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The contribution of coastal blue carbon ecosystems to climate change mitigation and adaptation

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Headlines

- Thriving marine coastal ecosystems which store carbon, known as blue carbon ecosystems (BCEs), are considered a significant sink of carbon within the discussion of climate change mitigation.
- Our calculations, consistent with findings of the Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC), find that BCEs have the potential to annually capture 0.5%-2% of the ~10 gigatons of carbon emitted globally each year. This range reflects the current coverage of BCEs and their potential for restoration, based on a subset of available data.
- The net carbon currently stored in these ecosystems below or above ground is of the order of a few years' worth of global net emissions (i.e. a few tens of gigatons of carbon).
- Therefore, BCEs need to be considered alongside a range of approaches to reduce the effects of climate change. Importantly, BCEs also provide a range of invaluable economic, health and ecological benefits to coastal communities e.g. protection against flooding induced by extreme sea level rise, and hosting the food web essential to sustainable fishing.
- BCEs are at risk worldwide for a variety of reasons including damage from sea level rise, population growth and deforestation if not effectively managed.
- Restoration projects could increase the geographic area covered by these ecosystems from 100 million to 170 million hectares. Successful long-term restoration relies on good management which can also help improve monitoring of carbon sequestration.

Introduction

The average global temperature has already risen by around 1°C and sea level by around 20cm since 1880, which is 200 times faster than at any time in human history, and the effects are being felt around the world. Immediate, ambitious and coordinated action is required to prevent further human-induced climate change. If human activities continue to increase the amount of greenhouse gases, including carbon dioxide, in the atmosphere, the consequences include an increasing severity of droughts, fires, and floods, collapsing animal and plant life, the complete melting of Arctic sea-ice in the summer, sea level rising over one metre by 2100, and major reductions in agricultural productivity[1–3].

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Drastically reducing the emission of greenhouse gases from transport, heating, energy and agriculture as rapidly as possible, together with removing a significant proportion of carbon dioxide from the atmosphere, is vital to limit further warming and irreversible damage. This paper explores the potential for blue carbon ecosystems (BCEs) to contribute to limiting anthropogenic climate change (mitigation) and helping to cope with the impacts of climate change (adaptation) and makes recommendations for policy approaches.

Climate change policy

The United Nations Framework Convention on Climate Change (UNFCCC), was established in 1992 as the basis for countries to work together to avoid dangerous climate change, with annual summits called the 'Conference of the Parties' (COP) to develop specific approaches. The Paris Agreement, negotiated at COP21 in 2015 and signed by 175 parties, included the international commitment to limit global warming to "well below 2°C" above the pre-industrial average temperature, whilst also pursuing efforts to limit warming to 1.5°C. Countries aimed to achieve these goals through their Nationally Determined Contributions (NDCs), a set of actions that each country is capable of, and committed to, achieving, and which increase in ambition over time. Article 7 of the Paris Agreement also provides a global goal to adapt to climate change, to contribute to sustainable development and effective adaptation to global temperature rise and provide periodic communications about adapting to climate change to the UNFCCC.

The 2018 Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C, considered possible ways that warming could be limited to this amount, and what would be the associated consequences. In that year, it was estimated that a further 158 GtC (gigatons of carbon) is likely to cause this degree of warming – that estimate is known as the 'carbon budget'[i]. In 2019, approximately 11 GtC accumulated globally. If this rate continues, the carbon budget will be used-up within 15 years. The IPCC 1.5°C report concludes that, in addition to rapidly reducing the rate at which greenhouse gases are emitted, it is also necessary to remove and store carbon dioxide from the atmosphere to limit warming to 1.5°C[2]. This capture and storage may be achieved either by using natural processes – relying on the ability of plants to capture carbon (in the form of carbon dioxide) and, through photosynthesis, incorporate it into their biological matter (biomass) – or by developing and operating new technologies that perform an equivalent purpose.

BCEs and climate change policy

BCEs (see Box 1 & 2) can potentially limit global warming in two ways. Firstly, by protecting natural stores of carbon to prevent the release of existing stores of carbon dioxide, and secondly, by actions to increase the amount of carbon dioxide they capture from the atmosphere and store for the long term. However, there is currently limited understanding, policy or legislation to support solutions in this area.

Recent reports that explore natural ways to capture carbon dioxide from the atmosphere focus on ecosystems on land[4,5], and international climate agreements give relatively little consideration to ocean and coastal ecosystems, despite their potential[6]. UNFCCC parties are asked to be "aware of the role and importance of terrestrial (land) and marine (ocean) ecosystems of sinks and reservoirs of greenhouse gases" and "promote and cooperate in the conservation... of coastal and marine ecosystems"[7]; however, ocean ecosystems are not specifically considered in the Paris Agreement[8].

Box 1: Defining blue carbon ecosystems

The community of plants, animals and microbes that exchange and store carbon in a coastal marine ecosystem (see Figure 1) is defined as a blue carbon ecosystem (BCE) in this work[3,14,15].

Mangrove forests, salt marshes and seagrass meadows are the best-known BCEs[14]; each with varying ability to capture carbon dioxide, potential for restoration, and other benefits that they bring to society (known as 'co-benefits')[16]. Other coastal ecosystems, such as kelp forests and warm-water coral reefs, have also been considered as BCEs, and information on the latter is considered in this paper for comparison.

BCEs are amongst the most productive ecosystems on the planet, growing quickly and storing organic carbon in the biomass of living organisms, soil and sediments[17]. BCEs can 'lock in' high density carbon, with seagrass meadows accumulating this carbon up to a depth of 10 m in their sediments[18]. As a result of very low oxygen levels, there is very slow decomposition of organic carbon to carbon dioxide, resulting in long-term carbon storage[19] (Figure 2).

Carbon is stored within plant biomass for the short term (seasons to decades), while, if undisturbed, carbon can be stored in sediments over geological time scales (decades to millennia)[20]. Actions taken to either increase this storage or prevent its loss could therefore help to limit global warming[14]. When BCEs are lost (e.g. through coastal development), this can release a high proportion of the stored carbon[21]. Estimates for the global carbon store for mangroves are within the range of 4-20 GtC[22-24], while seagrass meadows estimates are between 4-8 GtC[25]. If these ecosystems were completely lost, the carbon released would equate to roughly two to three years' worth of current global emissions.

The loss of BCEs can also adversely impact water quality, fisheries and biodiversity and increase the vulnerability of coastal communities to damage by storms and coastal erosion. The preservation and restoration of coastal BCEs therefore provides both climatic and non-climatic benefits to society and the economy.

i The remaining carbon budget of approximately 158 GtC (in 2018) was associated with a 50% chance of limiting warming to 1.5°C (114 GtC, for a 66% chance).

In comparison, conservation and deforestation on land are directly covered in the Paris Agreement, through REDD+ (Reducing Emissions from Deforestation and forest Degradation)[8]. Furthermore, compared to 114 parties that plan to use land-based approaches (for both mitigation and adaptation) in meeting their NDCs, only 59 of 161 parties plan to use the ocean[9]. Of these, 19 parties plan on restoring and conserving mangrove forests and two parties opt for seagrass meadows[9].

Box 2: Blue carbon ecosystems

There are a range of BCEs, all have recently experienced significant levels of decline.

Mangrove forests

Mangrove plants are shrubs or small trees (genus Rhizophera) that have evolved to grow in saline conditions and are found at the interface between land and sea in the tropics and subtropics[26] (See Figure 1 for global distribution of blue carbon ecosystems). Mangroves are found in around 123 countries[27], where they currently cover around 140,000km^2 [28] and make up 1% of tropical forest area[22]. They are typically found in sheltered estuaries and riverbanks[29] as well as other coastal locations. The coverage of mangrove forests, as measured from aerial images, has declined by an estimated 20-35% since the 1980s[20,22,26-28].

Mangrove plants are well adapted to survive at the land-water interface. They have aerial roots that help the plants respire when they cannot access oxygen from the waterlogged soils, submerged roots that extract nutrients from seawater by ultrafiltration, and salt-excretion mechanisms.

Mangroves absorb carbon dioxide, converting it through photosynthesis into living biomass. As with all plants, mangroves release some carbon dioxide back into the atmosphere when they respire. Additionally, dead biomass accumulates in the waterlogged soil where, without oxygen, decomposition is extremely slow[29] and may take thousands of years[30]. Consequently, mangrove ecosystems have a higher below-ground/above-ground carbon mass ratio than terrestrial trees[29]. If the ground is not physically disturbed, mangrove forests provide a highly effective method of natural, long-term carbon capture and storage.

Seagrass meadows

Seagrasses grow in both temperate and tropical regions on all continents except Antarctica. There are over 70 species of seagrasses, all flowering plants, known as angiosperms, which have evolved to survive submerged in coastal waters at depths of 1-3m[31]. The highest diversity of seagrasses can be found in the Malay Archipelago and around the coast of Australia, with up to 14 species in some regions[32] (See Figure 1). However, since the first recording of seagrass in 1879 their distribution has decreased by around 30%[33].

Seagrass leaves usually draw carbon dioxide out of the atmosphere in a greater quantity than the plants need to survive[34]. As a result, they have high biomass in their roots and rhizomes which also helps to trap organic debris from elsewhere[35], accumulating carbon-rich sediment that is structurally-secured by their root systems[25].

Salt marshes

Salt marshes are distributed globally, in temperate and subtropical regions[36]; they occur in 99 countries, covering approximately 55,000 km^2 and make up 0.2% of coastal areas[37] (see Figure 1). These ecosystems thrive along protected shorelines, estuaries and saline lagoons and develop on the upper portion of intertidal mudflats after they have been colonised by sediment stabilising plants[38]. Tidal inundation – when water covers otherwise dry ground during high tides and storm surges – is critical for the formation of salt marshes at elevations between the mean high water levels of neap and spring tides[39] (Figure 2). This range of elevations results in high flora speciation and biodiversity[40-42]. It is estimated that global salt marsh area has decreased by at least 25% since the 1800s, with a current annual decline of 1-2%[20]. Some areas, such as the coastlines of China and Europe, have seen a reduction in salt marsh habitat of up to 50%[39].

Salt marshes draw carbon dioxide out of the atmosphere and convert it into biomass relatively rapidly compared with other plants[43]. Up to 98% of the carbon stored in this ecosystem is found below-ground[36]. The topology, flora and dense root systems effectively trap both locally-derived biomass and that washed in from elsewhere as well as stabilising the carbon-rich sediment[17,44,45]. Frequently submerged by tidal waters, very low oxygen levels result in extremely slow decomposition that favours the storage of carbon, but may increase the release of methane, into the atmosphere[20].

Coral reefs

Corals are marine invertebrates that live in colonies, where they form intricate calcium carbonate skeletons that build up into reefs in shallow waters. Coral reefs are distributed throughout tropical and subtropical oceans, covering around 284,000km^2, which is less than 0.1% of the total ocean[13] (see Figure 1). Despite this, coral reefs support an estimated 35% of all living ocean species[46]. It is believed that 19% of existing coral reefs have been permanently damaged and lost globally, and 16% are currently severely damaged[47].

Coral reef ecosystems both absorb carbon dioxide through photosynthesis and the dissolution of carbonate skeletons and release it through respiration and the building of coral skeletons[48]. The carbon source-sink behaviour of corals is set by the balance between these processes[48-49]. This balance can vary between reefs due to topography, physical and biological factors, human disturbance and other factors, and can vary also over time and space within individual reefs and habitats[50]. Some situations mean coral reefs can absorb more carbon dioxide than they release[49], for that reason, they are included here as a BCE, although that grouping is not widely accepted[15,20,51].

BCEs and climate change

There is some evidence that BCEs (see Box 1) could help to limit global warming using similar mechanisms to ecosystems on land[3]. The IPCC's Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) assessed the role of mangrove forests, seagrass meadows and salt marshes for this purpose, through protection and restoration[3]. Importantly, 150 countries are home to at least one of these BCEs[52]. However, based on other studies[53,54] and considerations regarding feasibility, SROCC concluded that the scope for reducing greenhouse gas emissions by restoring BCEs was relatively modest; with an upper limit of 0.5% – 2.0% of current carbon emissions[3,55].

One of the main reasons BCEs are less widely used in NDCs than ecosystems on land is because it is much more difficult to measure the amount of carbon they store (i.e. carbon stocks), particularly below ground, and how those stores are changing; i.e. the carbon fluxes into and out of the system[56,57]. There are also crucial uncertainties over associated emissions of the greenhouse gases methane and nitrous oxide[58,59], and the likely losses of carbon in response to future warming and sea level rise. The limited number of studies of these processes show greatly varying results, depending on location[3]; a greater understanding of the role of BCEs in the climate system is therefore needed.

Moreover, a consistent mechanism to finance BCE restoration projects is lacking. Some projects have used a voluntary carbon market where polluters purchase credits from projects to offset their emissions, while others have operated through UNFCCC compliance market schemes such as REDD+ and the Clean Development Mechanism (CDM)[56]. Wider use of REDD+ in terrestrial settings has been criticised for potentially disrupting local peoples' livelihoods, causing food insecurity, corruption introduced by powerful stakeholders, the illegal acquisition of land and the introduction of monoculture plantations[60]. In addition, other issues need addressing, such as land use change in areas adjacent to those where the carbon stores are protected (indirect land use change or carbon leakage), poor forest protection leading to plants dying and releasing carbon back into the atmosphere (permanence) and accurate accounting of the carbon stored. Smaller community-based projects may be better funded and credited through voluntary carbon markets, as UNFCCC projects may have a minimum threshold required for carbon credits and have more rigorous and costly carbon accounting processes.

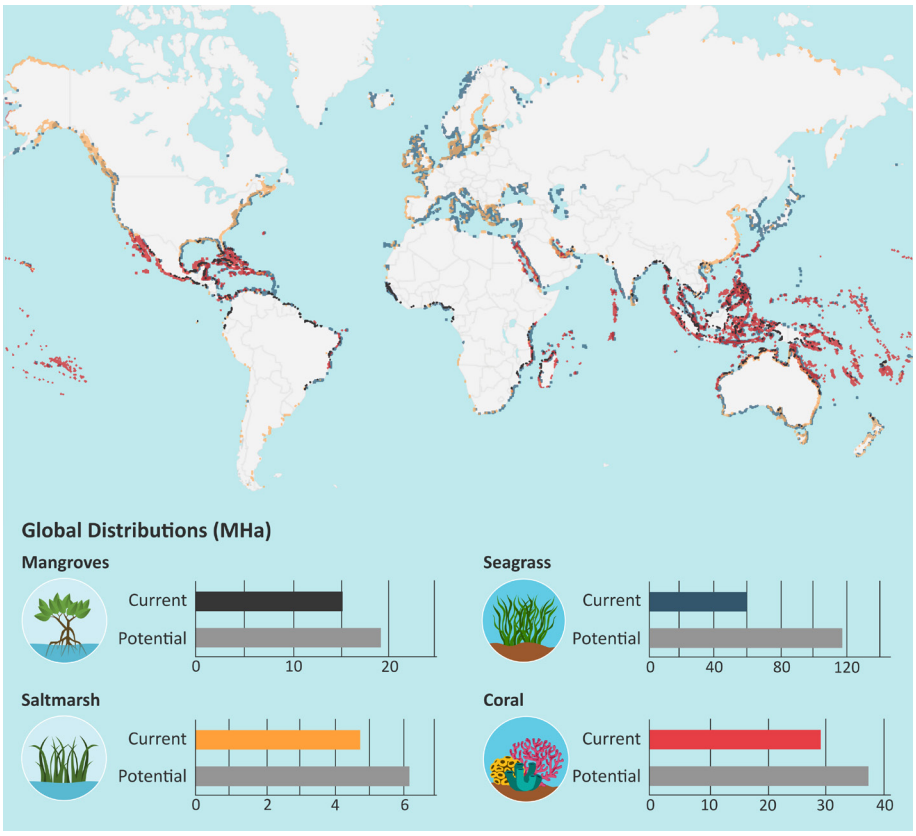

Figure 1: Map showing the global distribution of blue carbon ecosystems: mangrove forests (black)[10], seagrass meadows (navy)[11], salt marshes (yellow)[12] and coral reefs (red)[13]. Bar charts indicate the current estimated global area and potential global estimated area after restoration covered by each ecosystem in Mega hectares (MHa). For up to date distributions of blue carbon ecosystems, refer to https://data.unep-wcmc.org/. This image masks the potential for several of these carbon stores to co-exist in one geographical location, which is often the case.

Carbon storage potential of blue carbon ecosystems

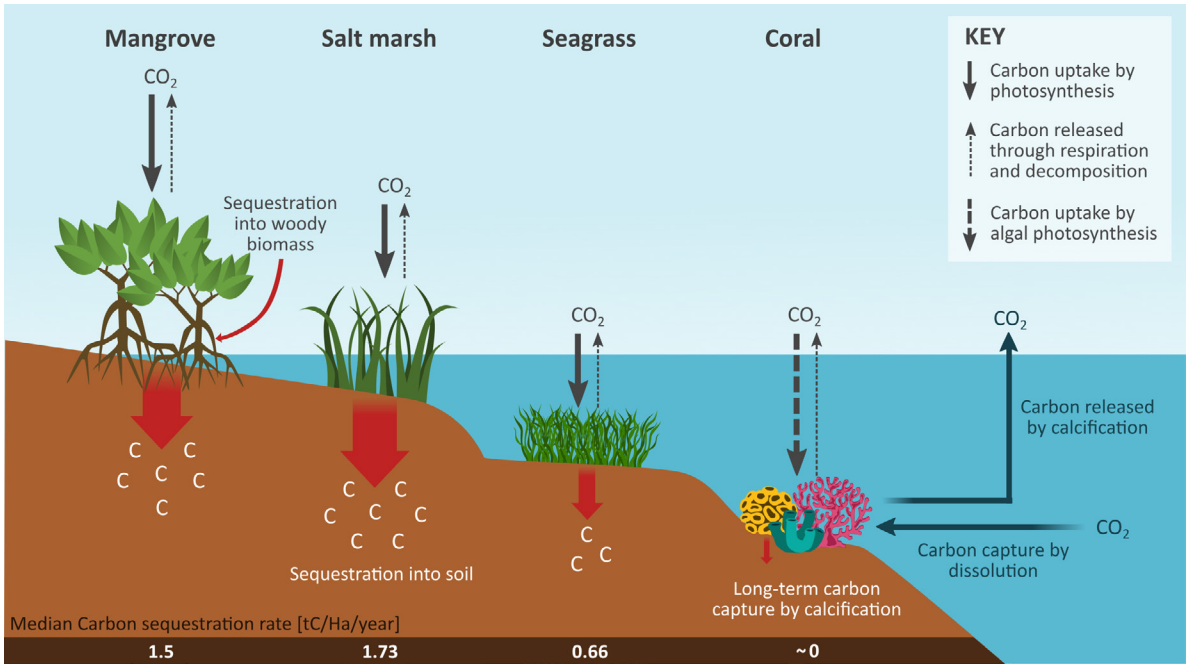

Figure 2: Mechanisms and quantity of carbon uptake by blue carbon ecosystems. Carbon dioxide (CO_2) is removed from the atmosphere via photosynthesis and converted into organic compounds. Some of the carbon these compounds contain is released back to the atmosphere via plant respiration; the rest is either stored or re-cycled in other ecosystem components, in living and dead biological matter above or below ground.

How much carbon could be stored by the restoration of BCEs?

Our own recent analyses[ii] suggest that BCEs could help to limit global warming by removing up to 0.12 GtC per year from the atmosphere if their global extent was restored as per Figure 3. Note that methane and nitrogen oxides have not been accounted for in this work. This is equivalent to roughly 1.3 times the UK's total annual carbon emissions[61]. Restored seagrasses would contribute approximately 80% of this total increase in carbon storage, mainly due to their large theoretical restoration area when compared to the other BCEs[iii]. The practicality of delivering the full carbon storage potential in these theoretical areas is a question for research and practitioners. Coral reefs have not been included in this calculation, since it seems unlikely that they can contribute significantly. Importantly, as with all BCE estimates, this calculation is based on limited data which are affected by a number of factors that still need exploration (see Box 3 which explores a number of factors that affect the accuracy of estimates that are made in this paper).

The IPCC SROCC gives two potential values for the additional amount of carbon that BCE restoration could remove from the atmosphere: 0.05 GtC per year for cost-effective restoration and up to 0.2 GtC as the theoretical maximum[3]. This range represents uncertainty concerning the extent of historical BCE sites that can be restored due to coastal urban development and pollution, which in some cases would be costly (and socially unacceptable) to restore.

To meet the more ambitious target of the Paris Agreement and limit global warming to 1.5°C along with continuing global economic growth, some modelling scenarios indicate the need to remove 10 GtC from the atmosphere each year by the middle of the century[2,5]. BCE restoration may contribute towards this target, but that action will need to be implemented alongside a range of other methods for climate mitigation (both removals and emission reductions, to achieve net zero). Comparisons to more established methods (e.g. reforestation) need to be prioritised; global datasets need to be improved; issues of ecosystem stability (storage permanence) need to be investigated; and methods for reporting carbon stocks and greenhouse gas fluxes need to be standardised to provide more accurate estimates for policy makers (see Box 3).

ii A literature review was conducted to calculate the median global area (ha) for mangroves (29), seagrass (10), saltmarsh (7), and coral reefs (11) in addition to their potential for restoration (9, 2, 8 and 11 respectively). Numbers in brackets represent the numbers of estimates from the scientific literature, included in this analysis. This global area was then multiplied by a median carbon sequestration rate per hectare per year (tC ha-1 yr-1) that was collated from a subset of available data from mangroves (21), seagrass (20), saltmarshes (14) and coral reefs (2), to calculate a theoretical global uptake rate of carbon (tC yr-1) for each ecosystem once restored. This was not designed to be a comprehensive meta-analysis of all available estimates and no standardisation across methods was attempted. The global total presented is a combined value for each ecosystem discussed. See supplementary information attached.

iii The theoretical area identifies hypothetical potential before ecosystem losses.

Box 3: Considerations when calculating blue carbon uptake

In order to present the figures in this paper, several assumptions have been made, based on a wide range of background data from scientific literature, such as geographic area of BCEs and rates and current values of carbon storage.

Geographic coverage. Our data, especially the historic data, contains estimates calculated using different data collection methods. There are generally two methods to scale up to global estimates; one using published literature[63] and another modelling data using geographic information systems (GIS)[10,30]. Values from published literature vary across time and space[10,28,29]. Additionally, global scale mapping of ecosystems using remote sensing has only been achieved with high resolution since 2010, because of the associated costs and a lack of computing facilities[10]. Previous estimates of the geographic coverage of each BCE were inconsistent and unreliable because of the compilation of disparate and incompatible geospatial and statistical data sources[10,64]. For example, the most recent and largest estimate of global seagrass coverage was over twice the area of the previous largest estimation[65]. This was due to the use of a modelled distribution method as opposed to the previously used sampling. Accurate geographical data of BCEs is imperative to gain accurate global carbon stock estimates.

Restoration estimates. Our calculations make the wholly unrealistic assumption that all historic BCEs can hypothetically be restored to 'theoretical' levels. However, many locations are now unsuitable for restoration due to the rising sea level, coastal erosion and increased urban development. For example, since 1996, 0.2% of mangrove forest area has been converted to urban landscapes and 16% of the ecosystem has been permanently lost due to sea level changes[30].

The paper also does not consider any areas that might accommodate new BCEs, either naturally or through novel engineering approaches.

Many studies assume that factors causing the original loss (e.g. coastal pollution, conversion to agriculture and aquaculture, and hydrodynamic changes) can be properly rectified. Furthermore, they do not take account of the effects of future climate change. Climate change could jeopardise or, in some cases, enhance restoration efforts. Areas of potential BCE restoration may be lost due to both warming and rising sea level, especially due to impacts expected in the global warming range of 1.5-2.0°C[3]. However, certain species (e.g. seagrass) may thrive in warmer conditions in some regions. Most restoration efforts are currently small in scale, not implemented to primarily enhance carbon sequestration and are often poorly planned or managed. This means that while values cited in this paper could be overestimated, with the correct management current BCE carbon sequestration could also potentially be enhanced.

The capacity to **capture and store carbon** varies across time and location because of several factors including temperature, light intensity, nutrient availability, salinity and tidal movement. For example, seagrass meadows of a single species have been measured to capture and store carbon three to four times faster at shallower depths of 2-4m than they do at 6-8m[66]. Moreover, methods of measuring this rate often vary, for example, sampling the carbon content of soil to different depths, giving different results[67]. Further, calculations often do not include post-depositional processes such a remineralisation and biomixing. Sampling methods need to be standardised and the environmental factors that promote carbon storage need to be better defined to provide more accurate global estimates and information to enhance restoration efforts.

Consideration should also be given to, and further research carried out on, other carbon dioxide removal methods.

Other proposed methods for large-scale removal of carbon dioxide from the atmosphere include: artificially enhanced weathering of rocks, whereby carbon dioxide reacts with finely-ground minerals and becomes stored in soils or the ocean; direct air capture and storage (DACS) technologies that chemically remove carbon dioxide from the atmosphere; and bioenergy with carbon capture and storage (BECCS), which stores underground the carbon dioxide captured from power plants burning biomass crops[62]. However, these alternatives also come with technological, environmental or socio-economic drawbacks that are not explored in this paper.

Figure 3 illustrates how much carbon could be removed from the atmosphere by a large-scale global campaign to restore BCEs. However, it is important to note that each of the input values had large uncertainty ranges, leading to high uncertainty in the figures shown (see Box 3).

For restoration projects to be effective and long lasting, it is necessary to carry out local and regional evaluation of the potential and actual amount of carbon stored. Such assessments should check the appropriateness of that approach in the local context as well as the carbon storage processes and this would improve the accuracy for estimates of the local and global restorable potential for each BCE.

Mobilising finance for blue carbon

The UNFCCC has developed international schemes whereby carbon dioxide that has been captured and stored by an ecosystem – such as a rainforest or a mangrove forest – can be quantified as a 'carbon credit' and bought by another party, supposedly cancelling out, or 'offsetting' the purchasers' emissions in other areas. Such schemes include REDD+ and the clean development mechanisms. REDD+, which was introduced in 2013, creates financial value for the carbon dioxide permanently stored in the forests of developing countries. Forest owners, or project developers can receive payments for reducing emissions from forested lands and investing in low carbon paths to sustainable development[68]. The CDM, which began in 2005, allowed carbon credits to be sold on the compliance market, allowing companies to buy credits to meet their international emission reduction commitments. This market allowed industrialised countries to invest in emission reduction projects in developing countries[69]. Even voluntary carbon markets, which sell credits to any buyers who wish to be more sustainable, can create the financial incentive required to reduce deforestation and promote the sustainable management of ecosystems. Such financial mechanisms will need to be adapted for BCE approaches.

Co-benefits of restoring BCEs

Beyond helping to limit global warming by reducing greenhouse gases in the atmosphere (climate change mitigation), restoring and protecting BCEs bring many well-documented social and economic benefits, as well as helping to adapt local communities to the growing effects of climate change (climate change adaptation).

A major co-benefit in many regions of the world is the protection from coastal erosion and flooding, which comes in two forms. Firstly, BCEs can act as a natural coastal defensive wall, reducing the velocity of water flowing inland and dissipating the energy of storm waves that threaten to inundate the land. BCEs can reduce wave heights by 35–71%[70], and seagrasses and corals are shown to reduce wave energy by up to 50% and 98% respectively[71-72]. Secondly, the tightly woven network of roots that are a feature of many BCE plants lock in soils and sediments, protecting them from the eroding action of waves by a factor of up to three[29,73-74]. By stabilising this sediment, it is estimated that mangrove forests could save $82 billion each year in flood damage costs[30]. As climate change causes the sea level to rise, the protective effect of BCEs from storms and flooding will become increasingly important, especially for densely populated coastal areas.

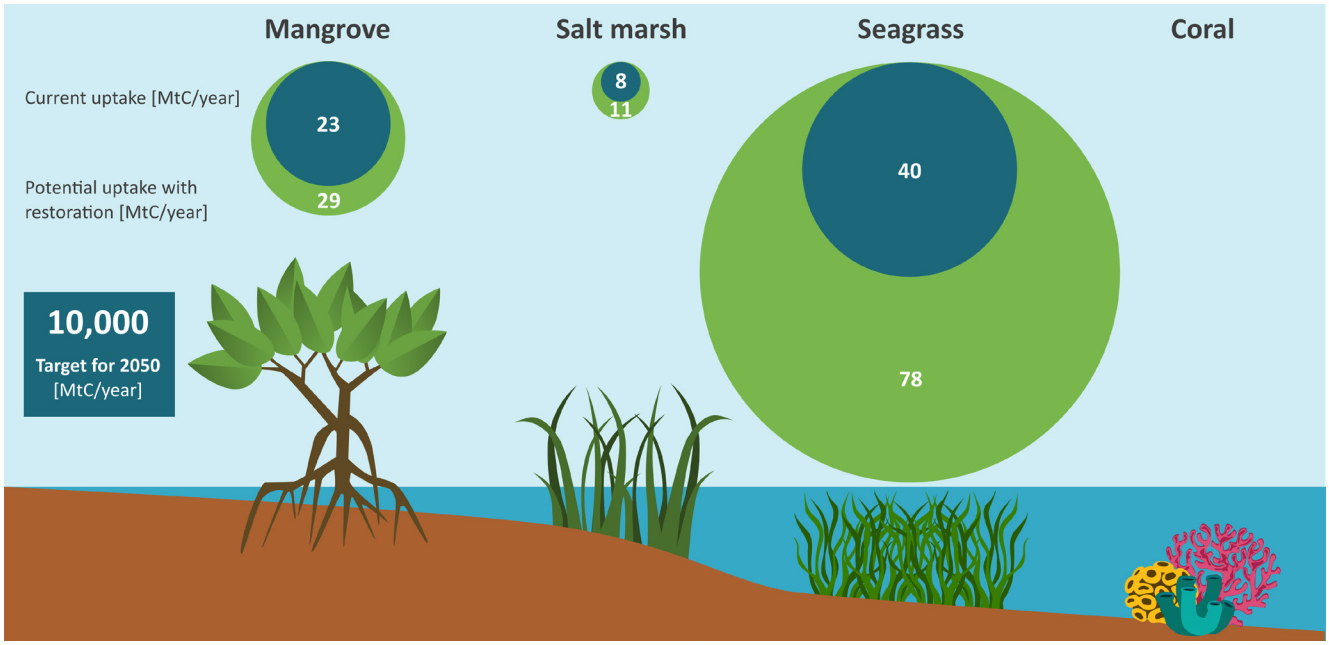

Figure 3: Annual median amount of carbon removed from the atmosphere by BCEs at present (blue) and following extensive restoration (green). 1MtC = 1,000,000 tonnes of carbon.

BCEs support exceptionally high biodiversity and provide habitats, nurseries and feeding grounds for aquatic life, providing great ecological benefits[29,74-75]. This is partly due to their ability to act as a natural filter of pollutants and so improving water quality[72]. BCEs offer the opportunity for ecotourism, often providing income that can surpass that from fisheries and promoting awareness for locals and visitors of the importance of these ecosystems. Mangrove forests alone contribute as much as $40-50 billion per year in benefits associated with fisheries, forestry and recreation[77].

The total economic value of BCEs can be as high as $34,000 per hectare per year with the global net worth of coral reefs[37], seagrass meadows and mangrove forests estimated at $0.6 trillion, $6.7 trillion and $2.9 trillion per year respectively. These benefits should be considered alongside the restoration cost of BCEs, and when selecting the most beneficial locations for restoration.

Summary for policymakers

BCEs have the potential to contribute to limiting climate change (mitigation) and adaptation to the impacts of climate change. This work has identified that BCE contribution to climate change mitigation through the anthropogenic carbon uptake needs to be implemented alongside a range of methods for removing carbon from the atmosphere and considered in the wider context of greenhouse gas fluxes. To enhance BCE carbon storage, global datasets, reporting methods and local management need to be improved. BCEs should not be considered only in the context of a primary sink of carbon. The restoration and preservation of BCEs can also provide a range of social, economic and environmental benefits, which can help to adapt to future climate change. The role of BCEs in sustainable fishing and protection against sea level rise are two significant examples.

In areas where habitat loss is currently a major issue the focus should be on the protection of BCE habitats to prevent further carbon emissions. In regions where ecosystems are not currently being destroyed, the focus should be on enhancing natural carbon capture, firstly through habitat restoration, and secondly through maximising carbon storage of existing systems.

The broader economic benefits of retaining BCEs, as well as the protection that they provide against climate change, amongst other hazards, are key drivers in choosing to restore BCEs. Detailed regional analysis of the monetary value that these ecosystems provide would provide further evidence to support the case for their restoration. This analysis should be conducted on local scales as the feasibility of restoration and magnitude of co-benefits will vary from location to location.

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