBILITY/FEASIBILITY

Not every project will be able to deliver and sell carbon credits and it does not always make sense to register a project with a certification standard. This is notably the case when resources required to issue and sell carbon credits equal or outweigh the revenues generated by the sale of these credits. For this reason, it is essential that project proponents understand the eligibility of their project(s) with respect to an existing certification standard and methodology, assess the resources required to go through each of the process steps (time- and money-wise), estimate the revenues that will be generated from the sale of carbon credits, and understand the risks related to double counting, emission reduction ownership and market.

Project types that are common on the carbon markets would require a very light assessment to be deemed eligible or ineligible, since information on existing projects would make the assessment much easier. On the other hand, complex projects such as those related to natural ecosystems would require a more thorough assessment as they feature many more parameters that could have an impact on the eligibility of a methodology or on emission reductions. In order to carry out a comprehensive assessment, key information is required. This includes:

Technology Background
- The project feasibility study
- An understanding of common practice in relation to the proposed project activity
- Expected project lifetime
- Financial analysis (including expected costs and revenues)
- Technical details of the most common alternative scenarios
- Project timeline (feasibility study, design, financial closing, commissioning, etc.)
- Monitoring, reporting and verification process to be implemented (if any)

Potential barriers
- List of barriers and challenges faced in developing such a project or activity (financial, legal, administrative, technological, etc.)
- Understanding of the permanence of carbon sequestration

Legal aspects
- State of regulation with regard to the proposed project
- Status of ownership of emissions sequestrated

Greenhouse gases
- Process related to emissions of and computation of CO_2, CH_4, N_2O (and any other relevant GHG) reduction, (if existing)
- Definition of temporal boundary

Depending on information available and the degree of certainty required, project proponents shall carry out the following activity to determine their project eligibility for an existing carbon certification standard.

3.1. Eligible activities and methodological assessment

One of the most important elements of carbon project eligibility is the possibility to use an existing GHG emission accounting and monitoring methodology. A core element of a baseline-and-credit mechanism is the calculation of baseline, plus project as well as leakage emissions, leading to the computation of total carbon sequestration or reduction. To do so, project proponents have to use an approved methodology. The CDM has about 200 of them, the VCS has 42, the Gold Standard 20+, the CAR has more than 20 of them and Plan Vivo has 3 "Approved approaches"[16].

While it is possible for project proponents to develop their own accounting and monitoring methodology, it is a resource-intensive process that can take up to two or three years, when accounting for the third-party auditing and carbon standard approval process. Unless there is a clear visibility to sell carbon credits at a price that would cover the methodology and carbon asset development work as well as contribute to the project revenues, it is not a cost-effective process. Methodologies define applicability conditions, baseline scenarios, the method for demonstrating additionality, the approach for accounting GHG emissions, and monitoring requirements.

This stage consists of finding the methodology that best matches the features of the specific project. Where no methodology exists, it is possible to either go through a dedicated process to amend an existing methodology or to create a new one.

Existing methodologies that are applicable to blue carbon projects are:

- CDM's AR-AM0014 "Afforestation and reforestation of degraded mangrove habitats";
- CDM's AR-AMS0003 "Simplified baseline and monitoring methodology for small scale CDM afforestation and reforestation project activities implemented on wetlands";
- Gold Standard's "Afforestation/Reforestation (A/R) GHG Emissions Reduction & Sequestration Methodology" (applicable for mangroves) with also a new methodology underway for other blue carbon ecosystems (e.g. seagrasses);
- VCS's VM0033 "Tidal Wetland and Seagrass Restoration";
- VCS's VM0007 "REDD+ Methodology Framework (REDD+MF)";
- VCS's VM0024 Methodology for Coastal Wetland Creation.

Plan Vivo is less prescriptive and recommends that projects develop to use scientific data. The following research papers have been used in Kenya and Madagascar:

- Mangrove carbon stocks and ecosystem cover dynamics in southwest Madagascar and the implications for local management [61].
- Mangroves of Kenya: The effects of species richness on growth and ecosystem functions of restored East African Mangrove stands [62].
- Allometric equations for estimating above ground biomass of *Rhizophora mucronata* Lamk (Rhizophoraceae) mangroves at Gaxi Bay, Kenya [63].
- Below-ground root yield and distribution in natural and replanted mangrove forests at Gazi bay, Kenya. Forest Ecology and Management [64].

[16] Source: http://www.planvivo.org/climate-benefit-estimation/approved-approaches/

3.2. Estimating costs associated with the full certification process

The costs of carbon assets development are often underestimated. To ensure the revenues from the sale of carbon credits at least cover these costs, it is essential to integrate these costs in the overall project development costing. The various budget lines to account for are:

- **Consultant fees.** Many organisations lack the technical capacity to carry out all or part of the carbon certification process and it is a common practice to work with third-party consultants for the development of the Project Design Document (PDD) and the environmental and social impacts assessment, and to have support during the validation audit, the monitoring and the verification audits. Depending on the complexity of the project, support for drafting a PDD may cost between €15,000 and €50,000; support for each validation and verification may cost between €5,000 and €10,000; and support for monitoring may cost between €5,000 and €20,000.

- **Auditing costs.** The pre-registration audit called validation and the post-emission reductions audit called verification may cost between €10,000 and €30,000, depending on the complexity of the project. The verification audits need to occur on a regular basis or each time the project proponent wishes to issue carbon credits.

- **Certification standard fees*.** Each standard has its own fee schedule for processing and managing applying or registered projects. Most of them apply fees at the time of registration and issuance. The VCS charges US$ 0.10 times the estimated annual volume of emission reductions (capped at US$ 10,000) for registration and US$ 0.10 per carbon credit issued (for the first million); Plan Vivo charges US$ 1,000 to US$ 4,000 for registration and between US$ 0.35 and US$ 0.40 per credit for issuance, as well as small fees for various preliminary reviews; and the Gold Standard charges US$ 3,500 for the preliminary review, US$ 1,500 for the issuance review and US$ 0.15 per credit, minus the preliminary review fee for issuance.

- **Transaction costs or fees.** The cost of marketing, negotiating, contracting and delivering a project´s carbon credits may vary greatly according to the type of organisation selling or buying (e.g. public authority vs small project developer or private buyer), the type of transaction (e.g. forward selling for multiple years vs spot selling for a single transaction) and the channel used to retail these assets (e.g. direct marketing vs through retailers or online platforms).

The costs from preliminary assessment up to the first delivery of the carbon credits may range from €50,000 to €150,000, excluding the potential costs of a new methodology development.

* as of 2020.

3.3. Anticipated flow of emission reduction credits from the project

Depending on the financial structure of the project being implemented, the revenues generated by the sale of carbon credits will be an essential part of the financial balance of the project. The revenues generated will be a factor of the volume of carbon credits generated and unit sale price on the market.

While it can be complex to quantify potential emission reductions, project proponents should attempt to do so at an early stage and over the project's lifetime or crediting period, with the help of the methodology chosen.

3.4. VERs price estimation and delivery timeline

The feasibility of a project and the carbon assets development work will depend on the revenues that could be generated by the sale of carbon credits. Depending on the financial structure of a project, they can contribute to a small portion or the entirety of the revenues.

As mentioned in previous section of this manual, prices for projects on the voluntary carbon markets depend on a wide range of factors. An average retail price should be estimated over the project lifetime or crediting period.

The price of VERs could be estimated through market reports or potential buyers:
- Market reports: among the most relevant publications are the State of the Voluntary Carbon Market report and the Voluntary Carbon Market Insights from news provider Forest Trends.
- Potential buyers: by far the best source of information, as these could provide their willingness to pay in a specific context.

To avoid a mismatch between the project's financial requirements and the revenues generated by the sale of carbon credits, it is useful to understand the various steps to generate and retail carbon credits. Project proponents should consider the entire timing for (i) the carbon assets certification process, including issuance of the carbon credits; (ii) contracting and selling; and (iii) delivery and payment of the credits. These three steps can overlap with each other to some extent where step (ii) could be taking place before or during step (i) (Fig. 15).

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3.5. Ownership of emission reduction rights

The ownership of emission reductions is both a theoretical and a complex issue. Emission reductions are the result of a project being implemented and a baseline scenario not happening. Emission reductions could in theory be owned by the organisation(s) financing the project activities, the owner of the land, the company developing the project, or even the host region or country. Very few countries have a legal framework that provides for these issues.

The ownership of emission reductions will link the various parties to the revenues generated by the sale of carbon credits and need to be carefully agreed upon at an early stage.

In most cases, project proponents or project investors need to ensure part or all the revenues generated by the project will be allocated to them.

3.6. Additionality assessment

Additionality is a core principle of baseline-and-credit mechanisms. It implies the demonstration that the sale of carbon credits will enable the project to be implemented and will trigger emission reductions or removals that would not have occurred without the sale of these carbon credits.

Since additionality needs to be demonstrated during the project validation audit, it is included in the PDD and needs to be anticipated. Project proponents should identify arguments to demonstrate that the revenues generated by the sale of carbon credits will enable the project to overcome the barriers that have prevented the project from happening in the past.

Projects using the methodologies VCS VM0033 Tidal Wetland and Seagrass Restoration v1.0 or VM0007 REDD+ Methodology Framework (REDD+MF) and located outside the USA, as well as all other CDM and Gold Standard methodologies, should use the CDM Combined tool to identify the baseline scenario and demonstrate additionality for A/R CDM project activities. This will lead proponents to demonstrate that the project is not financially viable without the sale of carbon credits and that it would not occur without it.

3.7. Criteria to select projects

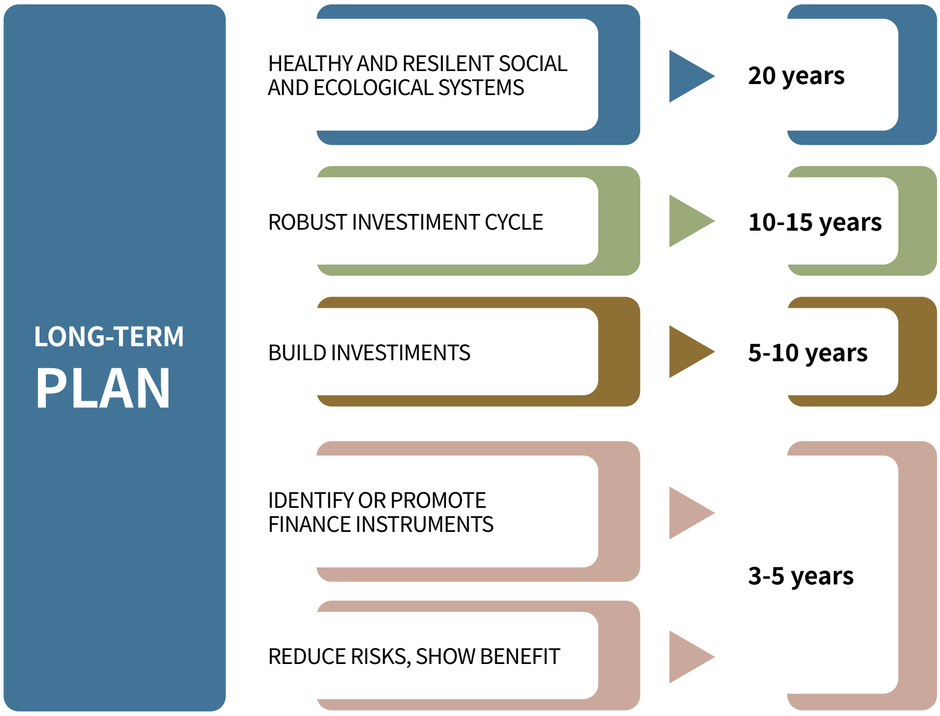
While it usually makes sense for project proponents to try to identify the conditions under which their project would be eligible for carbon finance, one can also think of developing or designing project activities to ensure their eligibility for an existing carbon certification standard.

Blue carbon projects would first need to:

- Meet the relevant methodology's numerous applicability conditions;
- Ensure that the value of the carbon sequestrated and carbon credits claimed at least covers the carbon project development costs, and covers a certain portion of the project activity costs;
- Ensure the ownership of the emission reduction goes to the project-funding organisation;
- Ensure carbon credit buyers have been identified at an early stage and committed to purchase the carbon credits at a pre-agreed price.

It is worth noting that projects requiring the lowest price per carbon credit would also be the ones more likely to find buyers and come to fruition.

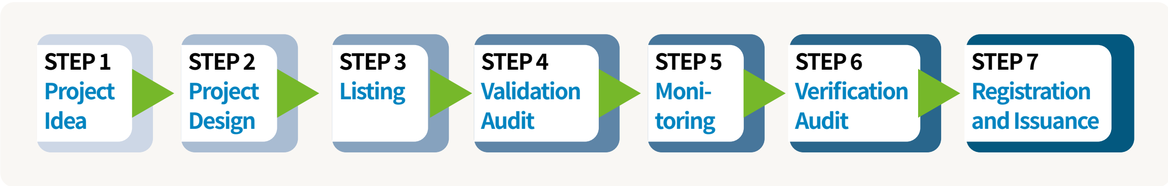
Figure 15: Graphical representation of the steps needed to develop investments that will support healthy and resilent social-ecological blue carbon systems.



CHAPTER 4:

(BLUE) CARBON PROJECT CERTIFICATION PROCESS

In order to generate offsets, a project developer must complete a rigorous process in order to ensure that real, quantifiable emissions reductions have been achieved. The process commonly take the following steps:



1. PROJECT IDEA NOTE DRAFTING

While **the project idea note (PIN)** has not officially been part of the certification process for existing carbon credit standards, it is nevertheless an important document. The PIN is a five-to-ten-page document summarising the project concept and can have multiple purposes:

- Support the project developer to structure, conceptualise, market and find funding for the project or the sale of carbon credits;
- Be used for potential investors to screen and assess the project(s);
- Be used to obtain official support and approval from authorities in the host country and potentially from the carbon credit purchaser's country; and
- Be used as a communication tool for various stakeholders.

When considering early-stage projects, sponsors and forward buyers of carbon credits can use the PIN to investigate the following:

- The likelihood of the project being funded;
- The project costs and revenues;
- How carbon revenues would impact implementation or address expected financing gaps;
- Expected volume of carbon credits to be delivered over the course of the project;
- What revenues carbon credits are expected to generate and how they compare to the costs associated with developing the carbon assets;
- The viability of the proposed project;
- The reliability and credibility of parties involved into the project;
- The credibility of the sustainability model and safeguards in place; and
- The compliance with environmental and social regulations.

The PIN is composed of three main sections. These are described below.

Project Description
- Objective of the project;
- Project description and proposed activities;
- Technology to be employed;
- Project developers/sponsors;
- Type of project;
- Location;
- Expected schedule; and
- Whether the host country has ratified the Kyoto Protocol and/or the Paris Agreement.

Expected environmental and social benefits
- Estimate of GHG abated/CO2 sequestered;
- Baseline scenario;
- Specific global and local environmental benefits;
- Socio-economic aspects; and
- Environmental strategy/priorities of the host country.

Finance

- Total project cost estimate;
- Sources of finance to be sought or already identified;
- Sources of carbon finance;
- Indicative carbon credit price; and
- Total emission reduction purchase agreement value.

A successful PIN should be able to demonstrate the project participants' knowledge, clear institutional arrangements, early involvement of credible technical, financial, and economic specialists to establish that all project selection criteria are in place, and sound legal arrangements related to ownership, operation and clients. It will also communicate in a credible way the viability and sustainability of the financing structure, project alignment with the host country, and potential project sponsors' social and environmental safeguards and sustainable development goals.

One of the most widely used PIN templates is that developed by the World Bank for its carbon funds.

2. PROJECT DESIGN DOCUMENT

The project design document (PDD) is the face of of a project on the global carbon market. It is used by auditors, certification bodies, credits buyers, external stakeholders and other third parties to assess the project and the quality of the emission reductions that you are claiming. It is therefore important that the PDD is of the highest quality, and that it follows not only the letter but the spirit of the relevant carbon certification standard.

While each carbon certification standard has its owned PDD template, they generally all follow the format of the UNFCCC (CDM)[17]. The template proposed by the Verified Carbon Standard (VCS) is one of the broadest and is therefore covered in this section. The PDD is usually articulated around five categories of information, as follow:

- Project Details;
- Application of the methodology;
- Quantification of GHG emission reductions and removals;
- Monitoring; and
- Environmental and social safeguards.

Project Details

Summary description and purpose of the project

The project summary description usually consists of a few paragraphs explaining the objective of the project, the location and context within which the project or activities would take place, the entities involved, and the expected impacts of the project. It can also provide the expected project lifespan and the emission reductions.

Sectoral scope and project type

The UNFCCC CDM has established 15 sectoral scopes under which each project could fit and new ones could be developed with the Paris Agreement. The scopes range from energy distribution to afforestation and reforestation through to transportation. The sectoral scopes are also used for selecting auditors to validate and verify the project. Each auditing body is accredited for one or several specific scopes.

[17] UNFCCC website: https://cdm.unfccc.int/Reference/PDDs_Forms/index.html

The project type defines the nature of activities, often characterised by the baseline (the current or most likely scenario in the absence of the project activities) and the project scenario (the proposed activities). In the afforestation and reforestation sectoral scope different project types would include afforestation/reforestation; improved forest management and reducing emissions from deforestation and forest degradation; and ecosystem restoration and rehabilitation.

Project proponent and other entities involved in the project

In carbon project development jargon, the project proponent (PP) is the most important project entity and is the main project developer. The PP plays several roles, such as project manager, coordinator, developer, investor, commercial promoter and others. The PP can be a private entity or a non-governmental or public organisation.

Project start date

The project start is not necessarily the date on which the project starts its operations. The project start date is a key concept used to indicate that certain decisions, without which the project could not begin its activity, have been taken. Notably, one of those decisions is the demonstration that carbon revenues have been taken into consideration before the project started.
The project start date is define as the date on which the project participants commit to making expenditures for the construction or modification of the main equipment or facility, or for the provision or modification of a service, for the project activity. Where a contract is signed for such expenditures, it is the date on which the contract is signed. Activities incurring minor pre-project expenses (e.g. feasibility studies or preliminary surveys) are not considered in the determination of the start date. For land use projects, it may be defined as the date on which site preparation begins.

The VCS defines the project start date as the date on which the project began generating GHG emission reductions or removals while the CDM defines it as the time when the land is prepared for the initiation of the afforestation or reforestation project activity.

Project crediting period

The crediting period is the period during which the project will be allowed to claim carbon credits for emission reductions.

The crediting period options vary from one carbon certification standard to another and may be a parameter to take into consideration when considering the suitability of a given standard.

Under the VCS, for all forestry and other land-use projects, the crediting period shall be a minimum of 20 years up to a maximum of 100 years. It may be renewed at most four times. Where a project fails to renew its crediting period, the crediting period ends and the project is no longer eligible for further crediting. The CDM allows for a choice between a single crediting period (to a maximum of 30 years) or a period of 20 years, with the possibility two renewals (for a total of 60 years). Plan Vivo offers the greatest flexibility with a crediting period defined as appropriate to the activity (lower limit of 10 years, an upper limit of 100 years) with 10-year increments.

In all cases, the renewal of the crediting period implies the reassessment of the chosen baseline ahead of the renewal.

Project scale and estimated GHG emission reductions or removals

To avoid certification processes becoming excessively burdensome for smaller projects, carbon certification standards have adopted slightly different rules for such cases. Smaller projects can take advantage of simplified procedures (e.g. no need for external third parties to carry out an audit); simplified accounting (e.g. disregarding minor sources of emissions such as transportation of materials or non-CO_2 emissions, or the use of conservative factors to replace monitoring); or lighter monitoring requirements. All methodologies do not apply to all project scales.

The VCS uses the estimated average annual GHG emission reductions or removals to categorise projects by size. Projects delivering less than 300,000 tCO_2e of emissions reduction or removal per year are classified as small scale. The CDM defines small-scale forestry projects as those not exceeding sequestration of 8,000 tCO_2e per verification period. Plan Vivo also has differentiated rules for various sizes of projects.

The VCS additionally requires a summary of estimated ex-ante emissions reduction to be provided in this section of the PDD (Project Design Document).

Description of the project activity, conditions prior to project initiation, and project management

This section is expected to contain a lot of technical information and should include:

- Description of current land-use practices and their effects (prior to project initiation);
- Description of the causes of land and ecosystem degradation or loss;
- Geophysical description (climate, ecological conditions, soils, topography, etc.);
- Presence of endangered species and habitats;
- Other critical factors affecting project management (e.g. roads, infrastructure, climate hazards);
- Information on any conservation, management or planting activities, including a description of how the various organisations, communities and other entities are involved;
- How the project activity contributes to sustainable development;
- Description of the organisational structure for the project and the roles of each organisation involved (use diagrams and tables if necessary);
- The capacity and experience of each organisation involved;
- A stakeholder analysis;
- A timeline (approximate) for project establishment, piloting, scaling up and monitoring;
- Explanation that the project has not been implemented to generate GHG emissions for the purpose of their subsequent reduction, removal or destruction; and
- Description of how the project meets the applicability conditions of the certification standard, if any.

Project location

The objective of this section is to ensure that the location of the project activity is clearly demarcated and does not overlap with the activities of any other certified project.

For land-use-related projects, under which blue carbon projects would fall, project location is often expected to be specified using geodetic polygons to delineate the geographic area of each project activity. Most standards require maps showing the overall project area and boundaries.

Compliance with laws, statutes and other regulatory frameworks

Not all certification standards have a section dedicated to the legal and regulatory framework under which the project activities are being undertaken. However, this information is necessary to populate various parts of the template as it:

- Can be used to explain the context of the project activity and the current baseline situation;
- Will enable the project proponent to demonstrate how the project will meet any legal requirements of the host country (including any written government approval for the project if required), and that the activities are not illegal and that all authorisations have been secured; and
- Can be used to demonstrate that the proposed project activities go beyond the legal requirements and that emissions reductions occur over and above such legal requirements.

Information provided should focus on the three aforementioned objectives and demonstrate that the project activities are in compliance with all and any relevant local, regional and national laws, statutes and regulatory frameworks.

Ownership and other programmes

The VCS is one of the most stringent standards when it comes to legal matters. As a result, the project descriptions are expected to be accompanied by one or more of the following types of evidence establishing project ownership accorded to the PP. Ownership is defined as the legal right to control and operate the project activities. Information that could be provided includes:

- Project ownership arising or granted under regulation or decree by a competent authority; or
- Project ownership arising from an agreement with the holder of property or contractual rights with respect to the land, vegetation or conservational or management process that generates GHG emission reductions and/or removals.

Application of the Methodology

Title and reference of Methodology

Each project must use an eligible and approved methodology and reference it. Each methodology has its own characteristics and is mostly defined by the type of activities implemented, the scale of these activities, and the hypothetical baseline scenario. Each project must then demonstrate how the proposed project activities meet the methodology's applicability criteria.

For blue carbon projects, and more specifically for seagrass, the most appropriate carbon accounting methodology are VM0033 - Methodology for Tidal Wetland and Seagrass Restoration and VM0007 – REDD+ Methodology Framework.

Applicability of Methodology

Each methodology uses applicability conditions to specify the project activities to which it applies and to establish criteria that describe the conditions under which the methodology can (and cannot, if appropriate) be applied. Any applicability conditions set out in tools or modules used by the methodology are also to be applied.

Methodology VM0033 is applicable to a wide range of project activities aimed at restoring and creating tidal wetlands and VM0007 is also applicable to broad range of activities but is more focused on conservation. Emission reductions and removals are estimated primarily based on the ecological changes that occur as a result of such activities (e.g. increased vegetative cover, changes to water table depth).

Project activities are expected to generate GHG emission reductions and removals through:

- Increased biomass;
- Increased autochthonous soil organic carbon;
- Reduced methane and/or nitrous oxide emissions due to increased salinity or changing land use; or
- Reduced carbon dioxide emissions due to avoided soil carbon loss.

For each methodology, applicability conditions are listed and the project proponent should demonstrate how the proposed project activities meet them. For instance, for methodology VM0033, eight eligibility conditions are listed:

- Project activities that restore tidal wetlands (including seagrass meadows) are eligible;
- Project activities may include any of the following, or combinations of the following:
  - Creating, restoring and/or managing hydrological conditions (e.g. removing tidal barriers, improving hydrological connectivity, restoring tidal flow to wetlands or lowering water levels on impounded wetlands);
  - Altering sediment supply (e.g. beneficial use of dredge material or diverting river sediments to sediment-starved areas);
  - Changing salinity characteristics (e.g. restoring tidal flow to tidally restricted areas);
  - Improving water quality (e.g. reducing nutrient loads leading to improved water clarity to expand seagrass meadows, recovering tidal and other hydrologic flushing and exchange, or reducing nutrient residence time);

  - (Re-)introducing native plant communities (e.g. reseeding or replanting); or
  - Improving management practice(s) (e.g. removing invasive species, reduced grazing).
- Prior to the project start date, the project area:
  - Is free of any land use that could be displaced outside the project area; or
  - Is under a land use that could be displaced outside the project area (e.g. timber harvesting), though in such case emissions from this land use shall not be accounted for; or
  - Is under a land use that will continue at a similar level of service or production during the project crediting period (e.g. reed or hay harvesting, collection of fuelwood, subsistence harvesting).
- Live tree vegetation may be present in the project area, and may be subject to carbon stock changes (e.g. due to harvesting) in both the baseline and project scenarios;
- The prescribed burning of herbaceous and shrub aboveground biomass (cover burns) as a project activity may occur;
- Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, project activities must include a combination of rewetting and fire management;
- Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, it must be demonstrated that a threat of frequent on-site fires exists, and the overwhelming cause of ignition of the organic soil is anthropogenic; and
- In strata with organic soil, afforestation, reforestation, and revegetation (ARR) activities must be combined with rewetting.

The demonstration can be done in a table format. On the other hand, a much less restrictive methodology is methodology AR-AM0014. Its applicability is subject to:

- The land being degraded mangrove habitat;
- More than 90% of the project area is planted with mangrove species; and
- Soil disturbance attributable to the project activity does not cover more than 10% of the area.

Methodology VM0007, also has specific applicability conditions for Wetlands Restoration and Conservation, including seagrasses.

Project boundary

The consideration for project boundary is usually defined in the applicable methodology, which may establish criteria and procedures for describing the project boundary and identifying and assessing GHG sources, sinks and reservoirs relevant to the project and baseline scenarios.

Project boundary can be defined as follows:

- **Temporal Boundaries.**
  In methodology VM0033 and VM0007, the temporal boundary of the project may be defined by peat and soil organic carbon depletion time.

- **Geographic Boundaries.**
  The project boundary can be defined as the delineation of a geographical area of the project activity under the control of the project participant as determined in accordance with the applied methodology.

The project proponent must provide the geographic coordinates of lands (including sub-tidal seagrass areas, where relevant) included in the project area to facilitate accurate delineation of the project area. Remotely-sensed data, published topographic maps and data, land administration and tenure records, and/or other official documentation that facilitates clear delineation of the project area must be used.

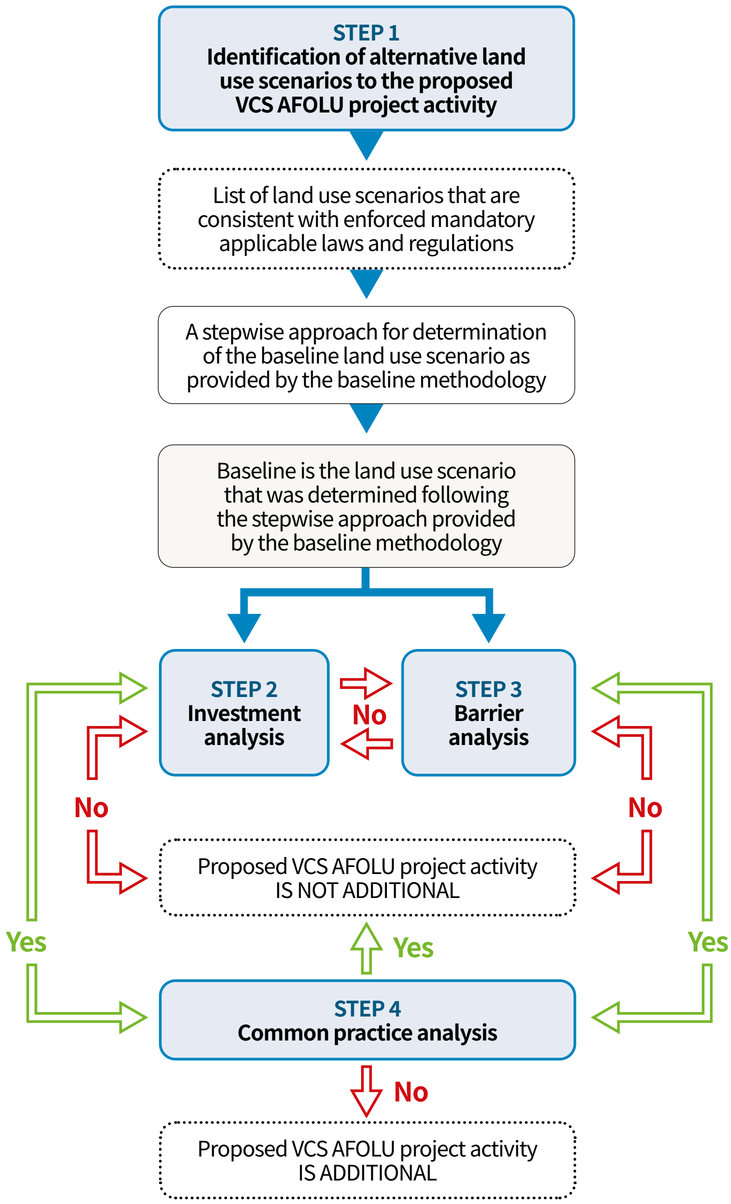
- **Carbon Pools.**
  The carbon pools included in and excluded from the project boundary are provided in the methodology. Methodology VM0033 recommends accounting for above-ground tree biomass, above-ground non-tree biomass, below-ground biomass, soil, and wood products. Only litter and dead wood do not have to be accounted for. Methodology VM0007 recommends accounting for below-ground biomass and soil carbon only and AR-AM0014 requires

above-ground and below-ground biomass to be accounted for, and dead wood and soil organic carbon to be optionally considered.

Carbon pools may be disregarded if accounting together for less than 5% of the total GHG benefit generated by the project.

- **Sources of greenhouse gases.** The GHG included in or excluded from the project boundary are listed in the methodology. GHG sources accounting together for less than 5% of the total GHG benefit generated by the project may not have to be accounted for.

Figure 16: Indicative flowchart of the CDM Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities. Source: CDM "Combined tool to identify the baseline scenario and demonstrate additionality for A/R CDM".



The CDM tool for testing significance of GHG emissions in A/R CDM project activities[18] may be used to determine whether increases in emissions are de minimis (Fig. 16).

Baseline scenario

The baseline scenario is the scenario that reasonably represents the sum of the changes in carbon stocks in the carbon pools within the project boundary that would occur in the absence of proposed project activity.

Methodologies often provide methods and guidance for identifying and justifying the baseline scenario.

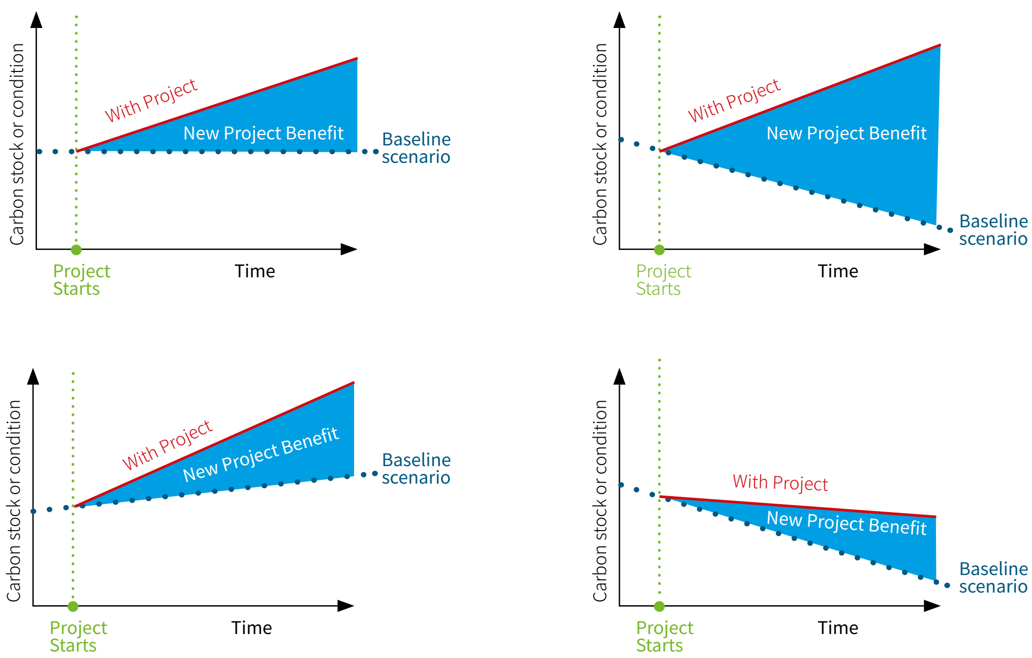
Additionality

Additionality can be defined as the ability of the project to increase actual net GHG removals, within the project boundary, with respect to what would have occurred in the absence of the project activity. In other words, it is the demonstration that the sale of carbon assets will enable the project to be implemented and trigger emission reductions or removals that would not have occurred without the sale of the carbon assets (Fig. 17).

The VCS, CDM, Gold Standard and Plan Vivo programmes usually require a project-based approach. For the VCS methodologies VM0033 and VM0007, projects outside the USA must use the latest version of the CDM Combined tool to identify the baseline scenario and demonstrate additionality for A/R CDM project activities.

The demonstration of additionality is mostly performed through steps two and three of the Combined tool in demonstrating the project is not otherwise viable in itself, because it faces barriers: insufficient funding, lack of willing landowners, community support, physical and ecological limitations, etc.

Figure 17: Blue Carbon potential is determined by the difference between the baseline scenario (when doing nothing) and the blue carbon project scenario (protection/enhancement). A project needs to have net negative emissions in order to claim blue carbon credits.



[18] Source: https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-04-v1.pdf/history_view

Quantification of GHG emission reductions and removals

Baseline Emissions

Using methodology VM0033 as an example, emissions in the baseline scenario are attributed to carbon stock changes in biomass carbon pools, soil processes, or a combination of these. In addition, where relevant, emissions from fossil fuel use may be quantified.

Emissions in the baseline scenario are estimated to be:

$$GHG_{BSL} = GHG_{BSL\text{-}biomass} + GHG_{BSL\text{-}soil} + GHG_{BSL\text{-}fuel}$$

Where:

GHG_{BSL} = Net CO_2e emissions in the baseline scenario up to year *t*; tCO_2e
$GHG_{BSL\text{-}biomass}$ = Net CO_2e emissions from biomass carbon pools in the baseline scenario up to year *t*; tCO_2e (*)
$GHG_{BSL\text{-}soil}$ = Net CO_2e emissions from the soil organic carbon pool in the baseline scenario up to year *t*; tCO_2e (**)
$GHG_{BSL\text{-}fuel}$ = Net CO_2e emissions from fossil fuel use in the baseline scenario up to year *t*; tCO_2e

(*): Refers to the change in carbon pool stored in the living biomass of plant between time (t) and some time in the past (for example t= 2020 and 2010)
(**): Refers to the change in carbon pool stored in the soil between time (t) and some time in the past. If the change is negative this is referred to as sequestration.

Project Emissions

Using methodology VM0033, emissions in the project scenario are attributed to carbon stock changes in biomass carbon pools, soil processes, or a combination of these. In addition, where relevant, emissions from organic soil burns and fossil fuel use may be quantified.

Emissions in the project scenario are estimated to be:

$$GHG_{WPS} = GHG_{WPS\text{-}biomass} + GHG_{WPS\text{-}soil} + GHG_{WPS\text{-}burn} + GHG_{WPS\text{-}fuel}$$

Where:

GHG_{WPS} = Net CO_2e emissions in the project scenario up to year *t*; tCO_2e
$GHG_{WPS\text{-}biomass}$ = Net CO_2e emissions from biomass carbon pools in the project scenario up to year *t*; tCO_2e
$GHG_{WPS\text{-}soil}$ = Net CO_2e emissions from the soil organic carbon pool in the project scenario up to year *t*; tCO_2e
$GHG_{WPS\text{-}burn}$ = Net CO_2e emissions from prescribed burning in the project scenario up to year *t*; tCO_2e
$GHG_{WPS\text{-}fuel}$ = Net CO_2e emissions from fossil fuel use in the project scenario up to year *t*; tCO_2e

Leakage

For land use and land-use change and forestry projects, leakage corresponds to the increase in GHG emissions by sources or decrease in carbon stock in carbon pools that occurs outside the boundary and that is measurable and attributable to the project.

Methodology VM0033 expects leakage to potentially come from:

- Activity-shifting leakage and market leakage; and/or
- Ecological leakage.

Net GHG Emission Reductions and Removals

The total net GHG emission reductions from restoring wetland ecosystems (RWE) project activity are calculated as follows:

$$NER_{RWE} = GHG_{BSL} - GHG_{WPS} + FRP - GHG_{LK}$$

Where:

NER_{RWE}	=	Net CO_2e emission reductions from the RWE project activity; tCO_2e
GHG_{BSL}	=	Net CO_2e emissions in the baseline scenario; tCO_2e
GHG_{WPS}	=	Net CO_2e emissions in the project scenario; tCO_2e
FRP	=	Fire Reduction Premium (net CO_2e emission reductions from organic soil combustion due to rewetting and fire management); tCO_2e
GHG_{LK}	=	Net CO_2e emissions due to leakage; tCO_2e

Monitoring

Monitoring consists of collecting and archiving all data necessary for estimating or measuring the net anthropogenic GHG removals. There are two categories of data parameters used in calculating GHG emission removals:

- Data and parameters available at validation; and
- Data and parameters monitored.

Data and parameters available at validation, and data and parameters monitored

These two sets of parameters are presented in separate sections and must present the following information:

- Data / Parameter: name of the parameter (e.g. following the equation naming)
- Data unit: the unit of the data/parameter
- Description: one sentence description of what the parameter corresponds to
- Equations: equation it refers to in the methodology (e.g. provide number)
- Source of data: approach adopted to find value or direct source
- Value applied: value applied and the corresponding justification
- Justification of choice of data or description of measurement methods and procedures applied: reasoning that leads to choosing the relevant data
- Purpose of Data: what this parameter is going to be used for
- Comments: any relevant comment to the parameter

In addition to the information above, the following additional information must be provided for data and parameters monitored:

- Description of measurement methods and procedures: method to monitor the parameter
- Frequency of monitoring/recording: how often the parameter will be (or was) monitored
- QA/QC procedures to be applied: method used to manage quality and uncertainty
- Calculation method: if parameter is obtained through calculation, calculation method is expected to be provided

The above information and tables will be presented and updated in the monitoring report and must be as accurate as possible.

Monitoring and sampling plans

The main objective of project monitoring is to reliably quantify carbon stocks and GHG emissions in the project scenario during the project crediting period, prior to each verification, with the following main tasks:

- Estimate *ex-post* net carbon-stock changes and GHG emission reductions; and
- Monitor project carbon-stock changes and GHG emission reductions.

The monitoring plan must contain at least the following information:

- A description of each monitoring task to be undertaken, and the technical requirements therein;
- Parameters to be measured;
- Data to be collected and data collection techniques;
- Frequency of monitoring;
- Quality assurance and quality control (QA/QC) procedures;
- Data archiving procedures; and
- Roles, responsibilities and capacity of monitoring team and management.

Methodology VM0033 and VM0007 provide guidance for managing uncertainty and quality as well as for stratification and sampling methods.

Safeguards

Environmental Impacts

A project may find itself in one of three possible situations with regard to environmental impact assessment (EIS):

- Local, regional or national regulation requires the project to carry out a partial or full EIA, it does not have adverse impacts, and it secures the relevant environmental authorisations from the authorities;
- The jurisdictional regulation does not require an EIA to be carried out, but the project must still secure the relevant authorisations; and
- There is no requirement for EIA and specific authorisation.

In any of these cases, this part of the PDD should present evidence of the situation and a summary of the processes completed and impacts assessed.

Local Stakeholder Consultation (LSC)

It is a requirement of all carbon certification standards that the project proponent conducts an LSC prior to the validation audit as a means of informing the design of the project and maximising participation from stakeholders. Such consultations should allow stakeholders to evaluate impacts, raise concerns about potential negative impacts, and provide input on the project design.

The project proponent shall establish mechanisms for ongoing communication with local stakeholders to allow them to raise concerns about potential negative impacts during project implementation.

The project proponent shall take due account of all and any input received during the LSC and through ongoing communication, which means it will need to either update the project design or justify why updates are not necessary. The project proponent shall demonstrate to the validation/verification auditors the actions it has taken with respect to the LSC and local stakeholder feedback as part of validation, as well as ongoing communications as part of each subsequent verification.

This section of the PDD should contain a description of the process for, and the outcomes from, the LSC, including details on the following:

- The procedures or methods used for engaging local stakeholders (e.g. dates of announcements or meetings, periods during which input was sought);
- The procedures or methods used for documenting the outcomes of the local stakeholder consultation;
- The mechanism for ongoing communication with local stakeholders; and
- How due account of all and any input received during the consultation has been taken. Include details on any updates to the project design or justify why updates were not necessary.

While no dedicated LSC report is required by the VCS or CDM programmes, project proponents may still decide to undertake an LSC. Some carbon certification standards, such as the Gold Standard, requires project proponents to produce and share such reports to document the outcome of consultations, any comments, criticisms or improvement suggestion(s) that were made, and any other relevant information.

Public Comments

Under all carbon certification standards, projects are subject to a 30-day public comment period. Under the VCS, the date on which the project is listed on the project pipeline (see next stage) marks the beginning of the project's 30-day public comment period.

With the VCS, any comments from the public are expected to be submitted to Verra and respondents shall provide their name, organisation, country and email address. At the end of the public comment period, Verra shall provide all comments received to the project proponent.

The project proponent shall take due account of any and all comments received during the consultation.

This section of the PDD should describe this process.

3. LISTING WITH THE RELEVANT CERTIFICATION STANDARD

Under the VCS, a registry account shall be opened by any market participant who wants to list a pipeline project, register a project and/or issue, trade or retire carbon offsets. A market participant can apply to open a VCS registry account at any time. All carbon certification standards require an account to be opened by the PP.

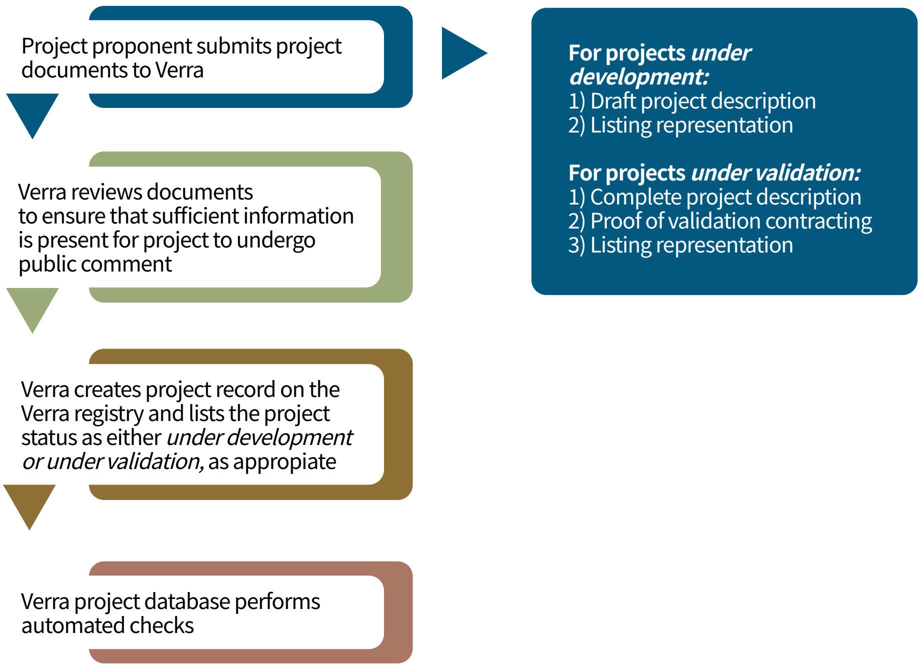
The VCS project database provides the central repository for all information and documentation relating to pipeline and registered projects. The database contains a project pipeline that lists projects before they are registered. Projects shall be listed on the project pipeline before the opening meeting between the Designated Operational Entity (DOE) or the Validation and Verification Body (VVB) and the project proponent(s) (see next stage).

The process that needs to be initiated by the project proponent(s) and can be initiated before validation (under development) or just after the DOE/VVB has been contracted for the validation audit (under validation). Figure 18 provides an outline of VCS process for listing a project.

More information is provided in the VCS *Registration and Issuance Process* document. As of January 2021, Verra applies a fee of US$ 500 for projects to be listed[19].

Unlike for the other relevant carbon certification standards, there is no listing phase under the CDM.

Figure 18: Pipeline listing process with Verra for VCS.



[19] Source: https://verra.org/oprfeeschedule/

4. VALIDATION AUDIT

The purpose of project validation is to ensure a thorough, independent evaluation of the project design, by a third-party independent entity. These are called a Designated Operational Entity (DOE) or Validation and Verification Body (VVB). The review is done against the requirements of the certification standard (e.g. VCS, CDM, Plan Vivo, etc.) and to ensure the information provided in the PDD is accurate. The validation also makes observations and recommendations based on field visits to the project area and identifies any corrective actions necessary before the project can be approved under the carbon standard.

The validation process is expected to go through the following sequence of actions:

- Identification of a potential DOE/VVB by the PP. All VCS projects must be validated by a specialised and accredited company, while standards like Plan Vivo allow the use of qualified individuals;
- Sharing of project information with DOEs/VVBs to obtain quotes. Depending on the DOE/VVB, the information shared can be the PDD, a PIN, or a short form provided by the DOE/VVB;
- Selection of the most suitable proposal and finalisation of contractual arrangements between the PP and the DOE/VVB. The selection of the most suitable DOE/VVB should consider:
  - Experience and knowledge of the selected carbon certification standard;
  - Familiarity with the project area, region or country;
  - Fluency in the language(s) used by the project participant(s);
  - Technical expertise relevant to the project; and
  - Ability to prepare the validation report in English (or other language approved by the carbon certification standard).
- Sharing of project information with the DOE/VVB. The project proponent(s) should make available the PDD, evidence of project ownership and any requested supporting information and data needed to support statements and data in the project description;
- Initial desk-based review by the DOE/VVB to assess the quality of information provided in the PDD and the project's suitability for the certification standard;
- Site visit by the DOE/VVB, to assess the accuracy of project documents and the capacity of the organisation(s) involved, and to determine that project participants are engaged on a voluntary and informed basis;
- Submission of the validation protocol by the DOE/VVB to the PP(s). The protocol includes the findings with regard to corrective action requests (CARs) and clarification requests (CLs);
- Addressing of the CARs and CLs by the PP(s);
- DOE/VVB technical review. Once all the CARs and CLs have been satisfactorily closed, the project undergoes a technical review by a second team of the DOE/VVB, which may come back with additional requests to be addressed;
- Submission of the draft validation report by the DOE/VVB to the project proponent(s) for review and comments; and
- Issuance of the final validation report by the DOE/VVB to the project proponent(s) to be shared with the certification standard.

The validation report describes the validation process, any findings raised during validation and their resolutions, and the conclusions reached by the DOE/VVB. When certifying for the VCS, the DOE/VVB shall use the VCS validation report template. The validation report shall be accompanied by a validation representation, which shall be prepared using the VCS validation deed of representation template. With other carbon certification standards, only the validation report is required, in a non-defined format.

The validation report is expected to include a validation statement that shall mention:

- The level of assurance of the validation;
- The objectives, scope and criteria of the validation;
- Whether the data and information supporting the GHG assertion were hypothetical, projected and/or historical in nature; and

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- The DOE/VVB's conclusion on the GHG assertion, including any qualifications or limitations.

Validation is a risk-based process and shall be carried out in conformance with ISO 14064-3:2018 and ISO 14065:2020. Auditors are expected to select samples of data and information to be validated to provide a reasonable level of assurance and to meet the materiality requirements of the specific project.

For VCS, projects shall be validated by an auditing firm that meets the eligibility requirements set out in the VCS Program Guide and in ISO 14065:2020.

DOE/VVBs are expected to follow the guidance provided in the VCS Validation and Verification Manual[20] when validating projects under the VCS programme.

Where the project does not meet the criteria for validation, the DOE/VVB is expected to produce a negative validation conclusion and provide the validation report and project description to the certification standard. The project is then ineligible for registration until the corrective actions required have been taken and the same DOE/VVB has provided a positive validation.

5. MONITORING

The definition and principles of monitoring have been listed previously, together with its purpose, data and parameters expected to be available at validation, data and parameters to monitored, and monitoring and sampling plans.

The elements that follow should be part of a successful and thought-through monitoring plan.

Monitoring parameters

Before the project starts its activities and ideally at the planning stage, it needs to be clear for project developer(s) and proponent(s):
- Which parameters need to be recorded and monitored;
- How they will be monitored;
- If they will be measured, calculated or estimated;
- The frequency at which they will or will need to be monitored; and
- The portion of the data that will be monitored (e.g. a sample, or the entire project).

Capacity building

Whether project developer(s) work with highly experienced monitoring officers or not, each project being specific, it is advisable to provide monitoring officers with training before monitoring begins. The training, which could be a half or full day, would cover:
- The purposes / objectives;
- The methods being used;
- A review of the potential issues and challenges;
- The expected results; and
- The quality control and assurance in place or to execute.

The attendance at each training session should ideally be recorded on signature sheet to be kept on file.

[20] Source: http://verra.org/wp-content/uploads/2018/03/VCS_Validation_Verification_Manual_v3.2.pdf

Data archiving

Archiving is the process of moving files that are no longer actively used to a separate storage device for long-term retention. Archived files remain important to the project proponent(s) and may be needed for future reference. Archives should be indexed and searchable so that files can be easily located and retrieved.

While none of the carbon standards provide archiving guidance, general rules applying would be to:

- Archive monitoring data after each issuance;
- Archive monitoring data until at least three years after the end of the project.

QA/QC procedures to be applied

The terms 'quality control' and 'quality assurance' are often used interchangeably or interpreted to mean different things.

Quality control (QC) is a system of routine technical activities, implemented by monitoring managers to measure and control the quality of the data as it is being collected. The QC system is designed to:

- Provide routine and consistent checks and documentation points to verify data integrity, correctness, and completeness;
- Identify and reduce errors and omissions;
- Maximise consistency; and
- Facilitate internal and external review processes.

QC activities include technical reviews, accuracy checks, and the use of approved standardised procedures for emission calculations and measurements.

Quality assurance (QA) is a planned system of review and audit procedures conducted by personnel not actively involved in the monitoring process. The review should be performed by an independent, objective third party to assess the effectiveness of the internal QC programme development, to verify that data quality objectives were met, and to reduce or eliminate any inherent bias in the monitoring processes.

There are three main steps for project proponents to follow in order to integrate QA/QC procedures as part of their monitoring process:

- Establish a written QA/QC plan;
- Implement the QA/QC plan; and
- Document and report the QA/QC activities.

More information can be found in the IPCC's paper on QA/QC of inventory systems[21].

Uncertainty and quality management

In the specific case of tidal wetland and seagrass restoration projects and other ecosystem restoration activities, to ensure that carbon stocks are estimated in a way that is accurate, verifiable, transparent, and consistent across measurement periods, PPs must establish and document clear standard operating procedures for ensuring data quality. At a minimum, these procedures must include:

- Comprehensive documentation of all field measurements carried out in the project area, which must be detailed enough to allow replication of sampling in the event of staff turnover between monitoring periods;
- Training procedures for all persons involved in field measurement or data analysis. The scope and dates of all training must be documented;
- A protocol for assessing the accuracy of plot measurements using a check cruise and a plan for correcting the inventory if errors are discovered; and
- Protocols for assessing data for outliers, transcription errors, and consistency across measurement periods.

[21] Source: https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/6_2_QA_QC.pdf

6. VERIFICATION AUDIT

Verification is conducted once the project implementation has been running for a certain period of time, decided by the PP(s) and guided by the methodology used. It is the ex-post assessment of the monitored GHG data and information. During verification, DOE/VVBs are expected to assess the monitoring report and:

- The extent to which methods and procedures, including monitoring procedures, have been implemented in accordance with the validated project description. This includes ensuring conformance with the monitoring plan; and
- The extent to which GHG emission reductions and removals reported in the monitoring report are materially accurate.

Under the VCS, validation and verification of a project may be undertaken by the same DOE/VVB and may occur at the same time as validation.

The verification process is expected to follow the same sequence of actions as the one described for validation.

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7. REGISTRATION AND ISSUANCE

While most certification standards require projects to be registered after validation (e.g. Gold Standard, CDM) and to undergo a more or less thorough (i.e. similar to the validation audit) registration process with the certification standard, the VCS requires registration to occur before the end of the first verification. However, VCS also offers project proponents the possibility to register after the validation.

If project registration is requested before validation, the following documents are to be provided to Verra:

- The PDD;
- The validation report;
- The validation representation;
- The registration representation; and
- Any AFOLU-specific[22] documentation, communications agreement, proof of right or proof of contracting.

If project registration is requested at the time of the verification/issuance, the following additional documents should be provided to Verra:

- The monitoring report;
- The verification report;
- The verification representation; and
- The issuance representation.

Under the VCS, once all the relevant project documentation has been submitted, Verra performs a review. The project review is a three-part process consisting of:

- A completeness check (undertaken by the VCS registry administrator) to ensure that all documents are complete and duly signed where necessary, the validation or verification has been completed by an eligible DOE/VVB and within required timeframes, and the GHG emission reductions and removals have not been issued under another GHG programme;

[22] Agriculture, Forestry and Other Land Use

- A completeness review (undertaken by Verra) to inform whether it will conduct a full accuracy review. The purpose of the completeness review is to ensure that appropriate information has been used to complete all project documents, that the baseline scenario and additionality have been correctly assessed, and that validation and/or verification has been completed by an eligible DOE/VVB; and
- An accuracy review (undertaken by Verra, at its discretion) of the project registration to ensure full adherence of the validation or verification to the VCS rules and the applied methodology.

Verra then sends its findings, if any, to the DOE/VVB, reviews its responses, and determines whether the project is eligible for registration/issuance.

The carbon credit issuance process can be carried out simultaneously to the registration process.

The details of the process are provided in the VCS Registration and Issuance Process guidance[23].

As of January 2021, a one-time US$ 300 fee for account opening and US$ 300 account annual maintenance fee are charged by Verra. The VCU issuance levy and any fees charged by Verra are payable based on the volume of carbon credit issued (not the total verification report volume) and are to be paid before the carbon credits are materialised onto an account. For AFOLU projects, the fees to be paid are US$ 0.16 per carbon credit to be issued (capped at US$ 10,000)[24].

OTHER CONSIDERATIONS

Buffer Pool

With the exception of the CDM, all relevant carbon certification standards address the risk of non-permanence associated with AFOLU project activities by requiring projects to set aside non-tradable buffer credits to cover unforeseen losses in carbon stocks. The buffer credits from all projects are held in a single AFOLU pooled buffer account, which can be drawn upon in the event of a reversal in carbon stocks in any individual project.

Under the VCS, the number of carbon credits allocated to the pooled buffer account is determined by the non-permanence risk report assessed by the DOE/VVB, in accordance with the requirements set out in the VCS AFOLU Requirements[25].

Under the VCS, buffer credits are cancelled from the AFOLU pooled buffer account where there are negative net GHG emission reductions or removals associated with the project.

[23] See Procedural section of https://verra.org/project/vcs-program/rules-and-requirements/
[24] VCS fee schedule: https://verra.org/oprfeeschedule/
[25] See Procedural section of https://verra.org/project/vcs-program/rules-and-requirements/

Programme of Activities (PoA) or Grouped projects

A PoA (or grouped projects under the VCS) sets out voluntary coordinated actions by PPs to coordinate and implement any policy/measure or stated goal (i.e. incentive schemes and voluntary programmes) that leads to GHG emission reductions or net anthropogenic GHG removals that are additional to any that would occur in the absence of the PoA, via an unlimited number of component project activities (CPAs).

Certain types of projects of smaller size (in terms of GHG removed or avoided) may suffer from considerable transaction costs undermining the contribution of the sale of carbon credits. There exists a threshold under which a project's GHG impacts would be too small individually for carbon asset development to make sense. Pooling similar projects together to create scale may help overcome some of these issues.

PoAs also create flexibility with regard to the time of inclusion of areas and kinds of activities, since the locations and times of implementation do not need to be known precisely in advance.

Since a project cannot be later turned into a PoA, project proponents may decide whether or not to develop a PoA at the stage of PDD development.

Where a PoA approach is chosen, project developers get their project documentation validated as a framework to which multiple projects can later be added.

Under the VCS, the PDD must provide eligibility criteria for the inclusion of new project activities. These will have to:

- Meet the applicability conditions of the GHG accounting methodology applied;
- Apply the pre-fixed technologies or measures specified in the project description;
- Have the baseline scenario determined in the project description for the specified project activity and geographic area;
- Have characteristics with respect to additionality that are consistent with the initial instance(s) for the specified project activity and geographic area; and
- Comply with the model leakage assessment.

PoAs create an umbrella structure that supports the inclusion of multiple and unlimited bundles of sub-projects over time.

Advantages of a PoA are that:

- Individual projects can be included periodically as the programme develops;
- The time needed for a project to be included in the standard can be shortened to a period of weeks rather than years. Since projects can only generate carbon credits from the moment they are registered, delays caused by lengthy validation and registration procedures cost project developers and investors considerable amounts of time and resources, including lost revenues from the sale of carbon credits. PoAs can mitigate this risk by offering fast-track "inclusion" procedures;
- It offers the possibility of unlimited replication of projects under one umbrella, making it possible for project developers to expand the geographical coverage to different host countries; and
- It allows innovative companies to register a PoA and open it to the inclusion of projects implemented by other project developers.

ANTICIPATED TIMELINE TO FULL CERTIFICATION AND ISSUANCE

The timeline to certification is presented in Figure 19. The time may vary for each of these stages.

Figure 19: Approximate certification time line. Source: Hamerkop Climate Impacts.

Project assessment 2 - 3 months	**STAGE A:** information and resource availability.
PIN (Concept Note) 1 - 2 months **PDD, LSC, EIA & GHG Reduction Calc.** 6 months	**STAGES 1 and 2:** availability of resources, key proponents, and authorities to release authorisation or clearance and feasibility studies.
Listing 1 - 3 months	**STAGE 3:** completeness and accuracy of information provided to the certification standard.
Validation Audit 4 - 8 months	**STAGE 4:** availability of the auditor, the readiness of project proponent for the site visit, the level of quality of the project documents, and the PP's ability and availability to solved issues raised by the auditors.
Monitoring 6 - 24 months	**STAGE 5:** availability and resources primarily (the monitoring period is to be decided by the PP).
Verification Audit 4 - 8 months	**STAGE 6:** availability of the auditor, the readiness of project proponent for the site visit, level of quality of project documents, and the proponent's ability and availability to solve issues raised by the auditors.
Registration & Issuance 1 - 3 months	**STAGE 7:** completeness and accuracy of information provided to the certification standard.

CHAPTER 5:

CONCEPTUALISING A BLUE CARBON PROJECT

PLANNING A BLUE CARBON PROJECT

A blue carbon project would be one that intended (1) to enhance the atmospheric carbon (GHG) removal service of a blue carbon ecosystem, (2) to protect the carbon stock accumulated, or (3) to develop a new blue carbon ecosystem. How this is achieved would depend on the specific ecosystem and site.

To be able to access the carbon markets, a project must implement methodologies that can prove that CO_2 has been accumulated or not emitted owing to the additional activities implemented through the project. This broadly implies two phases of project conceptualisation: the gathering of existing information and the design of the monitoring programme. Which variables need to be estimated and when would vary greatly among projects (see Chapter 6).

The spectrum of blue carbon activities includes conservation (avoiding the release of GHGs to the atmosphere) and restoration/creation (establishment of CO_2 uptake from the atmosphere and/or reduction in CH_4 emissions) (Fig. 20). That means a blue carbon project can protect the ecosystem against degradation (e.g. caused by the removal of vegetation or the loss and/or oxidation of wetland soil carbon) or can sequestrate carbon by creating carbon sinks in the form of growing vegetation (e.g. by restoring tidal marsh or seagrass vegetation), by enhancing carbon storage in soils and sediments (e.g. by inducing plant litter production and creating the necessary hydrological conditions), or by reinstating salinity conditions to reduce CH_4 emissions (Chapter 8).

A general approach on setting up a project is proposed in the sections that follow (see Identifying the project scope and sampling plan).

First of all, the project area and boundaries must be set and the project's feasibility tested. The following subjects need to be taken into account when looking into project feasibility and enabling factors:

- **Technical feasibility:** *What is the likelihood of a successful blue carbon project on this site? Is it possible to restore/protect or create a marsh or marine meadow on the determined site? Are the abiotic and biotic conditions of the site suitable for restoration?*
- **Permission:** *Is it possible to obtain a permit for the project from local or regional authorities?*
- **Support from stakeholders:** *Do local parties support the blue carbon project?*
- **Additionality:** *Will the blue carbon project contribute to GHG reductions over and above what already is being done?*

Examples of blue carbon projects include:

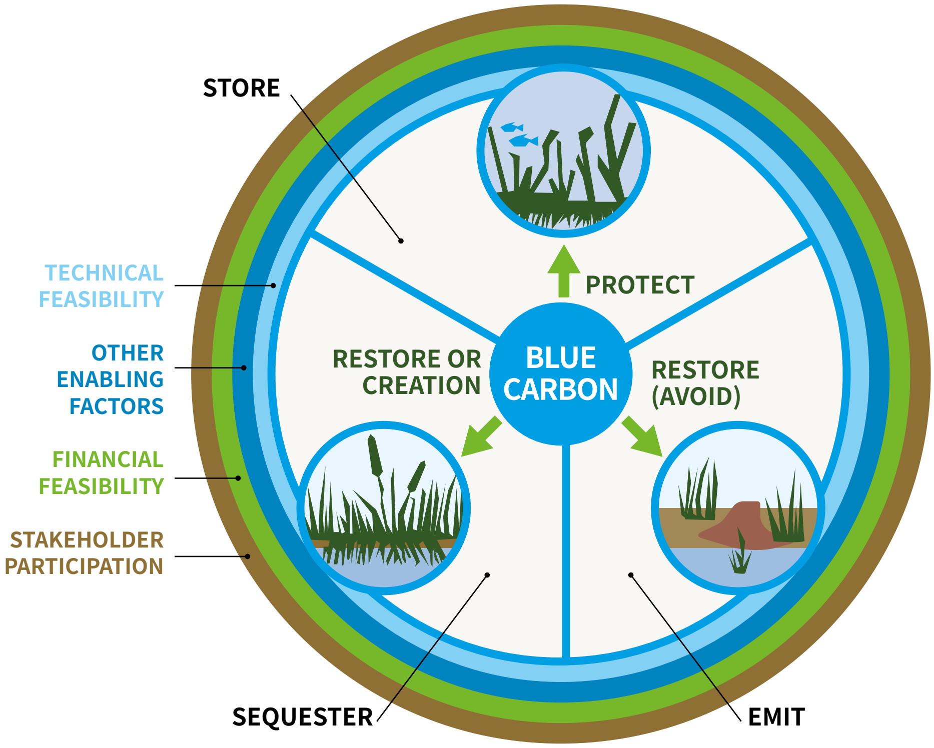
IN COASTAL SALT MARSHES:

- Restoration of marshes
- Creation of artificial marshes (afforestation)
- Improvement of degraded marshes
- Creation of protected areas
- Conservation through preventive measures

IN SEAGRASSES:

- Restoration of degraded areas inside a living meadow
- Revegetation in degraded areas
- Reduction of organic matter/chemical intrusion in the area of influence
- Restoration of natural hydrodynamism (e.g. sediment capture from rivers)
- Creation of protected areas
- Conservation through preventive measures (e.g. installation of eco-buoys, artificial reefs)

Figure 20: Graphical representation of the types of activities, outputs expected from blue carbon projects and enabling factors. The project can generate net negative emissions by avoiding the release of CO_2 by decreasing the oxidation of soil organic carbon ("avoided losses" or "stop-loss"); or/ and by increasing the uptake of CO_2 by increasing carbon sequestration in soils and plants through enhance protection, restoration or creation.



To explore the blue carbon potential of a project it is important to determine the carbon stock or fluxes in the specific project area. This can be done by blue carbon measurements within the project area, if a blue carbon habitat is already present. Where there is no habitat present, reference sites can be used as a means of determining the future potential of the project.

The **financial feasibility** needs to be determined: how expensive is the proposed blue carbon project and what are the opportunities to link the project to other projects in the area, to generate additional funding. Plus, it is interesting in this phase to look at the price of the project per carbon unit sequestered, as this will provide an insight into the price for future carbon credits [65].

When all above steps have been successfully undertaken, a blue carbon project can be realised, to be followed up with extensive monitoring of actual carbon storage on the project site.

The potential for blue carbon restoration projects to be implemented in Europe is mostly limited by economic cost. The market value of the carbon sequestered by the project is not, by itself, likely to pay for the entire cost of a restoration project, although that may be the case for some projects. However, the benefits of blue carbon ecosystem restoration go far beyond the carbon sequestration alone. Because of this, carbon credits generated by the project can be published in the voluntary carbon markets at a higher price than the price obtained in the compliance markets.

The importance of blue carbon ecosystems has long been known and has led to the restoration of such areas prior to the creation of carbon markets. Blue carbon actions would be far more effective if integrated in wider restoration projects than as the sole goal or financial source themselves.

Activities and safeguards for blue carbon projects

Safeguards are a set of principles, rules and procedures put in place to achieve social and environmental goals. As offset programmes continue to evolve, safeguards also evolve with principles and criteria that also aim to address society demands [66]. Voluntary standards for offsetting projects, being more aspirational in their principles and criteria, highlight the importance of not only protecting but also improving social and environmental conditions.

As mentioned previously, most safeguards standards required today by the voluntary mechanisms employ both substantive (safeguard principles and rules) and procedural elements. While implementation methods vary, many standards take a 'principles, criteria and indicators' approach, where parties establish a set of principles and broad norms (e.g. contribute to good governance), then detail a list of criteria that must be met to guarantee that norm (e.g. governance structures are clearly defined, transparent and accountable), and finally provide a list of indicators that should be exhibited to demonstrate compliance with the given criteria (e.g. information on governance decisions is made publicly available). Procedures, on the other hand, delineate the task of implementing, monitoring and enforcing safeguards.

With a similar approach, the IUCN Global Standard for Nature-based Solutions (NbS) includes a set of safeguard criteria and principles, with indicators to "certify" that actions and projects will "protect, sustainably manage and restore natural or modified ecosystems, as per the source address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (IUCN, 2020). Overall, carbon offsets and NbS safeguards help projects to identify, prevent and mitigate negative, unintended consequences that may arise from a given intervention. Credible safeguards are important both for ensuring conservation development outcomes are not undermined and for gaining public support for climate actions (GS, 2017).

Applying this in the context of blue carbon projects for the Mediterranean and European regions, here we provide a set of overarching principles for safeguarding environmental and social conditions, as broad guidance for project developers and climate finance (and offsetting) initiatives and standards. The proposed safeguards are derived from a number of stakeholder consultations for future blue carbon offsets projects in the region, involving climate finance consultancies, forest offset project developers, national and regional climate offices, NGOs, blue carbon scientists, and protected area managers, as well as technical teams and managers from different regional environmental agencies and institutions[26]. These safeguards aim to identify potential risks and adverse outcomes in terms of social, economic and environmental conditions, as well as to emphasise the importance of good governance, the benefits for biodiversity, and their contribution to climate change and sustainable development goals.
As more blue carbon projects develop in the region, new carbon finance and offsetting mechanisms might develop further safeguarding principles for standards, which a project would be required to meet throughout the entire project cycle.

[26] LIFE BlueNatura: IUCN reporting.

Overall safeguarding principles proposed for wetland and seagrass blue carbon projects in the European and Mediterranean context

SOCIAL AND GOVERNANCE

- The project includes **dissemination, awareness** and **training actions** for local stakeholders.
- The project will seek the **participation of local stakeholders** during its preparation and execution.
- The project will reconcile its uses to ensure other (community) objectives.
- The project promotes **gender equality.**

ENVIRONMENTAL

- The project is **compatible with other ecological values** and protected and priority species and habitats.
- It aims to **increase ecosystem services.**
- It ensures that thereis no reduction of the water table.
- It **establishes proceedings** that use natural materials as much as possible.
- It targets the **stabilisation of the marsh** in its natural hydrological or tidal system.
- If reforestation or forestation is done, it will use **native species** adapted to the place where the project is located.
- After the execution of a wetland project, the project location is in a **tidal area** (meso or polyhaline salt marsh).
- **The project does not generate negative effects** (displaced emissions, displaced activities that impact elsewhere) or, if it generates them, they are quantified and compensated or their impact is corrected.

PROCEDURAL

- The project is **replicable.**
- It is **measurable, verifiable** and **reportable** to ensure transparency and traceability.
- The governance structure is **clearly** defined and **transparent.**
- The project takes into account the **effects of climate change** and other hazards.
- The balance of all GHGs is **quantified.**
- The project ensures long-term soil **availability.**
- It aims to improve **water quality** or ensure that the quality is equal or superior to a control.
- Any hydrological restoration developed on coastal wetlands avoids **methane emissions.**
- It includes a model/management plan for the **project location.**
- It considers pre-execution the **economic feasibility** of project.
- The projects contributes to **sustainable development** (goals).

CARBON POOLS

To characterise a blue carbon ecosystem two main parameters are estimated: the **carbon stock** and the **carbon sequestration rate,** also known as the carbon flux to the soil. Carbon stock refers to the amount of carbon held in a known area. Carbon sequestration rate refers to how much carbon is trapped per area in a given time. The stock indicates how much carbon is currently held by the ecosystem and the sequestration rate indicates how much carbon is being removed from the atmosphere (or ocean), its efficiency as a carbon sink.

These two parameters are related through time. Knowing the carbon stock of an ecosystem and the time since that ecosystem was established, allows calculation of the average carbon sequestration rate. Although it is not uncommon, a large carbon stock does not imply a large carbon sequestration rate (see Chapter 7 for calculation methodology) and vice versa. In other words, our ecosystem may have accumulated carbon for thousands of years and have a large stock, but if the amount of carbon that sequesters per year is low, it has a low carbon sequestration rate and thus low efficiency as a carbon sink. On the other hand, it may be a highly efficient carbon sink but, as it has been accumulating for few years, its carbon stock is small.

Projects must account also for any significant sources and sinks of **other greenhouse gasses, such as CH_4 and N_2O,** that are reasonably attributed to project activities. The VCS for example defines the *de minimis* threshold at <5% of the GHG benefit; fluxes of CH_4 and N_2O lower than this are discounted in offset accounting. In the context of coastal wetlands, specific attention is needed to quantify these emissions, as some projects can incorporate benefits also in this regard (e.g. increasing saline waters may reduce CH_4 emissions as well as re-establishing carbon sequestration).

Most blue carbon projects will be interested in promoting the capacity of the ecosystem for carbon removal, its efficiency. Therefore, it will be necessary to demonstrate that the carbon sequestration rate has increased after the project´s intervention. On the other hand, the project can be based on preventing the loss of the existing stock: it will measure the existing stock and estimate the avoided losses. Those two characteristics are usually measured in tandem, estimating the sequestration rates from the stock and the average accretion rate. However, if the interest lies only in one of them, it may be economically profitable to estimate only that characteristic.

Blue carbon ecosystems are spatially heterogeneous; their carbon stocks and sequestration rates vary among ecosystems and between areas of the same ecosystem. Furthermore, the carbon concentration in the soil also changes with depth, due to decay and temporal variations in its accumulation. Thus, it is expected to find spatial and depth variability. To capture spatial variability in soil, replicate core-samples are taken; to capture depth variability the cores are divided in several subsection samples (See Chapter 6 for details).

If a blue carbon project is interested only in the soil stock or the average sequestration rate, capturing depth variability won't be necessary, as long as all the cores taken reach the same depth, the entire depth of the soil is sampled when estimating stocks, or the cores encompass the same time frame when estimating sequestration rates. This will allow us to compare among cores.

There is no specific sampling design and laboratory protocol that would work to develop all blue carbon projects. A given blue carbon ecosystem could be particularly interesting for the development of anti-erosion projects that would guarantee the stability of the stock, while other blue carbon ecosystems might have high potential to promote carbon sequestration efficiency. As the objectives are different, the parameters estimated and sampling designs would be different. Here, we will summarise the general protocol followed to estimate blue carbon stocks and sequestration rates in Europe and the Mediterranean basin, and provide references for further information. The proposed steps and indications draw heavily on the measurement guidelines for the sequestration of forest carbon [67], the Coastal Blue Carbon Manual from the Blue Carbon Initiative [65], the LIFE BlueNatura Project (2016-2020) [22, 32], and guidelines produced for other regional blue carbon ecosystems [68].

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Coastal Blue Carbon Ecosystems as GHG emitters

Blue Carbon ecosystems are also emitters of GHG, like CO_2, CH_4 and N_2O, derived mainly from the decomposition of organic matter trapped in their soils. Salt marshes have higher methane emissions than seagrass meadows (>70%). However there is high variability within these ecosystems. CH_4 fluxes in salt marshes average 224.44 µmol CH_4 m^{-2} day^{-1} and varied from −92.60 to 94.13 µmol CH_4 m^{-2} day^{-1}; while in seagrass systems average 64.8 µmol CH_4 m^{-2} day^{-1}; and varied from 1.25–401.50 µmol CH_4 m^{-2} day^{-1}. Variability derived from the high variability of environmental conditions where those ecosystems are found, including organic matter availability and quality, vegetation type, O_2 concentration, salinity, and groundwater [73]. Salinity is a key controller of methane emission in salt marshes, the higher the salinity the lower the CH_4 emission. Due to this, salt marsh methane emissions are low compared to emissions from fresh water wetlands.

The degradation of Blue Carbon ecosystems can increase methane emission by 1–2 orders of magnitude [74]. Although, specifically designed management actions can attenuate the emission of GHG. N_2O emissions will most likely be minimal to non-existent in pristine areas but may be significant in degraded areas [75].

IDENTIFYING THE PROJECT SCOPE AND SAMPLING PLAN

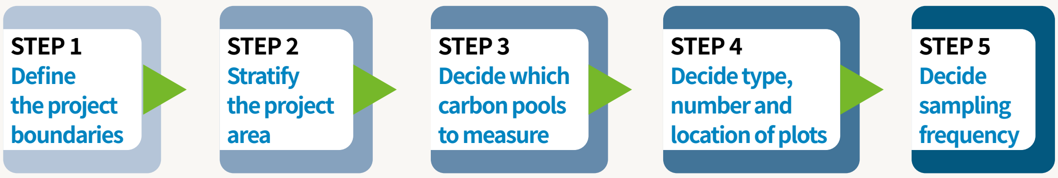
Clearly defining project objectives is an important step in the planning process. The project's aims, goals and available resources will determine the parameters estimated, the carbon pools to be measured, the geographic and temporal scope of the sampling, and the intensity of the sampling. During planning there is a series of logical steps that need to be taken including:

a) The objectives and scope of the project
b) The field sampling strategy
c) The laboratory analysis of the samples
d) The statistical analysis and interpretation of results for the whole project area

Define the project scope and objectives

Defining the project objectives is important in the development of the sampling strategy. Therefore, the project's goal and objectives need to be well defined prior commencing the sampling design. Figure 21 shows the steps required to successfully design a sampling strategy that will fulfil project objectives.

Figure 21: Shows the steps required to successfully design a sampling strategy that will fulfil project objectives. Coastal Blue Carbon Manual from the Blue Carbon Initiative [2].



Step 1: Project boundaries

The spatial coverage of the project is defined by the project objectives and resources and can vary in scale. The distribution of a blue carbon ecosystem may be continuous or in patches over a large area. The boundaries need to be mapped and defined, providing information about the full range of conditions over which the ecosystem occurs. The maps should bring together any information available on its distribution (continuous or fragmented distribution) and the health and physio-chemical characteristics that may influence the distribution. Once mapped, boundaries should not be changed, but if necessary, any changes made must be well documented so that the carbon stock and sequestration rate assessments can be adjusted to changes in area.

Planning project boundaries to estimate blue carbon stocks.
Life Blue Natura, Andalucia.

Step 2:
Stratification of sampling area

Stratification is the classification of a sampling area into zones or strata with similar characteristics. It is used to reduce sampling costs as the below-ground carbon stock is not homogenous. Once the sampling area has been defined, stratification can begin, banding areas with similar carbon stocks together into strata. If there is no knowledge of the actual carbon stocks in the area then the strata could be defined by characteristics that influence carbon stocks, e.g. depth, water temperature, substrate characteristics (rock or sand), wave exposure, nutrients, sedimentation rates, and water temperature [69-71]. However, there is a balance to be struck between the number of strata defined and the resources and time available [65].

An straightforward characteristic often used to stratify coastal marshes is the vegetal community, as it is determined by some of the same environmental conditions that control carbon accumulation. Usually, three areas would be easily found by their vegetal community: (1) high marsh, the area with the lowest tidal influence; (2) medium marsh, the area inundated at high tides; and (3) low marsh, the area where the soil is permanently saturated with water.

Seagrass meadows have been often stratified by bathymetry, e.g. in Andalusia, Spain, the LIFE Blue Natura project stratified seagrass meadow areas by shallow (1–6.9 m), intermediate (7–15 m) and deep (>15 m) strata, and by seagrass health (healthy, degraded, dead) [72]. Other conditions that may be used for stratification are areas influenced and uninfluenced by a river plume, the predominant vegetal species, vegetal coverage density, or the location being in open versus closed areas.

Step 3:
Carbon pools to be measured and other GHG

The most commonly measured carbon pools in blue carbon ecosystems are the above-ground live biomass, below-ground live biomass —consisting of the roots and rhizomes— and the soil carbon, consisting of dead roots and rhizomes plus soil organic matter. For some assessments there may be a requirement to also sample the above-ground dead carbon, consisting of both organic material such as leaf litter from the seagrass (autochthonus carbon) and organic material from nearby coastal or terrestrial habitats (allochthonus carbon). Certain standards require all pools to be assessed.

Generally, the carbon pool is only sampled if:
a) It forms a significant (>5%) portion of the total stock ; or
b) The carbon pool is unknown; or
c) The pool is changing or forecast to change significantly.

To prove the additionality of a blue carbon project, only those pools affected by the proposed intervention need to be measured. Recent studies suggest that, in contrast with mangroves, most of the carbon held in seagrass meadows and coastal marshes belongs to the soil carbon compartment (up to 98 and 99% respectively) [22, 23]. Therefore, this manual focuses on the sampling and estimation of this compartment.

A few examples:

PROJECT:
To avoid the burial of a *Zostera* meadow.

PARAMETERS TO BE ESTIMATED:
Soil sequestration rate and biomass stock.

The construction of a harbour at the entrance of a small bay has led to the burial of a *Zostera* meadow. The construction of a similar harbour is planned in another small bay. The environmental impact assessment predicts the same outcome for the *Zostera* meadow of the second bay. The modification of the construction project, allowing the circulation of water below the harbour, would avoid the accumulation of sediments inside the bay, preventing the burial of the meadow. We want to calculate how much carbon would be sequestrated or not emitted thanks to this modification. If the meadow is not buried, we will preserve its capacity for carbon sequestration, i.e., the carbon sequestration rate to the soil. The stock would be preserved even if the meadow were to be buried, therefore we cannot count it as a result from our intervention, and we do not need to estimate it. On the other hand, if the burial happens quickly the biomass stock would also be trapped, but a slow burial (over several months) would see the plant die and decompose (releasing CO_2). Thus, since we can say that our action would prevent the release of this carbon as well, we will measure the biomass stock.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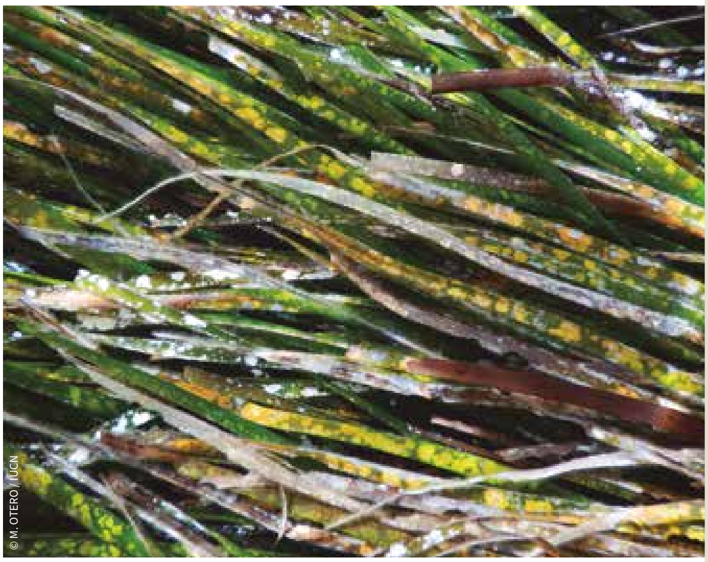
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PROJECT:
To prevent the erosion of the upper part of a *Posidonia* matte.

PARAMETERS TO BE ESTIMATED:
Soil carbon stock.

The upper 30 cm of a *Posidonia* matte (high organic carbon soil formed below some *Posidonia* meadows) are being eroded. We are developing a project that would prevent this erosion. Here, we are interested in the carbon stock of the soil, as our action would prevent its release. We will estimate the stock of the upper 30 cm that are in danger of erosion. As we are not interested in the depth variation of carbon concentrations in the soil, we can analyse the whole core as a single sample (see core sub-sampling section), using the saved budget to take more cores that would better capture the spatial variability of the meadow.

PROJECT:

Revegetation of a coastal marsh.

PARAMETERS TO BE ESTIMATED:

Additional carbon sequestration capacity of the soil, biomass stock.

A coastal salt marsh has been used as a dumping site for construction waste. We want to remove the rubble and restore the vegetation. This would promote the carbon sink capacity of the area. We will need to measure the carbon sequestration rate to the soil before and after our project. This can be done in two ways. We can take soil cores before the project and, using dating techniques estimate the carbon sequestration rates in past years. On the other hand, we can leave a small area unrestored and implement a sediment accretion rate estimation method (e.g. a horizon marker) in both the vegetated area and the unvegetated (with at least three replicates), allowing us to compare the sequestration rates with and without intervention throughout the duration of the blue carbon project. Furthermore, since the new vegetal coverage would generate biomass as a result of our intervention, we will measure the biomass stock as well.


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PROJECT:

To inventory soil carbon stock and sequestration rate.

PARAMETERS TO BE ESTIMATED:

Soil carbon stock and sequestration rate.

We have been requested to inventory the carbon stock and sequestration rates of an area. As we are going to estimate how much is held and how much has been sequestrating in the past decades (to estimate the current sequestration rate is not informative as it may not be representative of the average sequestration rate of the ecosystem), we will have to retrieve cores and date them, to infer the average accretion rate.

Step 4:
Determine the type, number, size and location of plots

Type

Temporary plots are cheaper, easier and quicker to assess. They are useful for single carbon assessments, such as for determining carbon stocks in an area. Permanent plots, on the other hand, enable direct comparison over time for assessing changes in carbon stocks, such as those related to climate change or anthropogenic actions, but are more expensive and slower to sample and set up, as permanent markers have to be installed. Furthermore, it is advisable to overestimate the number of plots needed in permanent plots, as is common to lose some of the plots over time. As blue carbon projects require a monitoring programme, permanent plots are recommended.

Number

The number of plots selected is governed by the accuracy required for the carbon stock estimates and the variability of those stocks within each layer of the soil. For REDD+ standard projects a common uncertainty target is less than 15% of the mean at a 95% confidence interval [76].

If there are no estimates of variability of carbon stocks, the sample number is set according to the resources available, with at least one plot in each stratum at each location. A circular plot example is shown in figure 22. Guidance from estimations carried out in Australia has suggested that 40 cores were sufficient to capture the regional variability over an area the size of the country, however the sample number may need to be increased over finer scales, e.g. looking at gradients in blue carbon [77]. A large number of smaller plots can help catch the within-strata variability better than a single large plot.

Location

Common types of plot distribution include:

a) **Linear:** most often used when measuring the effect of a variable on the carbon pools; assumes that the strata used represent the gradient of the variable (Fig. 22a).

b) **Random:** plots are picked at random within each stratum, without any prior knowledge of the carbon stocks within the strata, so that within-strata variability is represented by the samples (Fig. 22b).

c) **Probability-based grid design:** a grid is placed over the map, sometimes aligned with the strata, and only a single point is sampled within each grid ensuring that the sampling is spread out across the sample area (Fig. 22c).

Unless access or resources are restricted, random or probability-based grid sampling should be conducted. Significant differences in carbon stocks between plots in a stratum indicate strata were not correctly assigned. Increasing the sampling effort can help increase the accuracy of estimates or one can accept a loss of accuracy and report the within-strata variability. If the goal of the project is to estimate how much carbon has been sequestered or accumulated in a blue carbon ecosystem in the past, but there is no information on how much carbon there was previously, a control area would need to be sampled as well. A control area should be a nearby area, where the environmental conditions are as similar as possible. This would allow estimation of how much carbon is accumulated in the project ecosystem owing to the presence of the seagrass or coastal marsh. The carbon accumulated in the project study area minus the carbon accumulated in the control area is indicative of the likely carbon accumulated because of project implementation and your project viability.

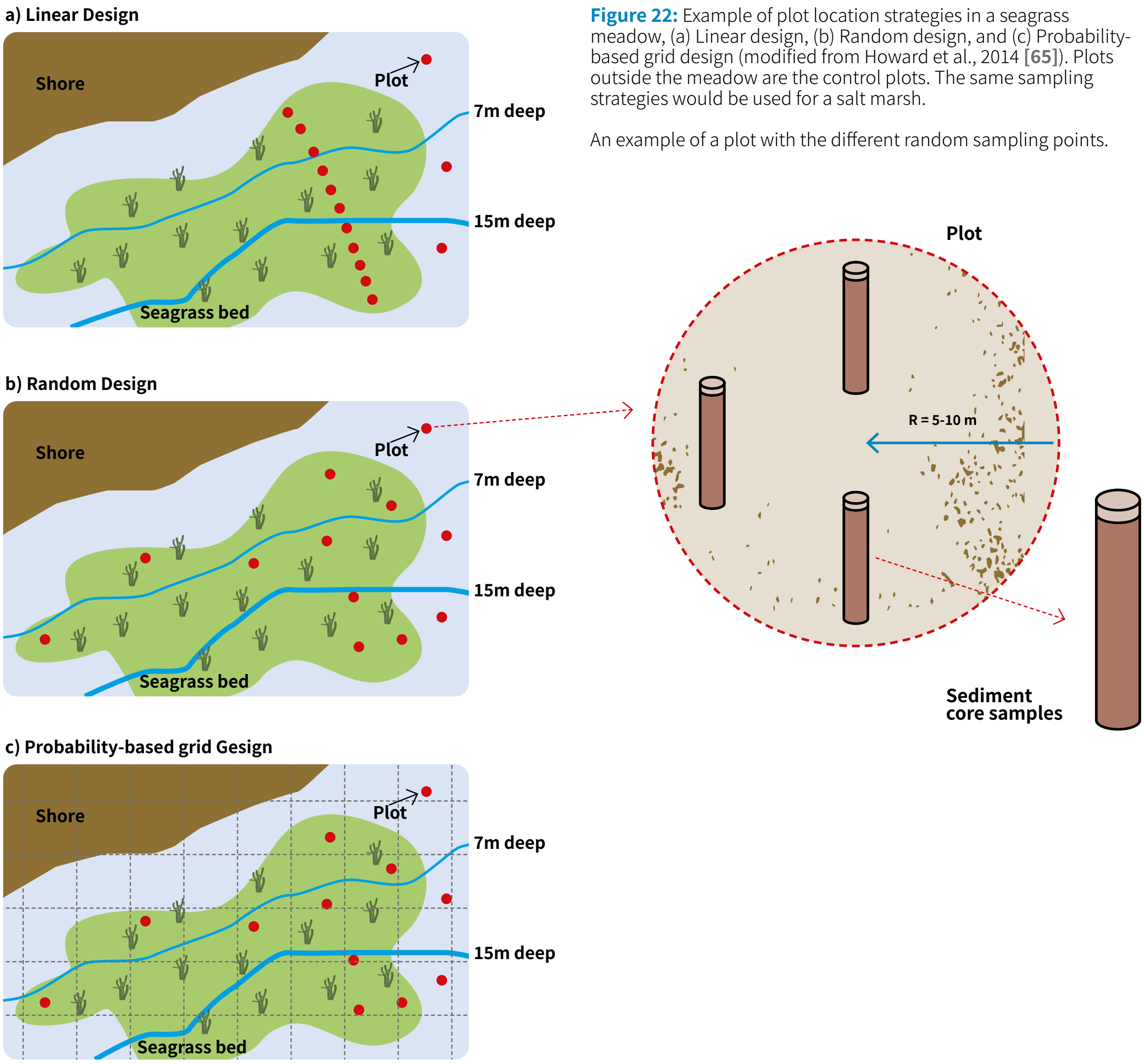


Figure 22: Example of plot location strategies in a seagrass meadow, (a) Linear design, (b) Random design, and (c) Probability-based grid design (modified from Howard et al., 2014 [65]). Plots outside the meadow are the control plots. The same sampling strategies would be used for a salt marsh.

An example of a plot with the different random sampling points.

Step 5: Sampling Frequency for Permanent Plots

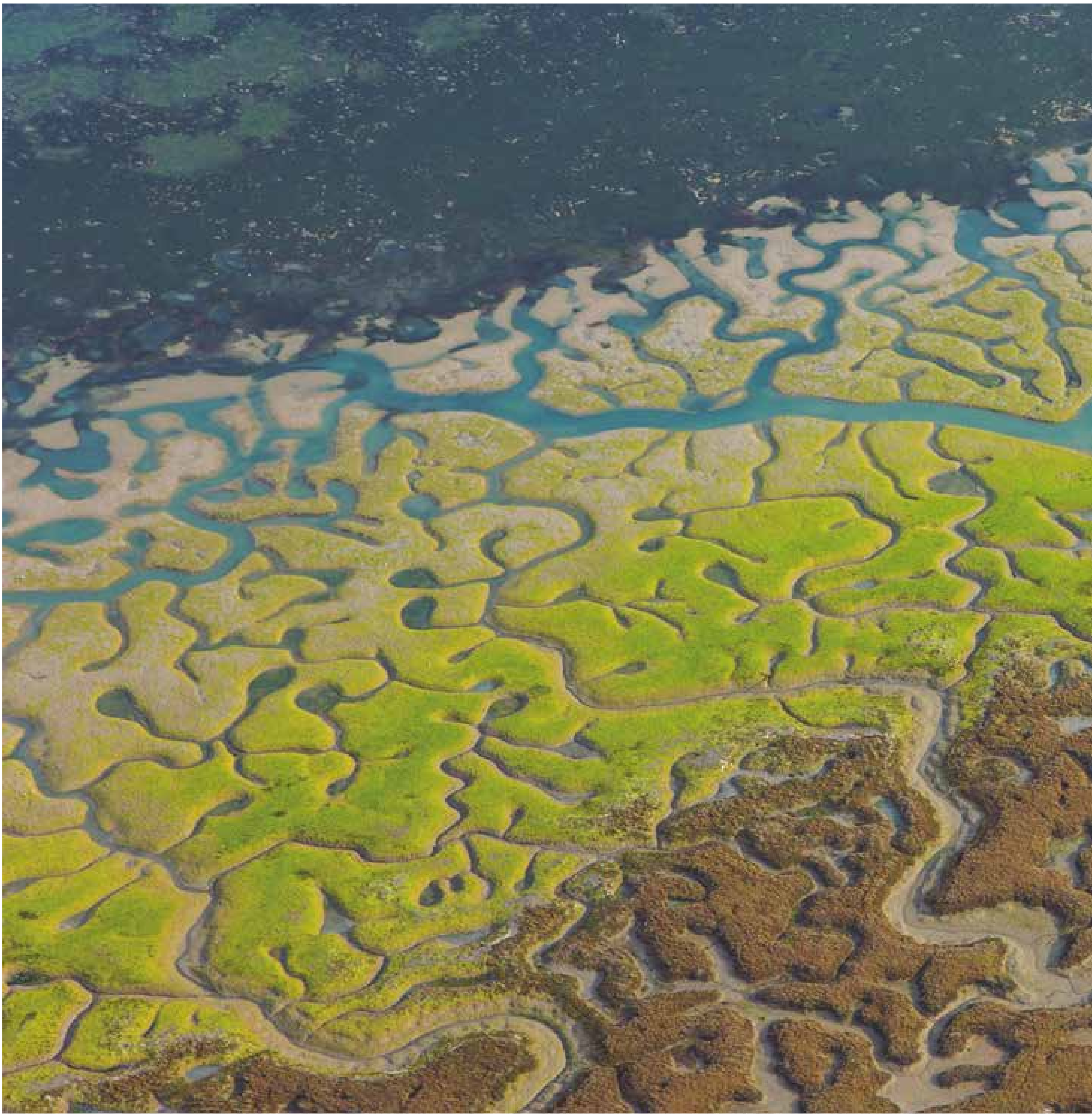
Sampling frequency will depend on the objectives of the project, the expected rate of change of the estimated parameter and the studied carbon pool [71]. Changes in below-ground stocks are slower than in above-ground biomass, which vary throughout the year. Sampling is recommended during the period of maximum biomass [78].

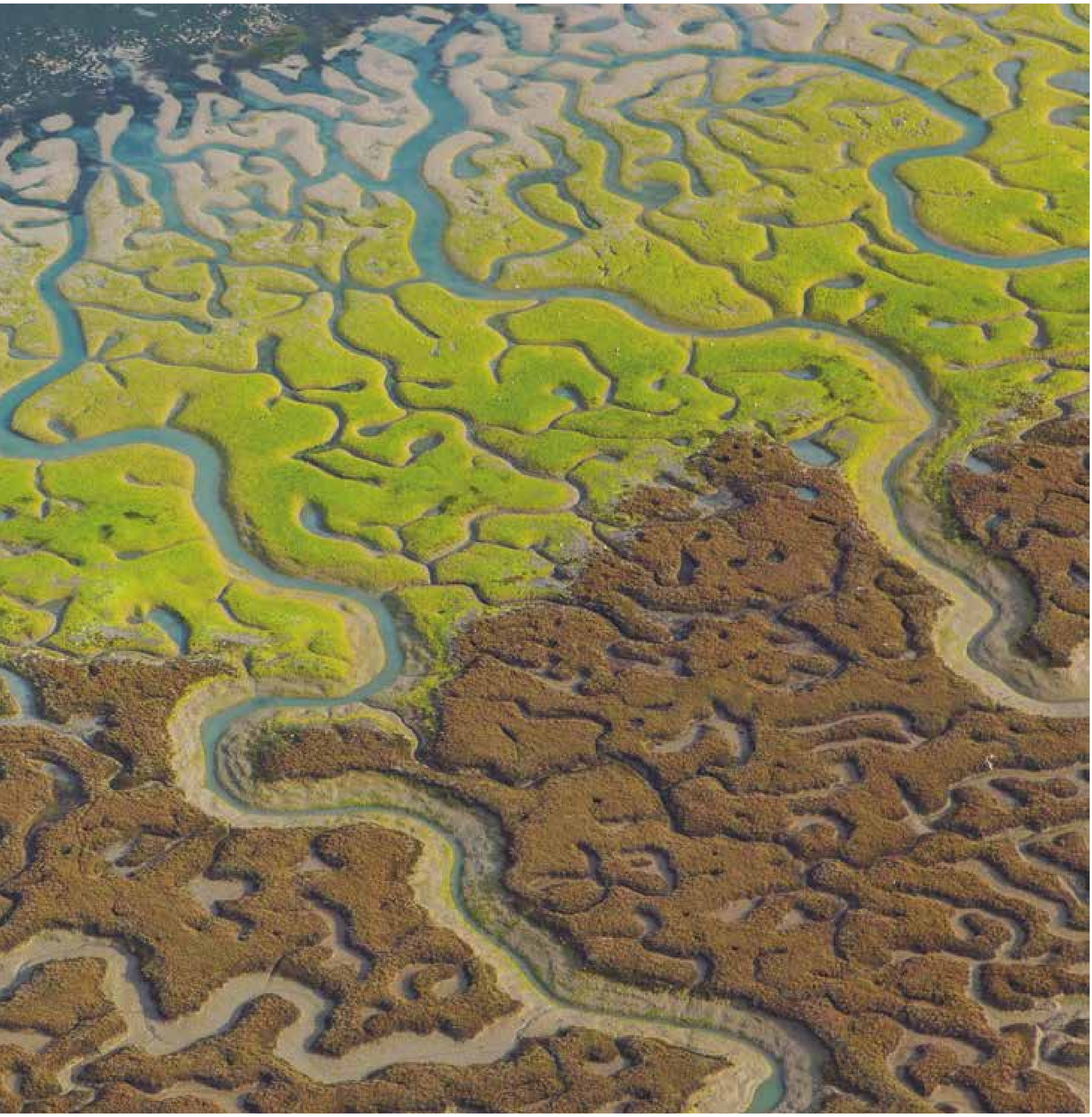
This would allow estimation of how much carbon is accumulated in the project ecosystem owing to the presence of the seagrass or coastal marsh. The carbon accumulated in the project study area minus the carbon accumulated in the control area will equal the carbon accumulated because of the project implementation.

For total carbon stocks, a five-yearly sampling period is common. Sampling intervals of 10 to 20 years are also common but may miss changes in stock or sequestration due to natural or anthropogenic stress. The frequency of the sampling period should meet the guidelines of the chosen standard for participation in carbon markets.

CHAPTER 6:

FIELD SAMPLING FOR SOIL CARBON STOCKS AND FLUXES





FIELD SAMPLING FOR SOIL CARBON STOCKS AND FLUXES

As up to 99% of seagrass and coastal marsh carbon is stored below ground as soil organic carbon [22, 23], the soil carbon pool is by far the most important carbon pool to accurately assess. However, living above-ground biomass can provide valuable estimates of ecosystem health and may be an added benefit of the project [22]. See the Coastal Blue Carbon Manual from the Blue Carbon Initiative for biomass carbon pool sampling and estimations [65].

To accurately measure soil carbon stocks three variables must be quantified: 1) **soil depth;** 2) **soil bulk density** (the volume occupied by a dry weight of); and 3) **organic carbon concentration.**

In addition, to measure soil carbon sequestration rates, the sediment accretion rate needs to be estimated.

SOIL DEPTH

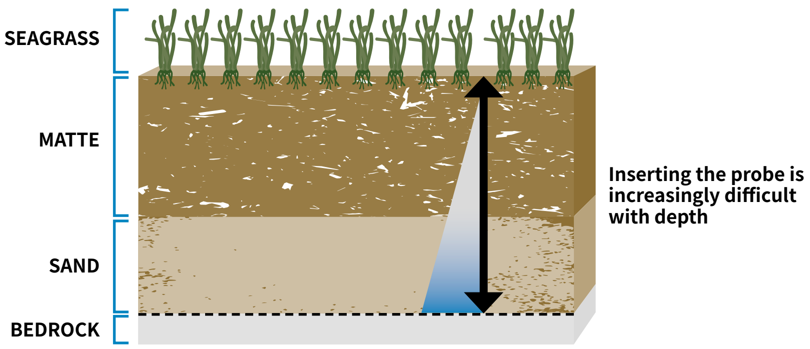
Soil depth can be measured with a soil probe, or pointed metal rod, that is pushed or driven into the soil until progress is halted (Fig. 23). This method will estimate the depth of the bedrock, the true soil depth, known as 'depth of refusal'. However, false readings can be created from a change in soil density or where the probe's progress is blocked by plant rhizomes. Hence, it is important to obtain a consistent soil depth estimate by sampling in three or more places around each core, and if a depth of refusal is recorded, soil cores need to be taken to at least this depth to validate the depth of the soil that corresponds to this depth of refusal.

In some seagrass soils, and especially for *Posidonia oceanica,* the very deep fibrous matte and underlying sand can prevent accurate determination of soil depth with a probe.

Depth is rarely measured under this seagrass ecosystem. Other methods such as mechanical corers as well as geophysical techniques are used in some instances to assess the depth of the below-ground carbon pool [80].

Measuring soil depth may not be logistically possible. To avoid the necessity of measuring the soil depth a standard depth can be adopted. The IPCC has recommended 1 m depth as a standard. If resources are low or cores cannot be taken to 1 m, carbon measurements from shorter cores (0-30 cm) can be taken and extrapolated to 1 m providing that a minimum of seven cores to 1 m are taken and used to develop log-linear equations (log Soil Organic C density (g) = S (d) + I where S = slope, and I = intercept) to predict the soil organic carbon density down to 1 m [77].

Figure 23: Measuring soil depth with a probe or rod (modified from Howard et al., 2014) [65].



Remote sensing techniques

Over the last decade non-destructive techniques have been developed that can be implemented at several steps of the Blue Carbon stocks estimations process, lowering cost and decreasing the project negative impact over the ecosystem [81, 82].

Mapping: The use of LIDAR software and drons is being successfully implemented in recent times. It yields high precision mapping at a very low cost. The most frequently used remote sensing technique to map seagrass meadows is the multi-spectral imagery, that process satellite images to obtain the dominant species and percentage of coverage of a given area. The quality of the maps resulting from this technique has increased with the development of new image processing techniques [81].
A common method for mapping salt marshes are elevation maps, which combine ground elevation data with the tidal range to obtain the potential distribution of a salt marsh [82]. The potential distribution can be checked against satellite images to obtain the final distribution of the ecosystem. This approach is particularly interesting because it allows to divide the salt marsh between high, medium and low marsh, division usually used as strata in salt marsh Blue Carbon projects.

Monitoring: Satellite images or remotely-sensed colour infrared imagery can be used to monitor land cover or marine meadow coverture changes. Changes in the vegetal community indicate changes in ecosystem conditions or the response of the ecosystem to anthropic activities.

Soil carbon estimations: High-resolution seismic reflection technology and seafloor morpho- bathymetric models have been tested with promising results to estimate the soil carbon stocks under seagrass meadows [80]. Soil cores are taken from the studied meadow to estimate soil carbon density and to calibrate the sound velocity data obtained from the high-resolution seismic reflection, to estimate the total volume of the soil from the meadow area. This volume can be translated into the meadow soil carbon stock by multiplying by the average carbon density.

SOIL DENSITY AND CARBON CONTENT

Obtaining soil bulk density and carbon content requires the extraction of relatively undisturbed soil profile samples. The simplest method is to push or hammer a tube into the soil, which is then capped and pulled back up with the vacuum inside the tube used to retain the soil sample. Manual coring is the most commonly used method in seagrass meadows. However, this method is not recommended for coastal marshes. Manual coring causes compression and the mathematical compression correction used does not correctly distribute compression among soil samples whose density changes drastically with depth, as is usually the case in coastal marsh soils. Therefore, for coastal marshes the use of non-compacting methods such as piston corers or the Russian peat corer are recommended [65].

Capacity training for manual coring in a salt marsh. Life Blue Natura project / IUCN-CSIC, 2019.

6.1. Manual coring

Manual coring has certain advantages such as low cost, high portability, and the possibility of doing it oneself. Its main disadvantages are that that it causes compression and that the depth of core insertion is limited and related to the strength of the operator and the density of the soil.

The corer is usually made from a PVC pipe (Fig. 24). It typically has an internal diameter of 5–7 cm, a wall thickness of 0.5 cm and a length of up to 2 m. The leading edge is sharpened to cut through fibrous material. When soils are sandy, a core catcher can be fitted to the bottom of the corer to reduce sediment loss during retrieval. Templates for self-made core catchers are available[27] and simple plastic core catchers can be purchased (Fig. 24a). It should be noted, however, that on retrieval, all soil (10–15 cm) below the core catcher is lost [83]. The corer can be capped and then hammered into the soil. Two holes may be drilled at the top of the corer allowing an aluminium bar to be passed through, which can be used to turn the corer as it is enters the soil (Fig. 24). The corer may also have predrilled holes (sealed with tape) along its entire length to allow for field ssubsampling of the extracted core (see below).

Equipment required

- 1 x perforated metal cap, lined with Teflon tape to protect corer top during hammering
- 2 x rubber plugs or PVC caps, for sealing the corer
- 2 x stiff sponges or flora foam, to occupy the space between the plugs and sediment core
- Waterproof adhesive tape, to seal corer ends
- 1 x sledge hammer (long-handled)
- 1 x plastic folding rule, for measuring core compression and corer penetration
- 1 x knife or scissors, for removing above-ground biomass prior to coring
- 1 x tenon saw, for cutting off the top of the corer (see below)
- 1 x waterproof tablet or notepad, for recording data (e.g. soil depth inside/ outside corer)
- 2 x permanent markers
- Syringes for sediment subsamples if using a predrilled corer (see Fig. 27)
- 2 x ropes (3 m long and 1.5 cm diameter), for core removal
- GPS receiver, maps, diving gear

Figure 24: PVC corer for seagrass and saltmarsh soils.

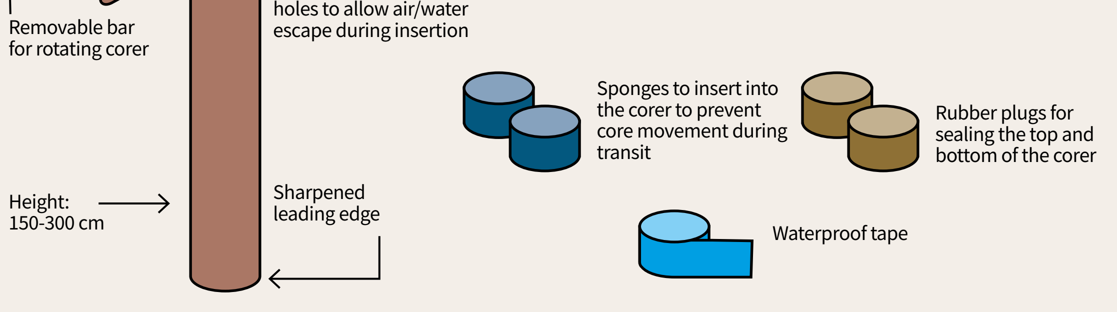
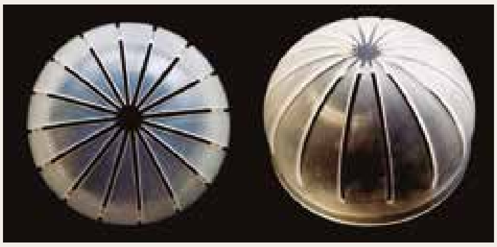


Figure 24a. Core catchers



[27] http://esslab.tamucc.edu/resources/corecatchertemplate.pdf

Coring procedure

The following procedure and steps are proposed for preparing and extracting corers for soil samples (adapted from LIFE BlueNatura project [22, 71]):

Step 1
Select place, and record location, station name, core label, core length and environmental data in a data sheet (Fig. 27a). If appropriate and feasible, soil depth should be measured with soil probe.

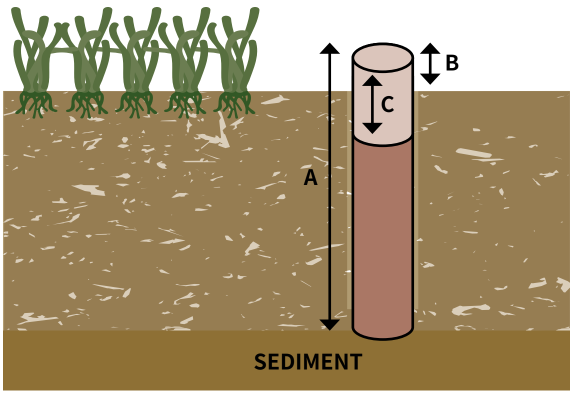
Step 2
A space between shoots should be chosen. Otherwise, the above-ground biomass should be removed from the selected place. The corer is held vertically with the leading edge on the soil. The rod is inserted into the holes at the top (for core rotation) and a metal cap placed on top of the corer. The corer is then driven as carefully as possible into the soil using a sledgehammer, with the corer rotated 180° every two hits to reduce core compression and cut through fibrous rhizomes and roots.

Step 3
Once the corer has reached the required depth, there should remain at least 10 cm of exposed corer to allow rope attachment. The height of the corer above the soil should be measured on the outside, for calculating corer penetration, and on the inside for estimating core compaction (Fig. 25).

The bulk-density of sediments will increase with depth and hence compression can vary with depth. So, if more accurate measurements are required, several inside and outside corer measurements can be taken as the corer enters the soil. If a rhizome or stone blockage has resulted in the "nail effect" and very little soil is present inside the corer, or the corer cannot be fully inserted to the required depth, another core should be taken in a nearby location.

Step 4
This step requires the removal of the rotation bar from the corer (Fig. 24). Then insert a plug or PVC cap into the top of the corer and seal it with waterproof adhesive tape, including the holes for the rotation bar. This helps prevent loss of material when the corer is lifted.

Figure 25: Measurements required for estimating core compression (modified from Howard *et al.,* 2014).



A total length of pipe
B the length of pipe outside the sediment
C the length of inside pipe

Step 5

Prior to lifting, it is also recommended to insert a 1.5 m metal pipe (about Ø15 mm), loosely fitted with a carriage bolt, into the leading end of the pipe. The pipe is hammered in alongside the PVC corer until it is level with the core bottom. The pipe is then pulled back up a few cm, releasing the carriage bolt which remains in the soil and allows water into the core bottom to break the air/water lock. This allows easier retrieval of the corer [83].

Step 6

Attach the centre of each rope to the corer using a clove-hitch knot, leaving four rope ends. At this moment, team members who are kneeling take up the rope tension and lift the core as they pull upwards. The process may need to be repeated, with the knots moved down the corer until the corer bottom is near the sediment surface.

Step 7

Immediately after the corer has been retrieved, the bottom of the corer should be plugged and taped.

Step 8

Afterwards, the top of the corer is reopened and the distance from the top of the retrieved material to the corer edge re-measured to determine if any material has been lost during corer extraction. If significant loss has occurred, then the core may have to be retaken. This is a common occurrence in coring. If no material or almost no material has been lost, the corer can be cut to 2–4 cm above the sediment, inserting foam or a sponge to fill the remaining gap before reinserting and resealing the plug or cap. This will stabilise the core and prevent material movement inside the PVC tube during transportation.

Important: the top and bottom of the core should be labelled, as it is not always clear in the laboratory.

Core sampling in Andalucia seagrasses. CSIC-Life Blue Natura.

Core treatment

Cores should be cooled to 4°C and kept in the dark prior to processing. The core can be frozen and defrosted prior to processing but subsequent refreezing should be avoided.

Subsampling the core

The decision about how to subsample the core is again dependent on the resources available, but usually more effort is applied to the top (20–50 cm) as this is where there are the greatest variations in carbon. Nevertheless, there is no set sampling interval. Taking samples every 5 cm for the first 50 cm has been suggested, with greater intervals thereafter [79]. Subsampling is done to account for the depth variation of the carbon in the soil. However, if the blue carbon project does not aim to estimate changes in carbon sequestration rates through time, the whole core can be treated as a single sample, homogenised and measured, saving money that can be invested in retrieving more replicate cores in the field. Thus, the accuracy of the estimation of the spatial heterogeneity in our ecosystem will be improved.

It is important that every core reaches the same depth if the single-sample strategy is going to be utilised. As the cores will have varying depths they can all be cut at the same depth. If the cores are compressed, this **compression needs to be taken into account** before discarding core material.

If a subsampling strategy is going to be utilised, the core can be subsampled in the laboratory or in the field (Fig. 26).

Field subsampling is done through pre-drilled holes in the corer that are taped over and sealed during the coring (Fig. 27). Once the corer has been extracted, it is kept vertical and the tape is peeled back to reveal the holes one at a time, starting at the core top. A syringe with the top cut off and having the same diameter as the pre-drilled hole is pushed into the soil with the plunger being pulled out as it is inserted (Fig. 27). Once the syringe has been removed the plunger is pushed back in slightly so that the protruding sample can be cut off flat, in line with the syringe opening. The sample volume can be read directly from the scale on the syringe in millilitres.

Samples obtained using this method are placed into labelled pre-weighed containers and the volume of sediment recorded (1 cm^3 = 1 cc = 1 ml). Here, it is good practice to have a data sheet for recording the variables that include columns headings: station ID, core number, core depth, subsample depth, volume of subsample, container number and weight, and wet weight of subsample.

Figure 26: Subsamples of cores for carbon analysis.

In the laboratory, subsampling is done by laying the cores horizontally and cutting the PVC into two equal halves using a circular saw or electric shears. A wooden or metal guide is used to ensure that the blade only just penetrates the PVC casing (and not the core) and cuts in a straight line along each side of the PVC corer. A sharp knife or a vibrating knife can then be used to cut along the joins between the two halves of the PVC corer to form two halves, known as hemicores or splits.

One of the hemicores needs to be divided up into the sampling intervals and a photographic record of the divisions taken, while the other hemicore can be stored frozen for reference or further analysis.

In the first hemicore:

1) A ruler is laid along the core length. It is recommended to photograph the core with the core label and the tape measure.

2) If subsamples are going to be taken, sampling intervals should be marked on the hemicore surface with a sharp knife (Fig. 28). If the whole core is going to be treated as one sample, the operator should ensure it is cut to the appropriate depth (if needed) and to retrieve all the material for homogenization.

Figure 27: Subsampling with a cut-off 3 cm diameter 25 ml syringe.

Figure 27a: Example of data sheet for cores.

Date	Station/core ID	Soil probe depth (cm)	Outside (cm)	Inside (cm)	Water depth	Comments
			↓	↓		

Figure 28: Core subsampling interval of 2 cm marked out on the surface of the hemicore.

6.2. Measuring sediment accretion rate

The sediment accretion rate, necessary to infer carbon sequestration rates to the soil, can be estimated from the same cores used to measure bulk density and carbon content by dating the material of the core, for example using ^{210}Pb or ^{14}C dating methods [22, 32]. This may be the only option if the project needs to estimate the past accretion rate in an area from which there is no previous information. However, these sediment dating methodologies can be expensive.

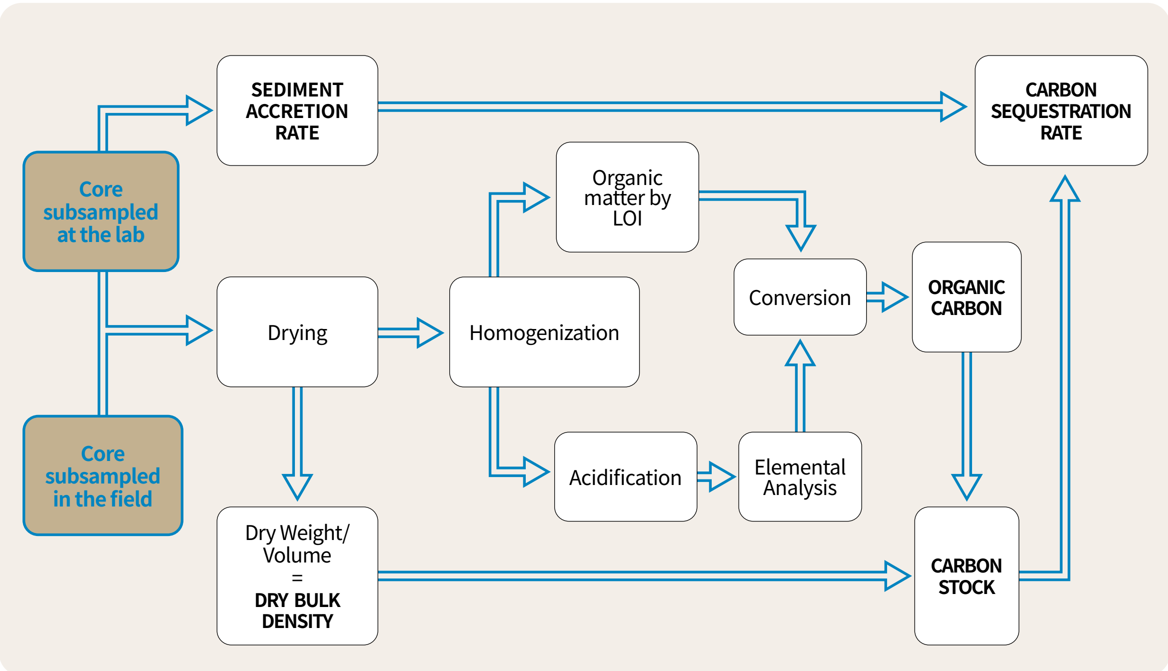
The Surface Elevation Table and the marker horizon method have been used to successfully measure tidal wetland elevation and accretion rates but are generally problematic in seagrass meadows [84]. Marker horizons measure vertical sediment accretion with a thick marker layer (e.g. white feldspar clay) that is placed on top of the sediment surface. Soil cores are later taken, and the amount of sediment accumulated on top of the marker is measured. The distance from the marker to the soil surface in the core provides the soil elevation. Adjustments based on a correction factor should be considered using this methodology if the coring method led to core compression. Sediment erosion tables in the field provide a constant reference for the measurement of the relative height of the soil over time [85].

Laboratory Analysis

There appears to be no standard method for laboratory analysis of soil samples, but the flow chart in Fig. 29 summarises the existing methodologies that could be used as a guide for estimation of carbon sequestration rates and carbon stock from field work.

Dry bulk density is estimated from the whole subsample (i.e. core section or syringe subsample). Other analysis can be carried out on fractions of the homogenised sample once dried. The dry bulk density and the organic carbon content are used to determine the carbon density of the soil.

Figure 29: Carbon stocks and accumulation rates estimation workflow.



Determining the subsample volume

The volume of a hemicore section can be calculated with the following linear regression [79]:

Volume (cm³) =

0.5 × the section depth × (π × core radius² (cm))

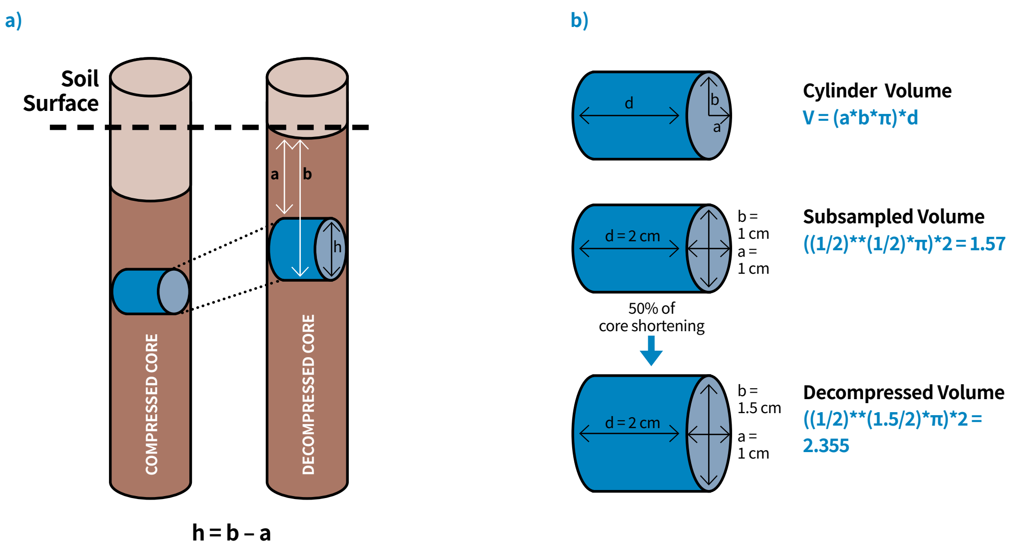
Core compaction correction factor

As indicated before, here it is important to consider whether the section depth has to be corrected for the core compression. For example, if the corer depth was 100 cm and the core was 80 cm, the section depth of 2 cm must be corrected by 80/100, so that the original (pre-compression) section depth should be estimated as equal to 2/(80/100) = 2.5 cm. Other manuals and protocols have recommended the use of log or exponential rates of compression [22, 86] as surface sediments are generally less dense and compressed more during coring.

Subsample compaction correction factor

For subsamples taken with syringes, the volume of the subsample taken can be read directly off the syringe as volume (ml) where 1 ml = 1 cm³. However, if the core has been compressed the syringe volume must be re-calculated. The material inside the core is compressed vertically but not horizontally. Therefore, after mathematical correction of the compression, the section of the syringe subsample won't be a circle but an ellipse. The decompressed depth of the upper and lower part of the ellipse can be corrected as in any other compressed core (Fig. 30a). Then, the volume is calculated as the volume of a cylinder with an elliptical section (Fig. 30b).

Figure 30: Example of how to calculate the corrected volume for syringe subsamples taken from compressed cores.



6.3. Dry Bulk Density

This refers to the density of the soil and is estimated from the dry weight of a known volume of soil.

1. Either the whole marked sample interval is lifted intact out of the core or a cut-off syringe can be inserted into the centre of the subsamples and placed in a pre-weighed labelled container. The sample can be spread out to facilitate the drying process.

2. The samples are placed to dry in an oven at 60°C until a constant weight is reached (higher temperatures can lead to loss of organic material through oxidation). For samples with high clay content, freeze drying is recommended (this helps disaggregation later). The final weight should be recorded as dry weight of sample.

Dry sample weight =

total dry sample and container weight – container weight

3. After 24 hours, samples are removed from the oven and placed in a desiccator to dry and cool for at least one hour before weighing. The process is repeated over additional 24-hour periods until the weight difference is less than 4%. If a desiccator is not available, samples can be kept in a closed room with air conditioning to keep humidity below 50% [68]. Samples normally require 48–72 hours to achieve a stable dry weight [65]. The desiccator prevents the absorption of water from the atmosphere and therefore weight gain. The dry weight should be noted and dry bulk density calculated as:

Dry Bulk Density (g cm^{-3}) =

Dry Weight (g) / Volume of Sample (cm^{-3})

Equipment required

- Balance – with two or three decimal places, e.g. in 1 g, 10% accuracy = 0.1 g, 1% accuracy = 0.01 g, 0.1% accuracy = 0.001 g
- Crucibles of an appropriate size for the samples – numbered and pre-weighed
- Desiccator – with purple silica gel; if white, put in 105°C oven for six hours to dry out
- Drying oven – set at 60°C

Samples drying in desiccator.

DETERMINING THE SOIL ORGANIC CARBON CONTENT

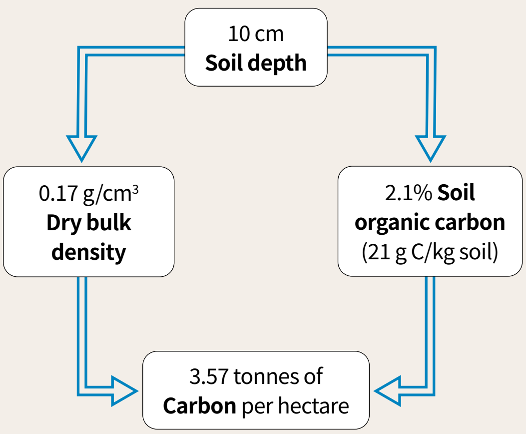
The soil organic carbon content is the proportion of organic carbon to the soil dry mass (Fig. 31). There are two main methods for measuring it:

a) An automated elemental analyser; and
b) A muffle furnace to determine loss on ignition (LOI). This involves estimating the weight lost during the combustion of organic material in a heated sample, and using empirical relationships between organic carbon and organic material.

A third method, using wet chemistry such as the Walkley-Black method, is not considered quantitative, produces toxic waste and is not often used [65].

Determination of the organic carbon content using an automated analyser produces more accurate estimates of carbon but is relatively more expensive, while LOI is cheaper and provides an estimate of total organic material that has to be converted to organic carbon content.

Figure 31: Example calculation of amount of soil organic carbon per hectare in a given depth of soil.



e.g. 10,000 m^2 in one hectare x 0.1 m soil depth x
0.17 g/cm^3 bulk density = 170 t/ha of soil
21 x 170,000 = 3,570,000 gC/ha =
3.57 tonnes of carbon per hectare

Equipment and materials needed:

- Heat-proof gloves
- Drier
- Muffle furnace – capable of up to 500°C
- Tongs
- Balance – two or three decimal places
- Crucibles of an appropriate size for the samples – differently numbered and pre-weighed
- Desiccator

Using the Loss On Ignition (LOI) method to estimate organic matter %

The steps to calculate the organic matter using the LOI methodology are as follows:

1. The dried bulk sample is homogenised by grinding it until a fine powder is formed.
2. At least 3 g of the homogenised sample are transferred to a crucible, and then it is dried at more than 100°C for at least five hours, to eliminate humidity, and then weighed.
3. Next it is heated to 500°C for at least six hours. Then it must cool to ~100°C before being transferred to a desiccator to cool to a temperature at which the sample can be safely handled and re-weighed.
4. The weight loss between before and after combustion at 500°C as a percentage of the total original dry sample weight is the percentage of organic material (% OM) or % LOI.

% OM =

[(Initial Dry Weight of soil - Weight of soil remaining after heating to 500°C) / Initial Dry Weight of soil] x 100

This percentage represents the loss of soil organic matter including carbon, hydrogen, nitrogen, oxygen, sulphur, etc. and hence must be converted to carbon loss. As % LOI and organic carbon of seagrass and salt marsh soils are highly correlated, the carbon content can be estimated from the % LOI using a calibration curve.

A few (~10%) samples should be sent for analysis to quantify the carbon content using an elemental analyser. The results obtained will provide the correlation between the total organic material results obtained from % LOI and the organic carbon content [68]. Here, it is advisable to estimate a conversion factor for each stratum sampled in the field.

If organic carbon data from an elemental analyser is not available, one of the following general conversion factors can be used:

Coastal marshes C_{org} =

$0.40 \times \%\,LOI + 0.0008\,(\%LOI)^2$ ($r^2 = 0.99$) [87]

Seagrass meadows if % LOI < 0.2 % C_{org} =

$0.40 \times \%\,LOI - 0.21$ ($r^2 = 0.87$) [38]

Seagrass meadows if % LOI > 0.2 % C_{org} =

$0.43 \times \%\,LOI - 0.33$ ($r^2 = 0.96$) [38]

Preparing samples for C elemental analysis

Homogenised samples for elemental analysis need to be acidified to remove the inorganic carbon or calcium carbonate that can be present in the soil from stones (limestone) or calcareous organisms such as shells.

The pre-acidification procedure to be performed is as follows:

1. Test whether the samples contain carbonates by adding 1M HCl to a subsample of soil and watch for effervescence. If carbonates are present, continue to step 2; if not present there is no need to acidify.
2. Take 1 g of sample and place in a pre-weighed glass centrifuge tube, adding 1M HCl to cover the samples and agitate or sonicate for 15 minutes to break up any lumps of material. Leave it until the effervescence stops. Add more HCL and agitate; if effervescence occurs repeat previous steps.
3. When no further effervescence occurs, indicating no remaining carbonate, the sample should be allowed to settle or centrifuged to remove suspended material before carefully removing supernatant with a pipette.
4. Samples are then rinsed by adding distilled or MilliQ water and agitated again and allowed to settle (or centrifuged), followed by removal of supernatant.
5. Step 3 is repeated two or three times more until the supernatant acidity is pH 7.
6. Samples are left to dry overnight at 60°C.
7. Weigh the sample in the tube and deduct the weight of the tube to give the decarbonated sample weight.

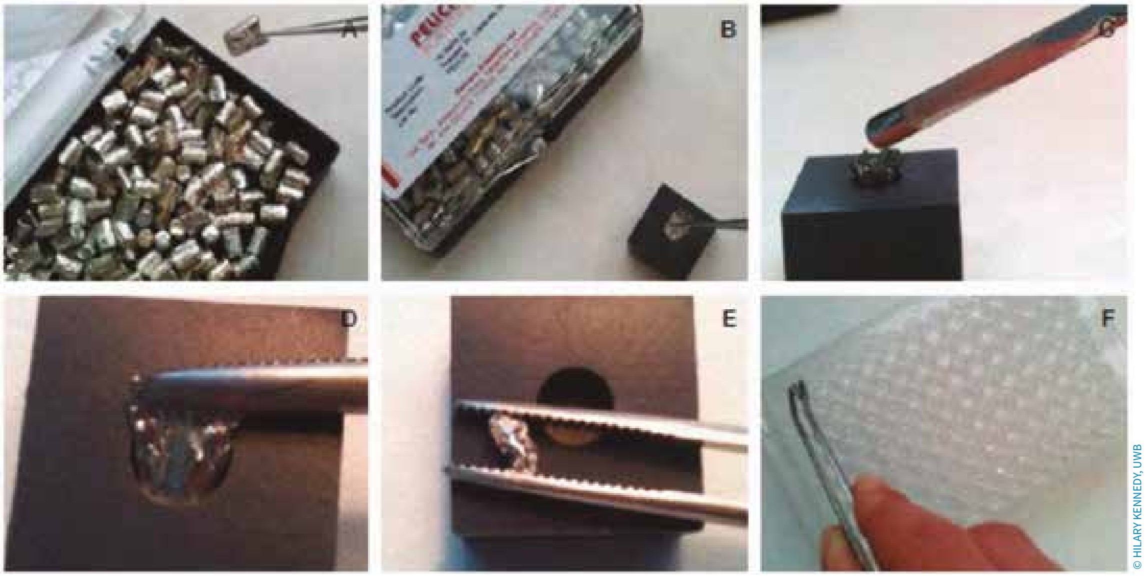


Figure 32: Preparation of samples for elemental analysis. (A) Tin capsule to be weighed; (B) after weighing, the capsule is placed on a clean surface; (C) sample added by spatula; (D) closing the capsule, folding the top; (E) compressing the capsule; and (F) placing the sample in the 96-well plate.

Sample preparation for elemental analysis

1. Part of the homogenised decarbonated and oven-dried sample is placed into a pre-weighed tin capsule. The exact quantity should be discussed with the auto-analyser operator and preliminary samples might have to be run to find out the carbon content of the samples.
2. The top of the tin capsule (containing the sample) is folded over twice and compressed to avoid any sharp points that may stick in the auto-analyser.
3. The capsule is reweighed and placed in a 96-well plate and stored in a desiccator (Fig. 32).
4. Note the well number, sample ID, weight of sample (weight of tin cup and sample minus weight of tin cup and original sample weight pre-acidification).
5. The samples are then ready to be passed to a specialised laboratory for the elemental analysis.

Equipment needed

- 1 microbalance
- Pressed tin capsules (6 × 4 mm or 8 × 5 mm)
- Forceps
- Spatula (curved spoon type is useful)
- Pre-drilled PVC block to hold tin cup (i.e. with 7 or 9 mm hole)
- 96-well plate

CHAPTER 7:

CALCULATING AND UPSCALING TOTAL CARBON STOCKS

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ESTIMATING CARBON STOCK

The total soil carbon stock within a project area is determined by the amount of carbon within a defined area and soil depth. This will provide estimates of the carbon stocks for the baseline study in the project area (see Accounting GHG Emissions at project scenario). Following the steps provided by the **Coastal Blue Carbon Manual from the Blue Carbon Initiative** to calculate the total soil carbon for a project area the following information is needed:

- Soil depth,
- Subsample depth and interval,
- Dry bulk density, and
- % organic carbon.

To calculate the total carbon stock of an area, the following steps need to be followed:

Step 1.
Soil carbon density: Calculated for each section of individual cores following the equation:

Soil carbon density =

Compression corrected DBD (g cm^{-3}) × (% C_{org}/100)

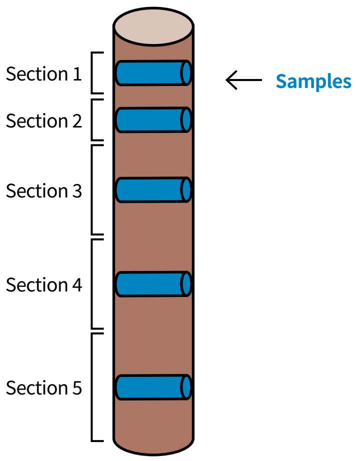


Figure 33: Section distribution in a syringe-subsampled core. Each section starts and ends at the midway point between two samples.

Step 2.
Soil organic carbon stock of each section in a soil core: estimated from the soil carbon density of each sample multiplied by the thickness of the sample, i.e. the length subsampled from the hemicore in the laboratory. In the case of samples taken from the cores with syringes, the first section thickness would be the distance between the top of the core and the medium point between the first and second sample; the second section thickness would be the distance between the medium point between the first and second syringe, and the medium point between the second and third syringe; and so on... (See Figure 33).

Soil organic carbon stock in core section (g C_{org} cm^{-2}) =

Soil organic carbon density (g C cm^{-3}) × compression corrected thickness of core section (cm)

Step 3.
Carbon stock in each core. Step 2 needs to be repeated for each core section and summed. If the core does not reach the required depth, normally 1 m, then carbon density will have to be extended down to that depth by extrapolating linearly integrated values of cumulative organic carbon stocks with depth [77]. **This is not compatible with the single sample method** (see soil core processing section).

Carbon stock in core section (g cm^{-2}) =

Section 1 CS + Section 2 CS + ...

Step 4.
Convert core stocks. (Step 3) to units used in the literature if necessary, i.e. t ha^{-1} or Mg ha^{-1}

Carbon stock in each core (t ha^{-1}) =

Carbon stock in core (g cm^{-2}) × 10

Posidonia oceanica matte.

Step 5.
Calculate mean and standard deviation of carbon stocks for each stratum.

Mean Carbon stock (t ha^{-1}) =

$$\frac{X_1 + X_2 + \ldots\ldots X_n}{N}$$

Strata Standard Deviation (σ) =

$$\frac{(X_1 - \overline{X})^2 + (X_2 - \overline{X})^2 + \ldots (X_n - \overline{X})^2 \ ½}{N\text{-}1}$$

Where:

X_1 = Carbon stock in core #1, and

$\overline{X}$ = mean carbon content in the core in a stratum,

N = the number of cores in that stratum.

Step 6.
Carbon stock for sample area: Mean carbon stocks (t ha^{-1}) multiplied by the stratum area and repeated for each stratum and totalled.

Sample area carbon stock =

(mean carbon stock in stratum 1 × area of stratum 1) + (mean carbon stock in stratum 2 × area of stratum 2) + … (mean carbon stock in stratum n × area of stratum n)

Step 7.
To report the uncertainty around the calculated carbon stock for the sample area, step 5 is repeated for each stratum and multiplied by the stratum area and the resulting carbon per area summed to obtain the total carbon in the ecosystem.

SD of carbon stock for sample area (σ)

$$\sqrt{(\sigma A^2 + \sigma B^2 + \ldots \sigma N^2)}$$

Where:

σA = standard deviation of the core average C for stratum A × area of stratum A

σB = standard deviation of the core average C for stratum B × area of stratum B

σN = standard deviation of the core average C for stratum N × area of stratum N

ESTIMATING CARBON SEQUESTRATION RATES AT BASELINE SCENARIO

As it was described before, emissions in the baseline (without project' scenario) are attributed to carbon stock changes in biomass carbon pools, soil processes, or a combination of these. For seagrasses and coastal wetlands, the net carbon sequestration rate or carbon flux is expressed in units of mass per unit area and time (e.g. 1 tC ha^{-1} yr^{-1}). Carbon sequestration rates are given as the average accumulation rate over a period of time. All accumulation rates must be estimated for the same time period (e.g. 100 or 1,000 years), allowing the comparison between areas [88].

The following example would use 100 years as the time frame to standardise the carbon sequestration rate.

Step 1.

Carbon fluxes can be estimated from the stocks in two ways. To calculate the average carbon flux in the last 100 years:

a) Multiply the average accretion rate of the last 100 years by the average carbon density at that depth (the depth at which the material is 100 years old).
or
b) Sum up the carbon stock of the core until the depth where the material is 100 years old and divide it by 100.

Both methods can be found in the literature and report the same values.

Step 2.

Calculate mean and standard deviation of carbon sequestration for each stratum.

As dating techniques are expensive, it is not uncommon to estimate the carbon sequestration rate only once per stratum. If the carbon sequestration rate has been calculated for several cores, the mean and standard deviation must be calculated for that stratum (see carbon stocks).

Step 3.

Total **carbon sequestration rate for sample area:** mean carbon sequestration rate (t ha^{-1}) multiplied by the stratum area and repeated for each stratum and totalled. This total is equivalent for example to $GHG_{BSL\text{-}soil}$ under Methodology VM0033.

Sample area carbon sequestration rate ($GHG_{BSL\text{-}soil}$) =

(mean carbon accumulation rate in stratum 1 × area of stratum 1) + (mean carbon sequestration rate in stratum 2 × area of stratum 2) + … (mean carbon sequestration rate in stratum n × area of stratum n)

Step 4.

To report the uncertainty around the calculated carbon sequestration rate for the sample area, step 3 is repeated for each stratum and multiplied by the stratum area and summed for the area.

SD of carbon sequestration rate for sample area (σ) =

$$\sqrt{(\sigma A2 + \sigma B2 + \ldots \sigma N2)}$$

Where:
σA = standard deviation of the core average carbon sequestration rate for stratum A × area of stratum A
σB = standard deviation of the core average carbon sequestration rate for stratum B × area of stratum B
σN = standard deviation of the core average carbon sequestration rate for stratum N × area of stratum N

ACCOUNTING FOR GHG EMISSIONS AND REMOVALS FROM SOIL IN PROJECT SCENARIO

As described, a blue carbon project must account for with-project emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Emissions may be negative (signifying removal of a gas from the atmosphere) or positive (signifying the release of a gas to the atmosphere).

If a project wants or needs to account for a greenhouse gas emission in soil under the project scenario, they generally have the following options to obtain values (For example for $GHG_{WPS\text{-}soil}$ under Methodology VM0033):

Accounting CO_2 emissions from soil under the project

Default values and emission factors

Default values and emission factors are provided in carbon accounting and monitoring like the VCS wherever such scientifically credible values are available. As such, projects that are restoring tidal marsh can estimate soil CO_2 sequestration using the default value provided in the Methodology VCS (see Table 2). There is no default value available for seagrass projects, so field-collected data will be needed for such projects unless published data are available.

The methodology also allows for projects to use externally published default values and emission factors in certain cases (when they are derived from peer-reviewed literature and are appropriate to the ecosystem type, conditions, and geographic region of the project area). Standards such as VCS allows projects to use the emission factors established by the Intergovernmental Panel on Climate Change (IPCC) for national GHG inventory accounting that in the case of seagrasses, is based on studies on *Posidonia oceanica*. These values may be used by project proponents in certain cases, but project proponents must justify their use as appropriate for project conditions.

As research is advancing, default factors undergo periodic re-assessment and might vary in the future.

Published values

In cases where measuring a specific carbon stock change (net GHG benefit) proves prohibitive, some carbon credit methodologies allow projects to estimate the change in both the project and baseline scenarios using values for the average rate of the emissions of a given GHG from scientific literature. Literature factor values must derive from the “same or similar systems” to reduce variability from geomorphic, hydrologic, and biological properties of the ecosystems.

Moreover, as observed in some restoration programmes, it can take about a decade for soil carbon sequestration rates and plant biomass to be equivalent to those of a natural ecosystems (Oreska *et al.* 2020) and values can vary over time.

Modelling

At present, there is very limited knowledge on carbon storage and fluxes before and after restoration programmes and as yet not many models are adequately developed and tested. Moreover, although some model estimations are available, carbon accounting and monitoring methodologies set exacting conditions for their use.

Proxies

Project proponents may also use proxies to estimate GHG emissions. A proxy is any environmental variable that is highly correlated to a greenhouse gas emission rate. Proxies are not well developed for tidal wetlands and seagrasses but some methodologies allows project proponents to justify the use of any proxy to the validator. For example, carbon stock change is used as a proxy for CO_2 emissions from the soil organic carbon pool.

Field-collected data

These default factors may over or underestimate the net GHG benefits and therefore it is always advisable for projects to make direct, stock-change measurements, account for the baseline sediment organic carbon stock, allochthonous carbon, or the enhancement of GHG fluxes.

The carbon accounting and monitoring methodologies recommend measuring the soil organic carbon stock repeatedly over time to quantify sequestered organic carbon enhancement (i.e., stock change). Projects therefore must conduct periodic monitoring, as the sequestration rate of soil carbon within an ecosystem may increase in a non-linear fashion and fluctuate after the ecosystem reaches maturity. Repeated stock change measurements can also provide a more reliable approach on how remineralization, especially in the upper mixed layer of the sediment, affects this organic carbon to determine sequestration for offset-credit accounting.

Additionally, projects need to take into account whether mineral or organic soils are present. Projects with mineral soils need to determine a deduction from the soil carbon sequestration rate to account for allochthonous carbon, this is the carbon that come from outside ecosystem.

Table 2: Examples of default emission factors from IPPC and values reported from the literature, modelling and field data.

Description	Value	Comments	Source of data or Reference
Annual CO_2 emission factor from the soil organic carbon pool at tidal marshes	1.46 t C ha^{-1} yr^{-1}	Default value for tidal marsh only be applied to areas with a crown cover of at least 50 percent	VCS Methodology VM0033
Annual emission factor associated with rewetting of seagrass on mineral soils at initiation of vegetation reestablishment	-0.43 t C ha^{-1} yr^{-1}	Based on two studies of *Posidonia oceanica*	IPCC Methodology Report (Equation 4.7, 2013 IPCC Wetlands Supplement)
Annual emission factor associated with rewetting of tidal marsh on aggregated organic and mineral soils at initiation of vegetation reestablishment	-0.91 t C ha^{-1} yr^{-1}	Tidal marsh of aggregated organic and mineral soils	IPCC Methodology Report (Equation 4.7, 2013 IPCC Wetlands Supplement)
Annual emission factor associated with saltmarsh on mineral soils at initiation of vegetation reestablishment	-6.64 tCO_2 ha^{-1} yr^{-1} (1.81 t C ha^{-1} yr^{-1})	Field based (Andalucía, Spain): Mid marsh revegetation area (1 site)	32
Annual emission factor associated with rewetting of tidal marsh on aggregated organic and mineral soils at initiation of vegetation reestablishment	-0.81 tCO_2 ha^{-1} yr^{-1} (0.22 t C ha^{-1} yr^{-1})	Field based (Andalucía, Spain): Re-wetted salt pan (1 site)	32
Annual emission factor associated with seagrass on mineral soils at initiation of vegetation reestablishment	-5.19 tCO_2 ha^{-1} yr^{-1} (1.41 t C ha^{-1} yr^{-1})	Field based (Andalucía, Spain): *Posidonia oceanica* seagrass meadow in recolonization phase (2 sites)	22
Annual emission factor associated with rewetting of seagrass on mineral soils at initiation of vegetation reestablishment	-0.21 t C ha^{-1} yr^{-1} 0.42 t C ha^{-1} yr^{-1}	Published: *Zostera marina* replanting meadow in Virginia, U.S.A. Range after 10 and 15 years respectively	109
Annual emission factor associated with regeneration of tidal marshes on mineral soils	-10.1 tCO_2 ha^{-1} yr^{-1} (2.75 t C ha^{-1} yr^{-1})	Average model upon different disturbance	110
Annual emission factor associated with regeneration of seagrass on mineral soils	-2–4 tCO_2 ha^{-1} yr^{-1} (0.54-1.09 t C ha^{-1} yr^{-1})	Average model upon different disturbance	110

Accounting CH_4 and N_2O emissions from soil under the project

The emission of these GHG can be measured and accounted different, depending on the conditions of the methodology. In general they consider:

- Published values, if such data exist.
- Default values– for CH_4 provided for tidal wetlands with a salinity low point or average greater than 18 ppt. For N_2O, may only be used when there are no published values available and when the project area does not receive hydrologically direct inputs from a point or non-point source of nitrogen. Seagrasses do not need to account for nitrous oxide emissions.
- In lower salinity marshes, accounting options for methane can use models and proxies if available while for nitrous oxide is only relevant on those circumstances of high direct nitrogen inputs.
- Field collected data using gas flux techniques, like the static chamber method. The static chamber method consists in the installation of a chamber above ground, that traps the emitted gases within. Several samples are taken from the chamber at known times and the increasing concentration in GHG of the samples comparing vegetated and cleared bare plots is used to calculate the GHG (CH_4 and N_2O) released by the soil. A more detailed description of gas flux techniques can be found at the Coastal Blue Carbon Manual from the Blue Carbon Initiative [75].

Cumulative, enhanced CH_4 and N_2O emissions attributable to the project intervention are estimated by multiplying the average enhanced (i.e., net) fluxes (g m^{-2} yr^{-1}) by area over time.

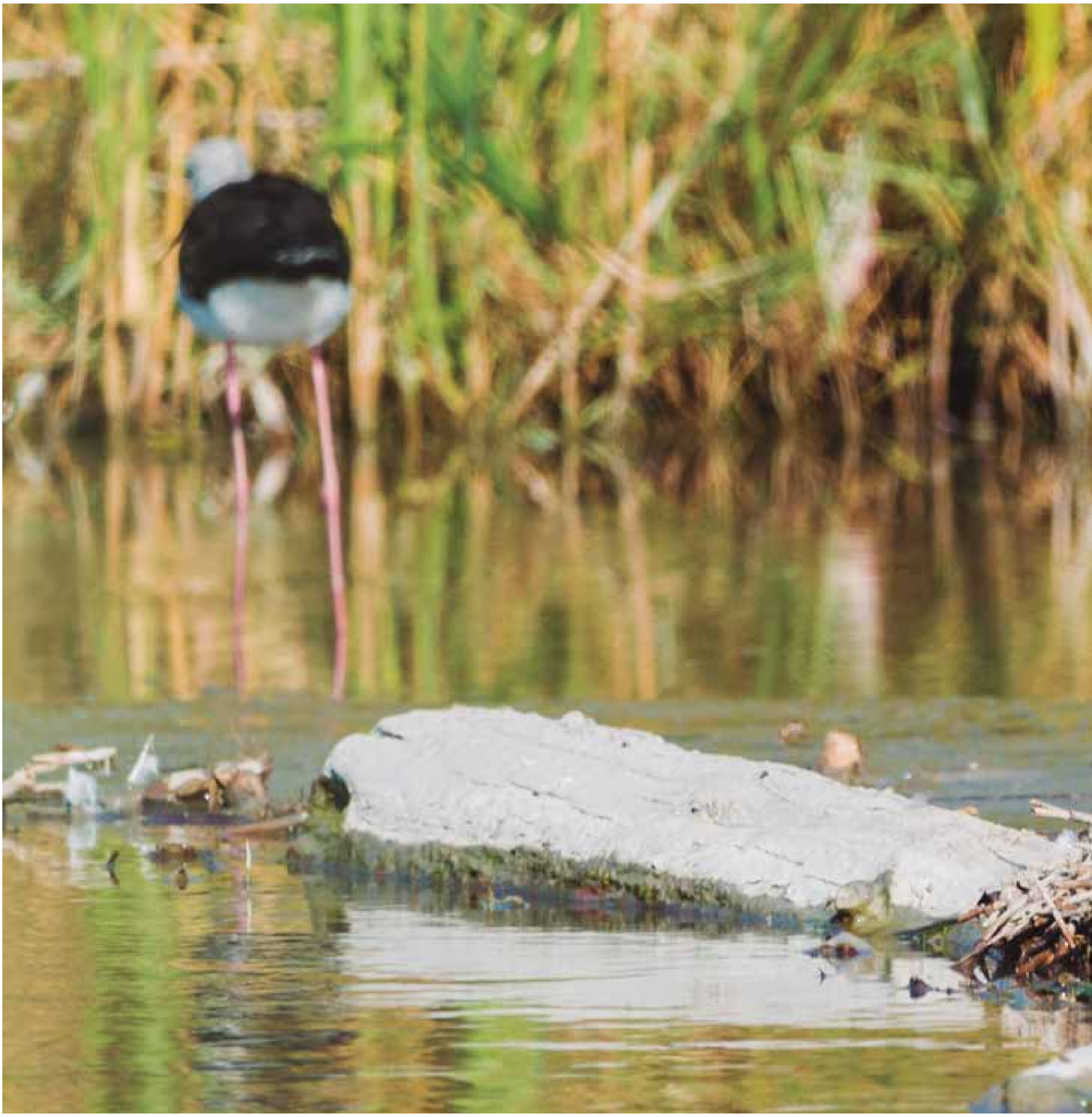
Project emissions from fossil fuel use and other actions

In addition, project scenario emissions also need to account for changes in biomass of vegetation and CO_2 emissions from fuel usage, e.g., where machinery use for earth moving activities is significant in blue carbon restoration and for any burning of vegetation that may occur during the project implementation.

The Net GHG Emission Reduction and Removals

The Net GHG (NER_{RWE}) will result from the differences between the baseline emissions and the project emissions, counting also leakages.

CHAPTER 8:
BLUE CARBON ECOSYSTEM RESTORATION



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BLUE CARBON ECOSYSTEM RESTORATION

Ecosystem restoration is a powerful tool to recover those ecosystems that have been lost or destroyed, together with their ecosystem services. The carbon markets provide a source of income to finance the restoration of ecosystems that, as salt marshes or seagrass meadows, would promote removal of CO_2 from the atmosphere or avoid the emission of stored CO_2.

Restoration projects focusing on blue carbon services can be financed through the voluntary carbon markets where private companies choose to buy carbon credits on a voluntary basis, most often as a tool for corporate social responsibility. It will also be important that restoration projects are integrated as part of local climate-change adaptation-planning to preserve the carbon and other ecosystem benefits of these habitats.

The given definition of restoration implies the return to a past state of the ecosystem owing to the actions of a given programme [89]. Restoration may benefit an area, however, we need to take into account that a restoration activity may improve one ecosystem parameter while deteriorating another. Therefore, the possible trade-offs coming from restoration activities need to be taken into consideration in any a given set of interventions, as well as the objective of minimising decreases in any existing ecosystem service [89].

Collaborating with local communities provides a useful source of knowledge about the previous state of the ecosystem to be restored. Following the Global Natured-based Solutions Standard[28], is important during restoration projects that the needs and aspirations of local communities are taken into account when the project is designed, as they can assist in safeguarding the restored ecosystem. This requires dialogue with the local communities before the project preparation and while it is being implemented [90].

Mitigation
Decreasing or compensating the impact of some known activity; includes a variety of management options.

Rehabilitation
Improving, augmenting or enhancing a degraded or affected area.

Restoration
Returning an ecosystem from a disturbed or totally altered condition to a previously existing natural or altered condition.

Passive restoration: refers to those actions that, by removing the environmental stressors or source of degradation, allow the natural recovery of the ecosystem. Passive restoration relies on the ecosystem's resilience, its capacity to return to a past state after the disturbance has disappeared. An example of a passive restoration would be the implementation of management regulations banning anchoring over seagrass meadows, preventing new impacts and allowing the local seagrass species to recolonise the affected areas.

Active restoration: refers to those actions that directly intervene in ecosystem management to correct the degradation state. This approach is usually utilised when the ecosystem does not have the capacity to recover by itself after the environmental stressors have disappeared or when the natural recovery is slow. Examples of active restoration would be the revegetation of a seagrass meadow, the construction of foreshore - permeable fence or the addition of sediments to elevate the soil surface in salt marshes.

Creation
Establishment of a salt marsh or seagrass meadow on a site that is documented not to have supported that ecosystem in the recent past.

[28] Criterion 5: NbS are based on inclusive, transparent and empowering governance processes. IUCN NbS Standard.

CONCEPTUALISATION AND DEVELOPMENT OF A BLUE CARBON RESTORATION PROJECT

Here, a stepwise approach to conceptualising and developing a restoration programme in salt marshes or seagrass meadows is proposed (Fig. 34), summarising previously outlined approaches to coastal ecosystem restoration [89, 91, 92].

Define goals and objectives

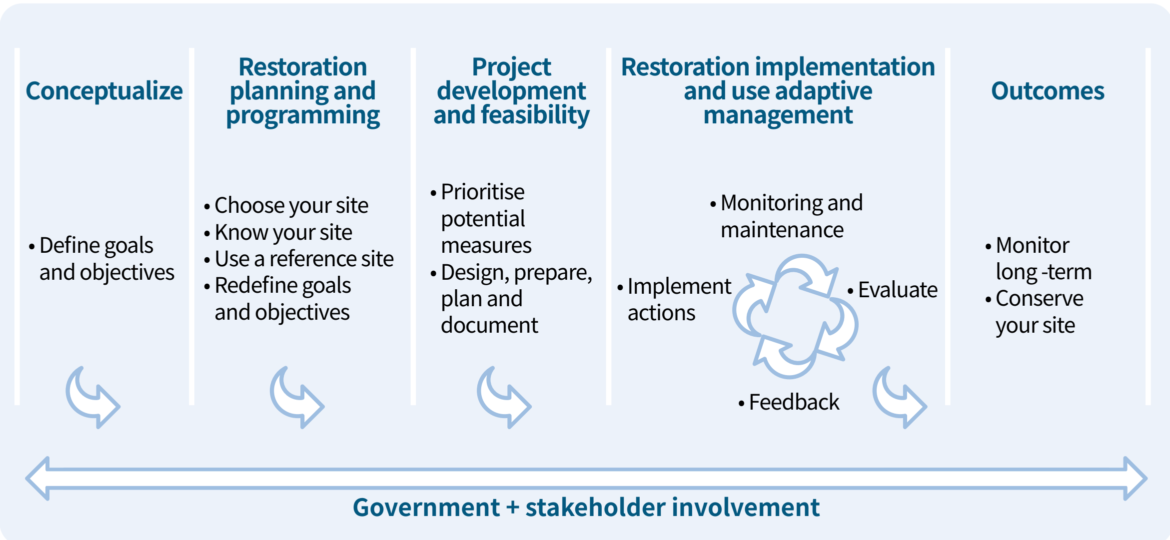
This would require the identification of the biological target (species or community) to be restored and familiarisation with its general biology and ecology. Also in scope here is the need to define the type of interventions and the ecosystem service that will be the focus. In the case of a blue carbon project, this should state and define which type of project it would be (see section above), including the objectives, long- and short-term goals and the success criteria.

Choose the restoration site

In some cases, the restoration location would already be known; in other cases, a landscape study would be needed to identify the best location to maximise success. Gathering information about the environmental conditions that affect the ecosystem service targeted in the proposed project is essential to find the most suitable location. Those areas where the cause of the ecosystem regression has disappeared, but no natural recuperation or a very slow recuperation has occurred, constitute interesting areas for active restoration projects, as the cause of the ecosystem's decline must be removed if the project is to be successful.

In seagrass meadow restoration, an ideal site to maximise restoration success would be a sheltered area with sufficient light, close to and at a similar depth to the donor meadow [93]. The bigger the area in which the project's intervention takes place, the higher the rate of success, as any negative effect of local variability would only partially affect the project [93, 94]. Poor site selection is often mentioned as a cause for restoration failure [95].

Figure 34: Schematic timeline for planning, implementing and conducting restoration project activities.



Know the project site

In this step, information about the current and past states of the chosen site is gathered. The key stakeholders need to be identified as well as legal requirements and responsibilities.

Use a reference site

A reference site is a less-degraded seagrass meadow or salt marsh in the same area, with similar environmental conditions, that can function as an indicator of how the ecosystem would be without or with less disturbance. This would allow for a better definition of the goals, project targets and tasks.

Redefine goals and objectives

The information gathered should be used to re-evaluate the viability of the project´s goals and to provide specific targets and tasks derived from its objectives.

Use adaptive management

No matter how detailed the initial information collection is, there will always be unforeseen events and consequences or new information available. Adaptive management means the continuous re-evaluation of the project to incorporate any new information or events.

Prioritisation of potential measures

When several techniques can be implemented, the following prioritisation is recommended: passive restoration > restoration with soft materials (soft engineering) > restoration with hard materials (hard engineering).

Accordingly, ecosystem-friendly alternatives that rely on some combination of natural or living materials, less common than traditional engineering approaches (i.e. hard-built infrastructure for coastal defence structures), can have high potential for private investment and work towards an approach of nature-based infrastructure or hybrid infrastructure.

Design, prepare, plan and document

This step integrates the information collected in the previous steps and ends with the preparation of an activity plan, including which techniques are suitable for the site, success indicators, a monitoring plan, and the required documentation. A cost-benefit analysis of the results would provide a realistic estimate of the funding needed, including the cost of a monitoring programme to test restoration success. A peer review of the project is recommended to ensure that the design matches scientific requirements, decreasing the probability of failure [95].

Involve stakeholders and licensing authorities

Collaboration with stakeholders and local authorities facilitates the obtaining of legal permission. Moreover, the more involved they are, the higher the probability of success in implementing the project. Local communities can provide invaluable information for the project as well as help to manage the restored ecosystem.

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Abandoned saltpans are potential sites for wetland restoration.

Restoration implementation and use adaptive management

Implement

This is the phase were the restoration actions are executed. All measurements of previous states of the ecosystem would be performed before the implementation. It is important to know what monitoring tasks are to be performed so that any necessary structure or task can be implemented during this phase.

Monitor long-term

The monitoring phase allows the impact and success of the project to be tested. It is possible that, after the implementation phase, corrections need to be done, like replanting seeds or digging new channels, as the goals of the project have not been reached. The monitoring programme would allow such a need to be identified. Monitoring programmes, for example every 5-10 years, are mandatory in blue carbon projects to be able to prove additionality.

Conserve the project site

Long-term that can also include new or updating existing regulations or legal frameworks (e.g. MPAs), is often needed to ensure that the site is functioning properly and that it does not return to a degraded state once the restoration activity has finished.

Evaluate measure of success

Clear restoration objectives allow for a measure of restoration success, as well as informs how to adaptively manage restoration to improve outcomes. Monitoring is used to determine whether the restoration activities are having the desired habitat response where the success might beyond the initial restoration objectives.

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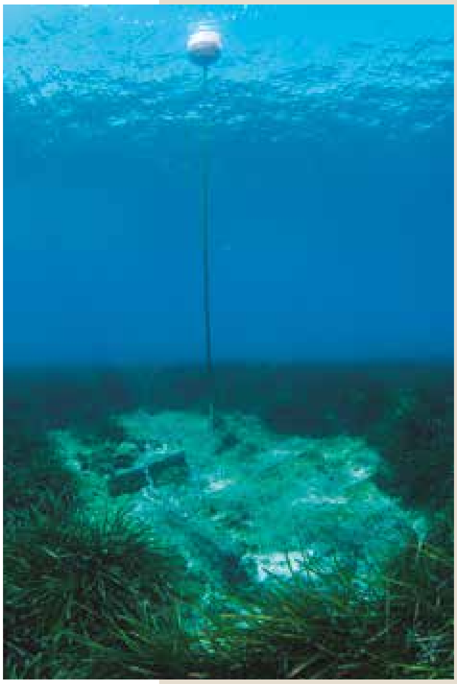

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Evaluation of a blue carbon restoration project in Agua Amarga, Cabo de Gata Nijar Natural Park, Andalusia, Spain

This protected area hosts one of the largest seagrass meadows in the Andalusia region. It is often visited by recreational small boats, particularly during the summer season.

Major damage to seagrasses seems to be caused by the use of homemade concrete block anchors with chains that break easily, as well as by the dragging of anchors and scraping of anchor chains along the bottom, as boats swing back and forth. This generates degradation of the seagrass and GHG emissions that increase over time. The study involved looking at:

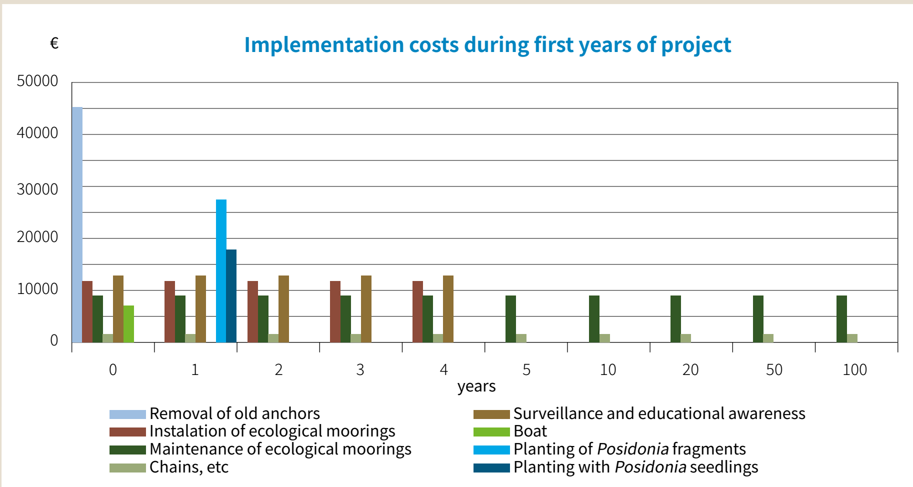
- Costs associated with the initial restoration activity (removal of concrete block anchors, installation of ecological moorings, replanting Posidonia with cuttings and seeds);
- Costs associated with carbon crediting and verification; and
- Costs associated with long-term management (maintenance and surveillance of ecological moorings, awareness education).

Information available for the area included data on sediment accretion rates, coverage, carbon stocks and carbon sequestration in the first metre of sediment in seagrass areas, with depth, as well as stocks and sequestration in other areas under degradation by mechanical action.

The exercise concluded with the assessment of the use of carbon markets. While the implementation of this type of project provides climate mitigation benefits, these interventions are better suited to non-carbon market incentives where private companies and funding mechanisms could invest in their restoration.

Reference: IUCN (2021). Viability study, Life Bluenatura

Figure 35: Assessment of implementation costs of a blue carbon restoration project in 2020, Almeria, Spain. Source: IUCN.



SEAGRASS MEADOW RESTORATION

Seagrass restoration is a rapidly maturing discipline, and despite the major gaps that still remain, a variety of tools and techniques have recently been developed that will improve the efficiency, cost-effectiveness, and scalability of restoration programmes, including those that could be part of blue carbon-financed projects [90].

Passive seagrass restoration is usually related to the restriction of damaging activities like high impact fisheries, anchoring of boats, or improvement of water quality through removal of sewage outfalls and agricultural run-off to tackle eutrophication or sand aggregate extractions. Therefore, stopping the cause of the impact and allowing the ecosystem to recover by itself via blue carbon projects could be valuable activities [10]. Introduction of legislation to protect ecologically important carbon sink habitats can also have potential as blue carbon projects.

The capacity of seagrass ecosystem restoration is high in fast-growing species, and for those with significant seed banks, but scarce in slow-growing species.

Unlike passive restoration, which ultimately relies on natural recolonisation, the most common efforts for **active seagrass restoration** are the revegetation of degraded or bare areas that could take place alongside other restoration actions focused on the management of threats and pressures in an ecosystem. This might include efforts such as the physical planting of seagrasses, distribution or planting of seagrass seeds, or coastal engineering to modify sediment and/or hydrodynamic regimes.

Revegetation projects proposing physical planting of seagrasses as one of these alternatives for restoration efforts have often been discarded due to high implementation costs and the failure of past restorations. However, recent attempts and methodologies had yielded positive results that allow us to more effectively identify opportunities for blue carbon projects that could facilitate the recovery of seagrass meadows today [4]. A revegetation project would involve using diverse techniques such as the transplant of seagrass shoots, seedlings or rhizome fragments (known as transplanting units), the dispersal of seeds to promote the development of a new seagrass meadow or coastal sediment, or hydrodynamic modifications to enhance the settlement of seagrass seeds, propagules or fragments.

Restoration project planting rhizome fragments of seagrass *Posidonia oceanica* at Pollenca Bay, Mallorca. Marine forest project funded by Red Electrica, Spain.

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Cymodocea nodosa seedlings.

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Posidonia oceanica seedlings.

Fast-Growing VS Slow-Growing Seagrass Species

Seagrasses represent a second colonisation of marine environments by terrestrial plants. Although they have developed a similar adaptation to marine life, there is a wide variability in life and reproductive strategies among them. From an ecosystem-management point of view, two groups can be identified, slow- and fast-growing species [97].

FAST-GROWING SPECIES are also known as colonising or opportunistic species. They quickly colonise areas where the environmental setting is favourable for seagrass growth and are the first seagrasses to appear after a degradation. They produce large quantities of seeds compared to slow-growing seagrasses. These are the species that benefit most from passive restoration strategies. Revegetation efforts with fast-growing seagrasses usually rely on seed dispersion. In Europe, the most extensive fast-growing genera is *Zostera,* distributed along the Atlantic coast and the Baltic Sea, followed by *Cymodocea*, very abundant in the Mediterranean Sea.

SLOW-GROWING SPECIES are those that form the most persistent meadows, have the highest productivity, and hold the largest carbon stocks. These species have a very low growth rate and a very small or no seedbank. The passive restoration of slow-growing meadows is difficult due to the low colonisation rate of these species. Usually, passive and active restoration techniques need to be combined. Revegetation projects with these species are usually based on the transplant of shoots, rhizomes or seedlings. The most common species in Europe is *Posidonia oceanica,* known as the seagrass species with the highest carbon stocks [38].

ACTIVE RESTORATION: COLLECTION OF TRANSPLANT UNITS

Seagrass restoration experiences have developed from small-scale pilot studies to large-scale transplantation trials, using a variety of techniques involving both manual and mechanical planting and a wide range of anchoring methods [90].

Transplant units can be seagrass seedlings, shoots or rhizome fragments. Commonly, they are obtained from an existing seagrass meadow known as the donor meadow. The choosing of the donor meadow is an important consideration, as this may influence the survival rate of the transplant units. The more similar the environmental characteristics of the donor meadow to the area to be restored, the higher the survival expectations, as the local seagrasses would be adapted to those conditions. For this reason, it is recommended to obtain the transplanting units from a nearby meadow at the same depth range [93]. This also minimises the need to handle the transplanting units as well as the time between collecting and transplanting, increasing the survival rate of transplants.

However, transplant unit collection has an impact on the donor meadow, which in the case of slow-growing species may offset the benefits of the restoration project.

Recently, both indoor and in situ small aquaculture systems have been tested to germinate and grow seagrass plants to a size where transplanting was possible, suppressing the need to collect transplanting units from an existing meadow [90, 98]. Only a few attempts have been undertaken so far, but the results obtained are promising.

Other source of transplanting units can be using seagrass wrack, often accumulated on beaches or in the marine waters of the shoreline. Both seeds obtained from wrack and storm-generated rhizome fragments have been successfully used as transplanting units [90], the latter being particularly interesting for *Posidonia oceanica* revegetation [98].

Here, the distribution of the transplant units in the area to be restored also influences success probability. Restoration plots with a higher seagrass density have higher survival rates due to the beneficial positive feedback among plants from the same area. On the other hand, the higher the number of restoration plots, the higher the chance of success as the risk of localised disturbances affecting a high number of the plots is minimised [93]. Thus, a high density within the plot and a high number of plots would always be advisable, aiming for a balance between the number of available transplanting units and the size of the area to be restored.

Manual collection of *Posidonia oceanica* adrift fragments.

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Production of *Posidonia oceanica* seedlings from beach-cast fruits.

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Revegetation techniques

Seagrass revegetation of an empty or degraded area can be done using seeds, fragments of living rhizomes or seedlings, however, there is evidence that seedlings are less effective as a transplanting unit [8]. There is no technique that would work in every project and the use of one or another would depend on the biological target and the selected site. Seed-based techniques are recommended in restoration of fast-growing species [97]. Their use in slow-growing species is less efficient, due to the low number of seeds produced by those species and the long time needed for the seedlings to grow. Nevertheless, the combination of transplanting and seed-based techniques has been reported to achieve good results in slow-growing species [99].

The main advantage of seed-based techniques is that they improve the genetic diversity of the population, increasing the resilience of the restored ecosystem [100].

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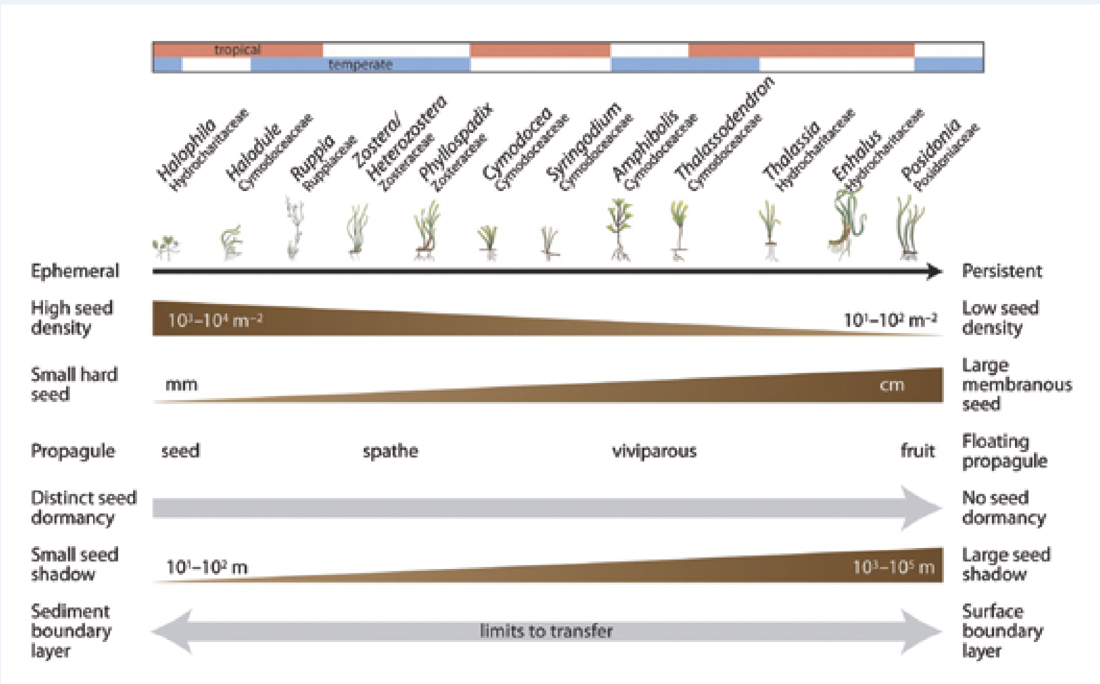
Posidonia oceanica fruits.

Reproductive characteristics of tropical and temperate seagrasses. Gary *et al.*, 2012 [108]



Seed-based techniques:

- **Fall broadcast seeding:** this methods consists of the free dispersion of seeds by hand or with mechanical dispersion methods [17].

- **Buoy-deployed seeding:** collection of mature reproductive shoots that are suspended in a mesh above the restoration area using buoys. This method can be deployed over large areas, ensures high genetic diversity, and facilitates the participation of citizens in the programme, thus also promoting environmental awareness and restoration efforts [102]. However, the suspended seagrasses are susceptible to grazing, lowering the available number of seeds. The recruitment effectiveness of this method is low and has only been tested for *Zostera marina* [90, 101].

- **Dispenser injection seeding:** with this technique, seeds are mixed with sediments and injected into the substratum with a modified sealant gun. The sediment is collected near the restoration area and sieved to obtain a fine-grained substrate. This method is especially useful for areas with strong currents, however, it has only been tested for *Zostera marina* seeds and is more labour-intensive than other techniques [90].

Buoy-deployed seeding.

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Dispenser injection seeding.

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Posidonia oceanica seedling plantings within “Bosque marino de Red Eléctrica project” Mallorca, Spain

2018
4 plots: 40x40 cm
16 seedlings
in each plot

SURVIVORSHIP:
2019, 55 ± 14 %
2020, 55 ± 14%

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2019 and 2020
9 plots: 40x40 cm
1/32/64 seedlings
in each plot

SURVIVORSHIP:
2020, 42 ± 23 %

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Transplant techniques:

A wide range of anchoring methods, including the use of staples, frames, iron nails or weights have been used. These experiences, particularly from those that revolved around restoration efforts of *Posidonia oceanica,* with low seed production, indicate that rhizome fragments showed a higher survival rate than seedlings. They are many variables that can play an important role in the rooting process and in the performance of a transplant (e.g. substrate, techniques, water dynamics, etc.). This also can be explained by the movement of tools used due to water dynamics, which may destabilise the rooting process. [93].

Despite significant losses of transplanted areas, concrete frames as weights have given positive results on large scales and in the long run on sand seabeds [114]. Other methods investigated with *Posidonia oceanica* on matte are giving encouraging results but they were used on smaller surfaces or monitored so far over a short time span and are still being evaluated. Furthermore, spontaneous colonization of *Posidonia oceanica* on seabed consolidated with stones in some sites monitored over the long term have shown positive results.

The use of rhizome fragments generated by the storm is a possibility but gives less guarantees[29].

Artificial seagrasses, biodegradable matte (or matrix) and biodegradable pots have also been used in seagrass restoration to increase the survival rates of planted meadows, especially in exposed sites, by lowering the hydrodynamic forces, stabilising the sediment grain size or preventing grazing [90].

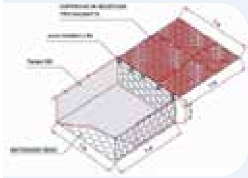
[29] http://www.lifeseposso.eu

Transplant techniques
(project Life SEPOSSO)

Spontaneous colonization
SUBSTRATE: rock

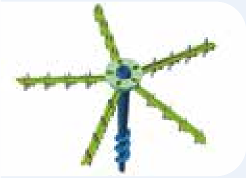
Cement frames
SUBSTRATE: sand

Mattresses
SUBSTRATE: sand

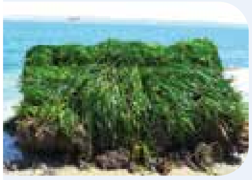


Mats
SUBSTRATE: matte

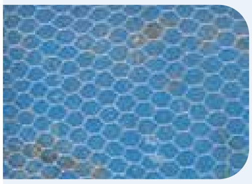
Degradable modules (star)
SUBSTRATE: matte



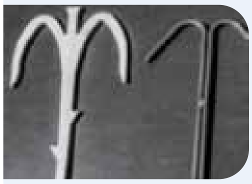
Clods
SUBSTRATE: sand



Metal mesh
SUBSTRATE: matte



Pickets
SUBSTRATE: matte



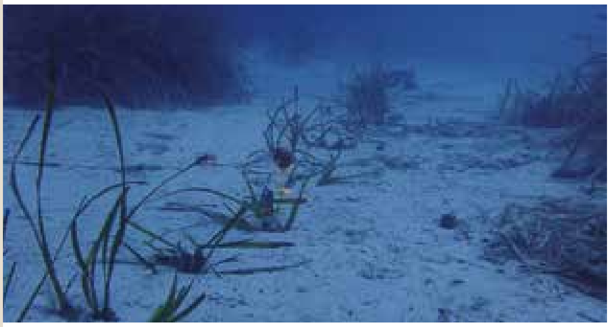
Seagrass restoration experiences

Revegetation of a *Posidonia oceanica* meadow disturbed by the laying of power lines

The installation of power lines between two main islands of the Balearic archipelago, Spain, disturbed a *Posidonia oceanica* meadow, leaving long trails of uncovered seabed. The promoting company financed a test planting to asess the feasibility of restoring the affected area.

The transplanting units were rhizome fragments naturally detached from the meadow and beach-cast fruits cultured in seawater tanks. Thus, the collection of transplanting units did not have a negative impact on donor meadows. Rhizome fragments and seedlings were anchored to the sediment. This approach obtained high survival rates, in the short-term (<1 year) [98].

Source: Red Eléctrica de España, Instituto Mediterráneo de Estudios Avanzados, (CSIC-UIB).



© RED ELÉCTRICA DE ESPAÑA E IMEDEA (CSIC-UIB)

Planted fragments of *Posidonia oceanica* rhizomes.

© RED ELÉCTRICA DE ESPAÑA E IMEDEA (CSIC-UIB)

Revegetation of 2 ha of a degraded *Posidonia oceanica* meadow

Two hectares of degraded *Posidonia oceanica* meadow were revegetated in the Pollença Bay (Mallorca), the first attempt of a *Posidonia oceanica* revegetation of that size.

The transplanting units were rhizome fragments naturally detached from the meadow that were anchored to the substrate. Two years after planting the survival rate was higher than 90%. The sheltered conditions of the area enable the meadow to survive storm events. However, the long-term success of the restoration has not yet been tested [98, 99].

Source: Red Eléctrica de España, Instituto Mediterráneo de Estudios Avanzados, Conselleria de Medi Ambient I Territori (Illes Balears) and Aeródromo Militar de Pollença.

COASTAL WETLAND RESTORATION

Restoration efforts for coastal wetlands in general may include proper management of existing marshes, introduction of legislation to protect ecologically important habitats, reduction of intense development along the coast, and restoration of damaged marshes. Preserving adjacent lowlands will also allow for salt marshes to adapt and migrate landward to survive rising seas.

Today, restoration techniques for coastal wetlands that include salt marshes and mudflats are more advanced than for other marine or estuarine habitat types. As previously mentioned, it is important to carefully consider in the preparation of blue carbon projects how to prioritise the selection of salt marsh restoration sites (e.g. ownership, hydrologic restrictions, presence of invasive plant species, history of dredged material or other fill placement, adjacent land use, local communities' concerns) as well as to evaluate the alternatives that offer the best chance of achieving the greatest outputs.

Solutions to restore these ecosystems can be directed towards passive restoration of degraded wetlands by targeting the source of the degradation, like preventing over-grazing or reducing the influx of nutrients from sewage, agricultural run-off and industrial waste. This would in turn restore the environmental conditions needed for salt marsh vegetation to settle. In atlantic marshes, grazing (at low density) can enhance carbon stocks because of vegetation set backs. In other cases, a passive restoration may not be possible, or the natural recovery capacity of the ecosystem may be very low, so more active restoration efforts would be needed.

Some management techniques have proved successful in maintaining or enhancing habitat use by wildlife in several cases. The water quality, salinity and hydrology requirements of different fish and wildlife species vary, and therefore management techniques applied to coastal wetlands to increase or enhance habitat for one species may have adverse impacts on others.

Additional actions to restore erosion at coastal marshes.

Placement of permeable wooden dams to increase sedimentation or prevent erosion. Case study estuarine marsh Wadden Sea, The Netherlands.

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Active restoration

A range of coastal wetland restoration and creation activities can provide net GHG benefits as well as helping to stabilise shorelines, mitigate damage to natural marshes and mudflats, and revegetate destroyed salt marshes and biodiversity. Best practices for salt marsh restoration include [89, 92, 103, 104].

Restoring natural hydrology and tidal morphology (elevation, slope and substrate)

As many marshes and mudflats have been drained, the reestablishment of tidal hydrodynamics is a critical first step in the restoration process. Drained organic soils continue to emit CO_2 until either the water table rises to near the surface of the soil or the stock of carbon is depleted. Removal of manmade barriers, such as dykes, dams and tide gates, or the development of new tidal channels are solutions used to restore the influence of the sea and freshwater in an area, increasing the water table and marsh surface elevation.

This will support a diversity of native salt marsh plants and animals and allow the natural flushing of nutrients across the marshland as well as the increase of carbon sequestration.

However, restoring the tidal influence in areas that have suffered subsidence effects may result in too much flooding time and can transform high marsh areas into mid or low marsh areas, and even to unvegetated tidal flats [92]. Therefore, it is recommended that restoration of the hydrologic conditions of an area should be preceded by evaluation of whether any substrate elevation or installation of water-level controls is required.

In other areas, where the degree of tidal flooding is sufficient, or where removal of water control structures or dykes is not feasible, restoration may focus primarily on replanting with native vegetation to accelerate natural recovery.

Restoring salinity conditions (reducing CH_4 emissions)

Salinity influences methane emissions from salt marshes: in dyked, impounded, drained and tidally-restricted salt marshes, substantial methane (CH_4) and CO_2 emission reductions can be achieved through the restoration of disconnected saline tidal flows.

Some coastal wetlands have blockage or restriction of tidal flows, through installation of dykes or tide gates, as a common method to protect coastal infrastructure; having been drained in the past for farming, mosquito control or development; or having had their water table raised or managed to reduce salinity, for aquaculture, roads or rice production, for example. As a result, they have become freshened and flooded due to retention of freshwater drainage from the watershed.

Increasing influence of the sea through tidal restoration in salt marshes, by removing tide gates and other flow restriction devices, will result in avoided methane emissions, providing further complementarities relative to enhanced CO_2 sequestration in other land-use-based climate change interventions, due to key aspects that result in rapid, substantial, and sustained reduction.

Improving wastewater and stormwater management

The management of stormwater can reduce the nutrients entering salt marshes from urban development (e.g. sewer systems) and rainwater runoff that contributes to unwanted algal blooms and pollution. This can be achieved by reducing the volume and frequency of stormwater runoff and increasing the quality of stormwater before it is discharged to downstream waterways and coastal wetlands. This can in turn improve water quality for salt marshes and seagrass meadows.

Removal of dredged material from salt marshes and restoration of soils

Drainage of salt marshes promotes the compaction of their soils, and if the tidal influence is later restored, the area may be flooded as the soil elevation is lower than before the drainage took place. Therefore, the direct addition of sediments or the promotion of their natural arrival is needed. On the other hand, the quality of the soil may not be adequate to sustain the vegetal community and nutrients or organic matter may need to be added.

Increasing sediment supply by removing dams or raising soil surface with dredged material in some other areas are potential activities to enhance carbon sequestration.

Planting/revegetation

If restoration does not result in natural revegetation, it may be necessary to plant propagules and plants to facilitate recovery, establishing local vegetal communities after restoring hydrology and soil condition. It is important to consider that revegetation not only recovers biodiversity but also influences the restoration of ecosystem services. Plants will generate changes in topography, sedimentation, oxygen or gas exchange carbon storage that ultimately will support the recovery of provisioning services (e.g. hydrological dynamics), regulating services (e.g. climate regulation, soil fertility and erosion) or supporting services (e.g. provision of terrestrial habitat).

To ensure a successful plant colonisation it may be necessary to control erosion, add nutrients, or establish fast growing species as 'foundation species or ecosystem engineers' while the slow growing species colonise the area. Furthermore, it is necessary to monitor the development of the vegetal community in the restored area to remove any invasive species, ensure diversity of salt marsh species and help sustain a healthy marsh, and to control the impact of grazing animals.

Recent advances in transplant designs draws on engineering knowledge [106, 107], as awareness and representation of local conditions can increase success in restoration programmes at landscape level. The use for example of biodegradable structures can for specific conditions assist the establishment of vegetation patches for transplanting, ameliorate hydrodynamic energy from waves and flow, and stabilize and accumulate sediment, resulting to enhance the survival and growth of small salt marsh grass and enable a faster restoration programme.

© CHRISTIAN KLEIN FROM PIXABAY

Carbon stock enhancement by maintaining a salt marsh at an intermediate state

Grazers can have a large impact on carbon sequestration in a salt marsh. They can alter carbon storage a) through above-ground biomass removal, (b) through alteration of biomass distribution towards the roots and/or (c) by changing soil abiotic conditions that affect decomposition and thereby carbon sequestration [105]. Managing livestock grazing can manage and enhance carbon stocks in mature marshes, particularly on marshes with fine-grained soils.

In the Netherlands, to keep coastal marshes in an intermediate state, grazers are being kept on the marsh system, including sheep, cattle, horses, and natural small grazers like geese. Grazing alone, and especially in old marshes, increased carbon content up to a kilogram of carbon per square metre.

Source: Community and Conservation Ecology Group, University of Groningen; Ecosystem Management Research Group, University of Antwerp; and The Spatial Ecology Group, Royal Netherlands Institute For Sea Research.

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Improvement of the hydrological connection of the salt marshes from the Ebro Delta

In the framework of a larger project to restore a coastal lagoon in the Ebro Delta, connectivity between dyke-isolated patches of salt marsh was restored, improving the resilience of the ecosystem to sea-level rise.

Source: Institut de Recerca i Tecnologia Agroalimentàries.

Evaluation of a blue carbon restoration project in Bay of Cadiz, Andalusia, Spain.

This area of 216 ha borders the Bay of Cádiz Natural Park. The proposed project area has a high state of degradation and altered tidal regime, arising from previous works to modify the terrain profile and land-use changes for the development of agriculture crops.

The actions envisaged in the project were aimed at improving the environmental conditions and optimising the conditions for carbon sequestration and reducing emissions of other GHG by restoring natural hydrology and tidal morphology of the area. This would promote the natural restoration of salt marsh plants and animals, and allow the natural flushing of nutrients across the marshland accompanied by an increase in carbon sequestration. GHG emissions and sequestration were assessed in terms of CO_2, CH_4 and N_2O taking into account also the above-ground biomass.

Here we show the evolution of the estimated emissions accumulated over time for the base scenario, the project scenario, derived from the execution of the actions, and the corresponding reduction in emissions.

Source: IUCN (2021). Viability Study, Life Bluenatura.

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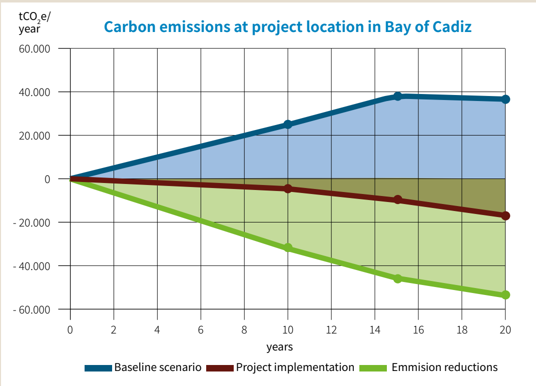
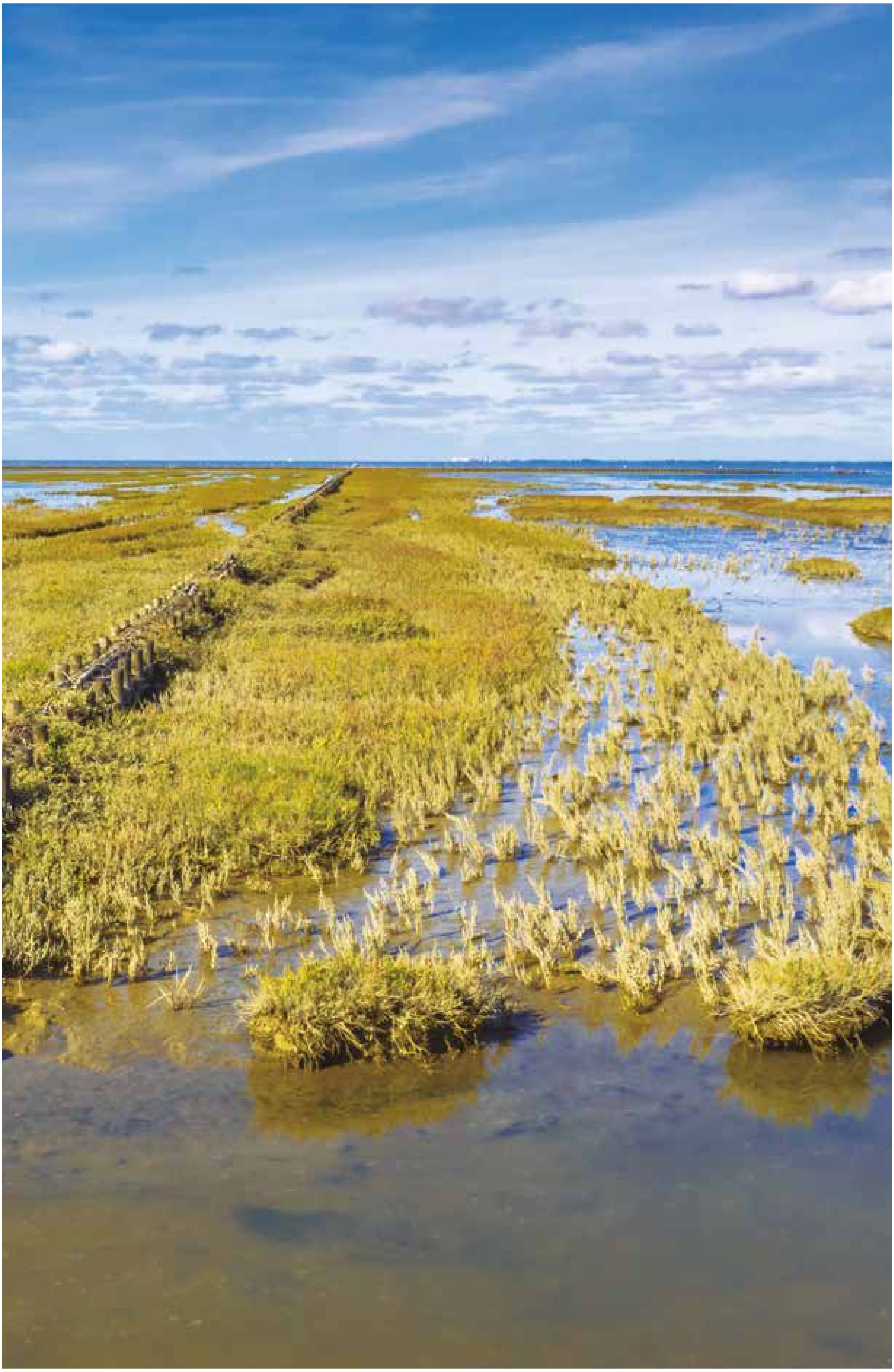


Figure 36: Blue Carbon potential is determined by the difference between the baseline scenario (when doing nothing) and the blue carbon project scenario (protection/enhancement).



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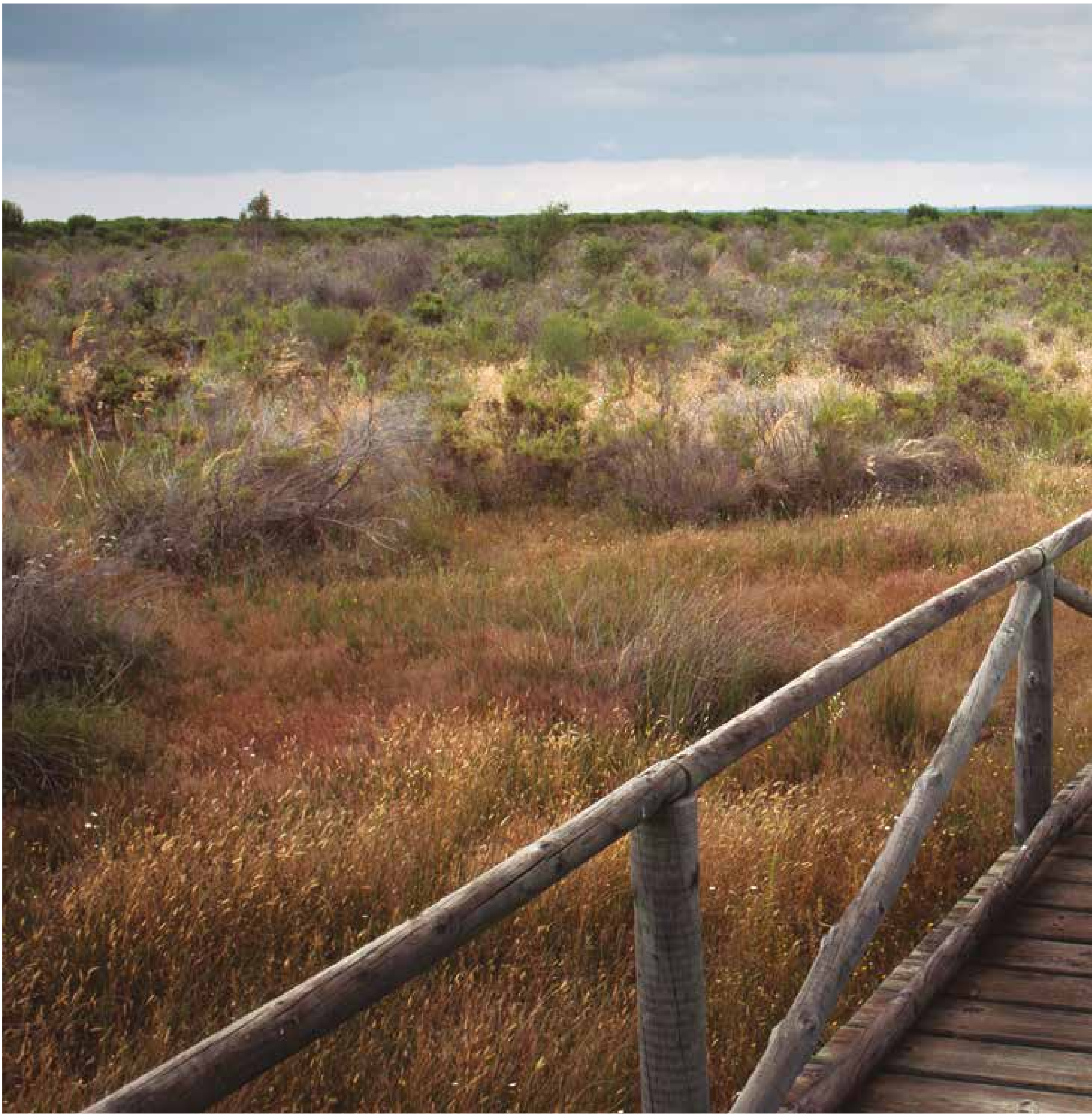
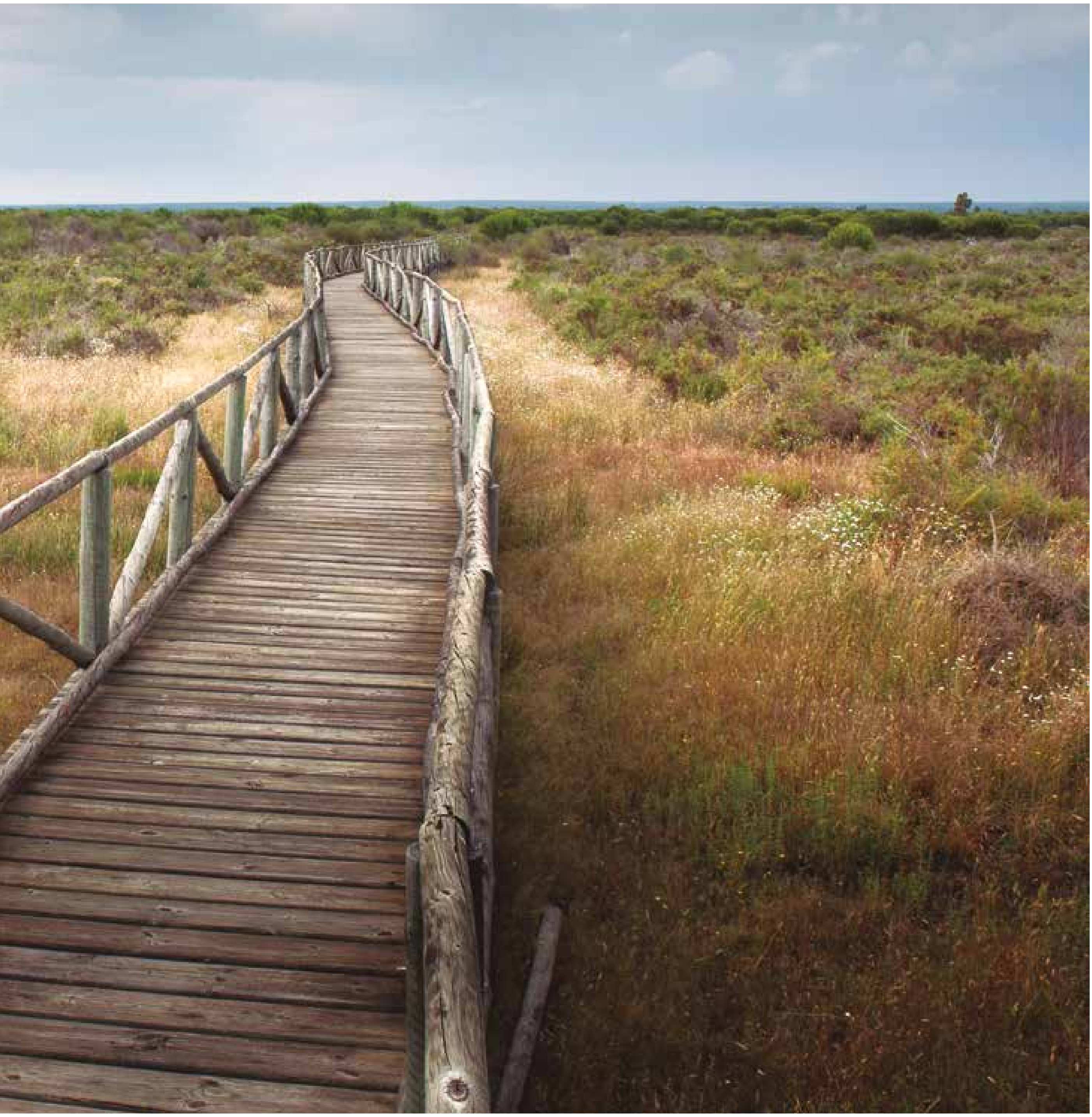
Protection of marsh habitat can be done (with high technical feasibility) by placing wooden dams along the eroding edge. The wooden dams will provide protection against wave energy and cause retention of sediment.This active restoration can prevent further erosion of the salt marsh.

CHAPTER 9:
FUTURE BLUE CARBON EFFORTS IN EUROPE AND THE MEDITERRANEAN





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FUTURE BLUE CARBON EFFORTS IN EUROPE AND THE MEDITERRANEAN

Nature-based Solutions, such as those that could be implemented in coastal blue carbon ecosystems, offer a way to build resilience to the consequences of warmer temperatures while helping to limit further temperature rises by acting as carbon sinks. Achieving the full potential of blue carbon ecosystems, however, requires improved protection measures and restoration, actions that will not only mitigate climate change but also increase other ecosystem services while delivering adaptation benefits. These works will contribute to the Paris Agreement and to the achievement of other international objectives in the 2030 Sustainable Development Agenda, such as the Sustainable Development Goals of Life Below Water (SDG14) and of course, Climate Action (SDG13).

Filling gaps in the knowledge would aid in developing effective policies and plans for protection and rehabilitation of blue carbon ecosystems. The enhancement of conservation and restoration efforts is very necessary to prevent further degradation, as ecosystems such as coastal wetlands and *Posidonia* seagrass meadows hold large standing carbon pools (previously sequestered and stored) that could be released to the atmosphere (e.g. in the form of CO_2 and CH_4), exacerbating the climate problem. Such efforts will avoid further emissions and mitigate the risks of future climate-related impacts.

Robust and efficient voluntary carbon markets can enable financing of these efforts and engage the private sector to take more ambitious steps towards compensating for its contribution to climate risk. So far, voluntary carbon offsets are more known outside Europe but they have the potential to be equally useful in the Mediterranean and European regions to upscale restoration and conservation efforts.

The range and diversity of organisations active on the voluntary carbon markets internationally is reflected in the diversity of motivations when buying carbon offsets. Organisations active on the voluntary carbon markets are looking for carbon offsets that fit their priorities, match their budget, and offer social and environmental benefits beyond the emission reductions (e.g. poverty alleviation, biodiversity conservation, etc.)[30]. Each carbon-offset buyer may have very specific requirements related to the type of impact that their own businesses generate.

As blue carbon ecosystems lie in the public domain in most countries, ownership of the schemes requires consultation with local stakeholders and government right from the start of project development to ensure that their interests are considered and that there is long-term commitment.

From a private investor perspective, the first demand of voluntary carbon-offset buyers is to be certain of the quantity and in some way the quality of the carbon credits they are acquiring. Convincing a company to pay for a product that seems to be intangible is certainly a challenge, which to date has only been overcome with the use of robust carbon quantification methods. In addition to verified carbon credits, companies frequently seek other types of social and environmental impact, such as the protection of biodiversity or the improvement in the quality of life of the communities in the area impacted by the projects.

The demand for voluntary carbon projects is still not particularly high but it is expected to grow (subject to the trajectory of the COVID-19 pandemic[31]) with the increased demand for Nature-based Solutions and Natural Climate

[30] Source: State of Voluntary Carbon Market 2016 (Forest Trends, 2016)
[31] https://www.environmental-finance.com/content/analysis/strong-growth-predicted-for-voluntary-carbon-market.html

Solutions projects. Prices for blue carbon projects will need to be adjusted based on a project costs so as to ensure project sustainability, and perhaps also quantifying the beyond-carbon benefits. This is particularly important given the additional costs associated with working in the marine environment.

In some cases, blue carbon projects will have substantial climate change mitigation benefits and therefore be strong candidates for entering volunteer carbon markets. But not all the projects could be financed by the carbon markets and some will be better suited to use non-carbon market incentives, uncertified schemes, or subsidies to change practices.

The recognition of the climate change mitigation and co-benefits impacts of coastal blue carbon ecosystems is timely; the challenge now is to build on these early successes and stimulate an increase in the scale and pace of their conservation and restoration.

GLOSSARY OF TERMS

Allowances:
Allowances are freely tradable units that are allocated to the regulated participants in an emissions trading system. Each participant in the emissions trading system must surrender an allowance for each tonne of CO_2e emitted.

Allochthonous carbon:
Carbon produced in one location, transported and deposited in another.

Autochthonous carbon:
Carbon produced and deposed in the same location. In the context of blue carbon systems, this type of carbon results from vegetation uptake of CO_2 from the ocean and/or the atmosphere that is converted for use by plant tissues and decomposes into ambient soil.

Brokers:
Brokers are matchmakers between buyers and sellers of carbon credits (they do not buy the credits themselves).

Coastal blue carbon:
The carbon stored in mangroves, salt marshes and seagrass meadows, within soil, living biomass and non-living biomass carbon pools. Coastal blue carbon is a subset of blue carbon that also includes *ocean blue carbon* that represents carbon stored in open ocean carbon pools.

Carbon Offset:
One carbon offset represents a quantity of greenhouse gas (GHG) emissions reductions, measured in units (metric tons) of carbon dioxide equivalent (CO_2e) that occur as a result of a discrete project. The emissions reductions from that project can be sold to enable the purchaser/owner to claim those GHG reductions as their own. These reductions can then be used to reduce, or offset, any GHG emissions for which the purchaser is responsible.

Carbon offset standard:
A standard that helps to ensure that carbon offset projects meet certain quality requirements, such as additionality and third party verification. Several offset standards exist within the voluntary and compliance carbon markets and each has a different set of requirements depending on its focus and scope.

Carbon sink or Carbon pool:
A reservoir of carbon. A system which has the capacity to absorb and stores more carbon from the atmosphere than it releases as carbon dioxides. Carbon pools include aboveground biomass, belowground biomass, litter, dead material and soils.

Carbon stock:
The absolute quantity of carbon held within a pool (e.g. wetland) at a specific time. The units of measurement are mass (e.g. tCO_2/ha).

Carbon sequestration:
The process of removing carbon from the atmosphere and depositing it in a reservoir.

Carbon sequestration rate (or flux:)
The transfer of carbon from one carbon pool (e.g. atmosphere) to another (e.g. wetland) in units of measurement of mass per unit area and time (e.g. $t\ C\ ha^{-1}\ yr^{-1}$).

Crediting Mechanism:
A crediting mechanism allows the remuneration of emission reductions by issuing tradable offset credits for emission reductions actually achieved.

Emission reductions (carbon credits):
Represent the prevention of one tonne of carbon dioxide equivalent (tCO_2e) from entering the atmosphere, also known as carbon credits, which are used for carbon offsetting. They can include:

— Verified Emission Reductions (VERs) for voluntary climate action
— Labels for Certified Emission Reductions (CERs) for meeting compliance targets.

GHG inventory:
An accounting of GHG emitted to, or removed from, the atmosphere over a period of time.

Greenhouse gases (GHGs):
The atmospheric gases responsible for causing global warming and climate change. The major GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_20). Less prevalent —but very powerful— greenhouse gases are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Mitigation:
In the context of climate change, a human intervention to reduce the sources or enhance the sinks of greenhouse gases.

Nationally Determined Contributions (NDCs):
A term used under the United Nations Framework Convention on Climate Change (UNFCCC) whereby a country that has joined the Paris Agreement outlines its plans for reducing its emissions. Some countries' NDCs also address how they will adapt to climate change impacts, and what support they need from, or will provide to, other countries to adopt low-carbon pathways and to build climate resilience. According to Article 4 paragraph 2 of the Paris Agreement, each Party shall prepare, communicate and maintain successive NDCs that it intends to achieve.

Registries:
Most offsets transacted in voluntary markets are tracked by registries. Registries provide an extra level of accountability and assurance regarding issuance, holding, and acquisition of credits. Registries do not actively market offset credits, but buyers may become aware of credits available for sale through a registry.

Soil organic carbon:
The carbon component of soil organic matter. The amount of soil organic matter depends upon soil texture, drainage, climate, vegetation and historical and current land use.

Verified emission reductions (VERs):
A Verified Emissions Reduction is a single unit (one tonne) of CO_2 equivalent reduction captured as a carbon credit for use as a commodity within the voluntary carbon market.

Voluntary Carbon Market:
The voluntary carbon market is a market for the voluntary compensation of greenhouse gas emissions. It enables companies and individuals to voluntarily offset their carbon footprint.

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IUCN is working with many partners and members on sustainable coastal management around the world. Some of the key initiatives that have helped propel international action on blue carbon are below:

The Blue Carbon Initiative (BCI) is leading technical and policy analysis to inform adequate methodological and policy development.

The International Partnership on Blue Carbon (IPBC) is bringing together various governments and stakeholders to share lessons learned on national carbon accounting and leveraging project implementation.

The Blue Natural Capital Financing Facility (BNCFF) is working with project developers, businesses and investors to advance bankable blue endeavours with clearer conservation and climate impacts.

Save our mangroves now! (SOMN!) is conducting carbon assessments and enhancing awareness and political action to conserve mangroves.

The Blue Solutions Initiative is developing and establishing a global platform to collate, share and generate knowledge as well as to build capacity for sustainable management and equitable governance of our blue planet, including climate adaptation and mitigation measures and projects.

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