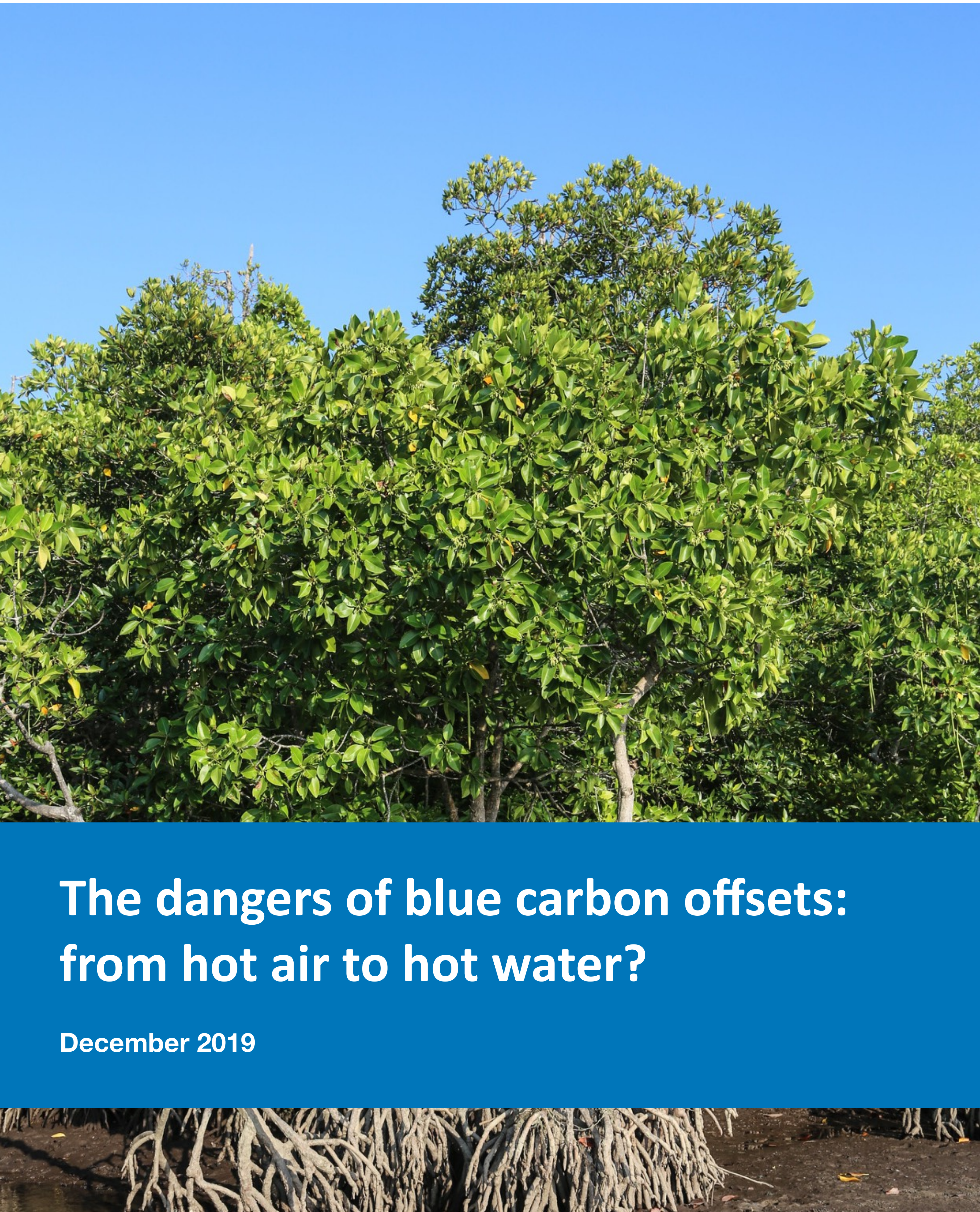

The dangers of blue carbon offsets: from hot air to hot water?

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Briefing by Climate Analytics

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Cover image
Mangroves in Banda Aceh, Indonesia
Photo by Mokhamad Edliadi/CIFOR

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The issue

As the interest in using nature-based solutions to mitigate climate change grows, 'blue carbon,' which means carbon sequestered in coastal ecosystems, is also garnering attention. A number of countries have proposed including blue carbon in their Nationally Determined Contributions (NDCs), and there is growing interest among some governments and fossil fuel companies in blue carbon as an offset mechanism. This briefing unpacks the key challenges and risks associated with the blue carbon concept by considering three key questions. What is the real potential of blue carbon as a mitigation measure? To what extent is carbon storage in coastal ecosystems threatened by current and future climate impacts? And is there a danger that focus on blue carbon could detract from reducing emissions from fossil fuel use?

Key messages

- Using blue carbon to achieve national mitigation targets risks diluting mitigation ambition in other sectors, which could jeopardise our ability to limit warming to 1.5°C. Blue carbon must not be a replacement for rapid emissions reductions in other sectors.

- The climate effects of carbon stored in natural ecosystems and carbon emissions from fossil fuels are not equivalent. This means any attempts to measure and set targets for carbon sequestration in coastal ecosystems should be kept separate from emissions targets in other sectors. Lessons from accounting for carbon flows in land use, land use change and forestry (LULUCF) have shown that integrating nature-based mitigation offsets under national mitigation targets creates loopholes, hot air, and measurement, reporting and verification (MRV) challenges.

- Under present reporting and accounting arrangements losses from extreme events and climatic disturbances do not have to be counted by governments as emissions. For blue carbon, this would mean that the losses of carbon from marine heatwaves, sea level rise extreme events or multiple stressors would not be recorded in national emissions accounts, even though the prior storage of carbon could have been counted as a sink towards climate targets. Recent die-back of coastal ecosystems during heatwaves (e.g. in Shark Bay, Australia) have illustrated how significant the losses of carbon can be.

- Focusing on the climate sequestration component of coastal ecosystems within a mitigation context is also problematic because their potential to reduce emissions and draw down CO2 from the atmosphere is highly uncertain and too small to be an effective mitigation strategy. The IPCC found that coastal 'blue carbon' ecosystems have a limited global sequestration potential of about 0.5% of present day emissions annually (SROCC, IPCC 2019).

- Ecosystem restoration may only provide benefits if global emissions remain low. The vulnerability of coastal ecosystems to climate change impacts means that the effectiveness with which they draw down carbon and the permanence of their carbon storage may be jeopardised under the levels of warming and sea level rise implied by the current set of emission reduction commitments (Nationally Determined Contributions or NDCs).

- According to the IPCC, exceeding 1.5°C would lead to the near-complete loss of tropical corals, and warming of 3°C or more – where current NDCs are taking us – would lead to high to very high risks for many coastal ecosystems (including seagrass, salt marshes and kelp forests) (SROCC IPCC 2019).

- It is essential to prevent the degradation of coastal ecosystems, but carbon sequestration is not necessarily the most valuable service these ecosystems provide. The wealth of potential co-benefits from coastal ecosystem conservation and restoration, beyond carbon sequestration, are justification enough for schemes to incentivise their protection. Additionally, there are substantial capacity constraints for the measurement of ecosystem-related carbon fluxes in many developing countries.

- In summary, the science is very clear: protecting coastal ecosystems and the valuable services they provide – including in adaptation – requires rapid emissions reductions in all sectors to limit warming to 1.5°C. High uncertainties and impermanence pose significant risks to the use of blue carbon removals as an offset for other emissions (e.g. natural gas emissions) remaining high, or their transfer in the Paris Agreement's market mechanisms. Treating nature-based mitigation as equivalent to any other form of mitigation could have dangerous consequences for the ecosystems that such measures would seek to protect.

What is blue carbon?

Blue carbon refers to the carbon sequestered in coastal ecosystems – namely mangroves, sea grasses and salt marshes[1]. Deforestation and degradation of mangroves and other coastal ecosystems is progressing at an alarming rate. According to the IPCC, "nearly 50% of coastal wetlands have been lost over the last 100 years, as a result of the combined effects of localised human pressures, sea level rise, warming and extreme climate events (*high confidence*)" (IPCC 2019).

Estimates of the total amount of carbon stored in these natural ecosystems globally are highly uncertain, as are estimates of the carbon sequestered each year through natural processes and the potential for blue carbon to contribute to mitigation. The IPCC's assessment in its SROCC found a theoretical maximum potential of 2% of current global emissions potential, which drops to ~0.2 GtCO2/yr (0.05 GtC/yr; only about 0.5% of current global emissions) if cost considerations are considered. According to the SROCC, even this magnitude would require a scale of ecosystem restoration that would be challenging because of the semi-permanent and going nature of most coastal land use changes.

The coastal ecosystems associated with blue carbon provide numerous other crucial services, both for people and for biodiversity. The need to conserve and protect these vital ecosystems is garnering increased attention but this has led to discussions over the use of blue carbon to incentivise such efforts. However, a focus on the carbon sequestered in coastal areas risks distracting from the need to urgently mitigate emissions in other sectors, as well as the need to preserve the life-supporting ecosystem services that coastal ecosystems provide.

What are the risks of using blue carbon to offset emissions?

There are three fundamental problems with using mitigation through land or ocean-based natural systems to offset CO_2 emissions: uncertainties, climate change impacts, and the risk of offsetting. These are described below.

Uncertainties

The uncertainties in the measurement of carbon flows in the highly variable environment in the coastal zone are much higher than the uncertainties in emissions in other sectors. There are also uncertainties over the permanence of ocean-based mitigation, and the risk of leakage of emissions through coastal change elsewhere. These uncertainties mean that mitigation using coastal ecosystems cannot be treated like-for-like with other forms of mitigation.

[1] Carbon sequestration in the open ocean is not typically considered a Blue Carbon option. In the open ocean, human

1. Changes over time

Tropical mangrove forests change over time. Mangroves are non-linear systems that are not in equilibrium, as they have adapted to grow on continually evolving shorelines. The amount of carbon sequestered by mangroves and other coastal ecosystems varies substantially between locations and as a function of time. While mangroves are often described as being far more intense carbon sinks than tropical forests, some mangrove systems may not actually accumulate any carbon. For example, a survey of 17 Australian seagrass habitats revealed an 18-fold difference in the carbon stored (Lavery *et al* 2013).

2. Measurement uncertainties

The measurement of carbon storage is difficult and should be interpreted cautiously. Some of the processes involved in drawing down carbon into sediments are highly site specific, or are still not well accounted for. Adame et al. (2017) compared estimates of mangrove root biomass calculated using allometric equations with values measured in the field and found field measurements to be on average 40% smaller (with some samples showing a difference of over 1000%). Another challenge is that a number of processes in coastal systems are poorly understood. For example, the fate of carbon once it has been deposited in a coastal area is still unknown (Atwood *et al* 2017).

Scientists try to assess how carbon sequestration of Indonesia's mangrove forests.
Photo by Center for International Forestry Research (CIFOR)

It is also very difficult to determine which emissions and removals are natural and which are anthropogenic. Only anthropogenic emissions and removals should be included in mitigation targets.

These measurement challenges are a particular problem for those developing countries with limited capacities for monitoring and reporting emissions and removals, leading to data gaps and even greater uncertainties.

3. **CO_2 effects**

Mangroves and seagrasses may experience enhanced productivity due to higher CO2 levels (IPCC AR5). Distinguishing this effect from human interventions to enhance productivity and thus carbon storage will be difficult.

4. **Permanence and leakage**

As with other land-based carbon sequestration, ensuring permanence and preventing leakage is very difficult. Climate change impacts on coastal ecosystems can lead to a reversal of carbon sequestration in the future (see below). In addition, conservation of one area may displace deforestation or degradation to another area, leading to leakage, and ensuring the longevity of carbon stored in conserved or restored mangroves requires a strong MRV system (Murray *et al* 2009).

Impacts

The recently released IPCC Special Report on Oceans and Cryosphere in a Changing Climate has brought new evidence on the devastating impacts that future climate change could have on coastal and ocean ecosystems, pointing to the importance of protecting the oceans by enhancing ambition across all sectors.

According to the IPCC's SROCC, exceeding 1.5°C would lead to the near-complete loss of tropical corals, and warming of 3°C or more – where current nationally determined contributions (NDCs) are taking us – would lead to high to very high risks for many coastal ecosystems (including seagrass, kelp forests and salt marshes). **Only limiting warming to 1.5°C can prevent land and ocean ecosystems from experiencing high to very high levels of risk**.

Such impacts could affect carbon storage (IPCC AR5 (2013)). The IPCC's SROCC highlighted the implications of these impacts for carbon sequestration: *"Under high emission scenarios, sea level rise and warming are expected to reduce carbon sequestration by vegetated coastal ecosystems (medium confidence)" (Chapter 5, SROCC)*

Emissions that result from such reversals may go unaccounted for, or removals may be overestimated or reversed. The regional variation in climate impacts, and their acceleration in frequency and intensity with future warming, will make designing a robust system for accounting for natural disturbances very difficult.

1. **Sea level rise**

Research has shown that coastal ecosystems in some regions are vulnerable to sea level rise. If sediment supply is sufficient for mangroves to grow in pace with sea level then ecosystems can continue to survive and to sequester carbon, but in many regions sediment supply is not sufficient (Lovelock et al. 2015). For example, in the Indo-Pacific – home to over half of the world's mangrove forests – sediment delivery is declining, largely due to human activity, e.g. damming rivers. Mangrove forests at sites with low sediment supply and low tidal range – such as the Gulf of Thailand and the Solomon Islands – are particularly vulnerable, and could be submerged by 2070 under even a low level of sea level rise (Lovelock et al. 2015).

Mangroves in Malaita, Solomon Islands. Photo by Wade Fairley

The IPCC SROCC found that mangrove and marsh restoration would only be effective of up to rates of 0.5-1cm local sea level rise per year. These levels will be far exceeded under a high emissions scenario (the SROCC gives a best estimate of 1.5cm global sea level rise by 2100 under a RCP8.5 scenario), and under scenarios close to current NDC ambition levels, sea level rise will also *likely* exceed 1cm per year towards the end of the century (Nauels *et al* 2017). Only under a Paris Agreement scenario may rates of global sea level rise stay below 0.5cm per year (IPCC 2019). However, even under such a scenario some systems may still come under pressure because regional sea level rise in many tropical regions will be well above the global average.

The IPCC's SROCC found that*:"Globally, 20–90% of current coastal wetlands are projected to be lost by 2100, depending on projected sea level rise, regional differences and wetland types" (B6.2, SROCC SPM)*. It also states that *"Under high emission scenarios, sea level rise and warming are expected to reduce carbon sequestration by vegetated coastal ecosystems (medium confidence)" (Chapter 5, SROCC).*

Exchange at SBST IPCC SROCC Special Event, COP25 Madrid, 5 December 2019

Fiji intervention:

We have learned that impacts on ocean ecosystems are already very concerning. The IPCC SROCC assessed that coastal ecosystems with adaptation potential face clear efficiency limits under ongoing climate change. Mangroves and salt marshes, for example, would only provide ecosystem-based adaptation potential below 1cm of global mean sea-level rise per year. Could the SROCC authors please clarify which scenarios would allow sea-level rise rates to be limited to below 1cm by the end of the 21st century?

IPCC WGI Co-Chair response (based on session notes):

For a scenario with mean projected warming of 1.6°C by the end of the 21st century (RCP2.6), the projected average global sea-level rise rate is 4mm per year, with an upper likely range up to 6mm, for a warming of around 2.5°C by 2100, the projected average global sea-level rise rate shows a median value 7mm per year, with an upper likely range of 9mm per year, which is close to 1cm per year. Current evidence therefore suggests that warming needs to be less than around 2.5°C by 2100 to limit global sea-level rise rates to less than 1cm per year.

2. Sea level extremes and fluctuation

The IPCC SROCC has found with high confidence that extreme sea level events that are historically rare (once per century in the recent past) are projected to occur at least annually in many locations by 2050, especially in tropical regions. Such events can be very damaging for coastal ecosystems.

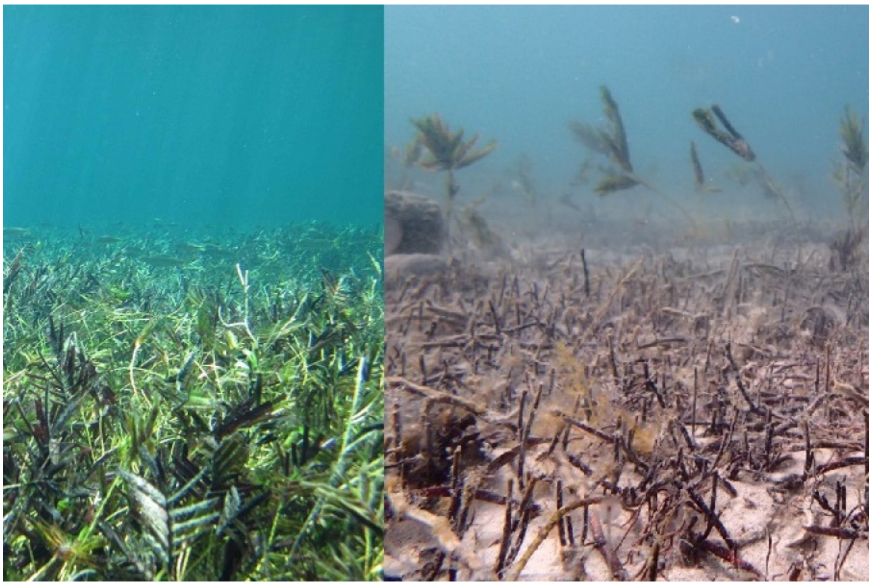
In some regions sea level can fluctuate with changes in rainfall. For example, the Indo-Pacific experiences low rainfall and low sea levels during El Niño, and this can lead to salinization of the soil and mangrove mortality (Lovelock *et al* 2017). Intensification of ENSO under climate change and associated fluctuations in sea level may lead to mangrove degradation and carbon release, and may further increase mangrove vulnerability to other impacts of climate change, pollution, and other human influences (Lovelock *et al* 2017).

3. Ocean warming

The IPCC SROCC has found that *"Marine heatwaves have very likely doubled in frequency since 1982 and are increasing in intensity (very high confidence)."*[2]

It further states: *"It is very likely that between 84–90% of marine heatwaves that occurred between 2006 and 2015 are attributable to the anthropogenic temperature increase."*[3] Such climate-change attributable ocean heat waves have already had severe impacts on coastal ecosystems.

For example, for a four-month period in 2010/2011 sea temperatures in western Australia were 2-4°C above average, damaging 36% of sea grass beds in the Shark Bay area (Arias-Ortiz *et al* 2018) . Two years later, these ecosystems had only partially recovered (Nowicki *et al* 2017). Recent research suggests that 2 – 9 MtCO2 could have been released during the three years following the heat wave, increasing Australia's land-use change emissions by 4-21% per year (Arias-Ortiz *et al* 2018).



Shark Bay seagrass example before 2011 heat wave (L) and study site in 2013 (R). Credit Shark Bay Ecosystem Research Project. Shark Bay, Western Australia. Photo: Joan Costa

[2] https://www.ipcc.ch/srocc/headline-statements/

[3] IPCC SROCC SPM Para A.2.3, https://www.ipcc.ch/srocc/chapter/summary-for-policymakers/

Such warming events are projected to become more common in the future, which is particularly concerning given the slow recovery rates of many coastal ecosystems and the potential for adverse climate change feedbacks due to carbon release.

4. Interacting stressors

Many coastal species are able to cope with highly variable environments, but the interactions of multiple stressors can amplify negative impacts and drive ecosystems into alternative states. For example, one study found that a marine heatwave in combination with a flooding on land, leading to sediment discharge and high water turbidity in the near-shore marine environment in western Australia, resulted in loss of seagrass biomass both above and below ground, and ultimately reduced the resilience of the ecosystem to future disturbance (Fraser *et al* 2014).

5. Impacts on carbon sequestration

Increased CO_2, warmer temperatures and moderate increases in sea level can increase rates of plant productivity and carbon sequestration. However, these same drivers can also act to reduce the carbon pool, for example, warmer temperatures and increased CO_2 can also increase decay rates, lowering the rate of carbon sequestration. How these factors will play out in the future, especially in the context of the negative impacts outlined above, is very uncertain.

Offsetting and carbon transfers

A key finding of these IPCC's SROCC is that nature-based mitigation **must not be a replacement for rapidly accelerating emissions reductions in other sectors**: *"The potential climatic benefits of blue carbon ecosystems can only be a very modest addition to, and not a replacement for, the very rapid reduction of greenhouse gas emissions." (SROCC Chapter 5, executive summary).*

Offsetting reduces the ambition of mitigation in other sectors, and can lead to lock-in to carbon intensive infrastructure. Previously insufficient mitigation action means that a substantial volume of negative emissions will be needed *in addition* to ambitious action in all other sectors, so there is no space in emissions pathways for the use of mitigation from nature-based systems to offset emissions in other sectors, unless those emissions are prohibitively expensive to mitigate.

The uncertainties and vulnerabilities associated with blue carbon mean that it will not work to deploy blue carbon as an offset for other emissions that remain high. Any movement of carbon credits and debits between nature-based systems and other sectors risks leaking the high uncertainties associated with blue carbon to mitigation in other sectors, making it difficult to monitor progress and to ensure that action is in line with the Paris Agreement. Furthermore, the IPCC SROCC notes that ecosystem restoration may only provide benefits for less sensitive systems and if global emissions remain low.

These high uncertainties and vulnerabilities pose significant risks to the transfer of blue carbon removals between countries via market mechanisms. The rules for the Paris Agreement market mechanisms are still being agreed, and if removals can be traded under these mechanisms with insufficient safeguards in place to address impermanence and uncertainties, this could undermine the credibility of the markets system.

Lessons learned from LULUCF accounting

A number of relevant lessons have been learned from the land-use, land-use change and forestry (LULUCF) sector:

- The development of accounting rules for the LULUCF sector under the Kyoto Protocol allowed governments to develop complicated rules, whose implications are beyond the understanding of most policy makers, scientists and members of civil society. These rules have enabled some emissions to go uncounted towards national emissions targets, creating 'hot air' that undermines the need for rapid emissions reductions.
- For example, under Article 3.7 any country that had land-use emissions in the base year (1990) can include these in their reference year emissions when calculating their reduction target. Any decreases in emissions *excluding* land-use relative to the base year *including* land-use emissions are awarded. For example, a substantial decrease in deforestation rates since 1990 is allowing Australia to comply with its 2020 Kyoto target when accounting rules are applied, despite a continued increase in fossil emissions (Climate Action Tracker 2015, 2017).
- Now countries vary widely in how they incorporate the LULUCF sector in their NDCs, which leads to considerable uncertainty in emissions reduction targets (Grassi and Dentener 2015, Fyson and Jeffery 2019), particularly where governments have chosen to include LULUCF in their overall emissions target without specifying its contribution. The inclusion of blue carbon in the NDCs presents similar challenges.
- Losses from extreme events and climatic disturbances do not need to be counted in national emissions accounts. Under present reporting and accounting arrangements losses of carbon from marine heatwaves (as at Shark Bay), sea level rise extreme events or multiple stressors (as in the massive mangrove dieback in Australia's Gulf of Carpentaria) could be excluded from national emissions reports, even though the prior storage of carbon could have been counted as a sink and counted towards climate targets.

What are the alternatives?

Coastal ecosystems are threatened by a number of stressors: coastal infrastructure, tourism, agriculture, aquaculture, dam development, pollution, and overfishing, among others as well as climate change. The rapid rate at which they are being degraded is particularly concerning because mangroves and other coastal ecosystems are vital for coastal communities, providing essential food and resources as well as building resilience to climate change impacts through coastal protection and erosion reduction. It is these benefits of coastal ecosystem restoration that should drive conservation and restoration efforts.

The IPCC's SROCC pointed specifically to the adaptation benefits that coastal ecosystems provide to low-lying coastal regions, including Small Island Developing States. However, the report highlighted that ecosystem-based adaptation is only an effective option under the lowest levels of warming.

There are **limits to the effectiveness** of coastal ecosystem-based adaptation at higher levels of warming. For example, coral reef conservation and restoration may be ineffective if warming exceeds 1.5°C; conservation and restoration of wetlands such as marshes and mangroves has decreased effectiveness at 2°C. At 2°C and above, there will be an increasing need for hard coastal protection infrastructure, and a greater risk of coastal community relocation. These findings further amplify the need to reduce emissions in line with the 1.5°C warming limit of the Paris Agreement, which must come alongside efforts to conserve and restore coastal ecosystems.

It is difficult to generate economic incentives for conservation of coastal ecosystems because many of the services that they provide do not have a market price, and often decisions that result in their degradation are made by bodies for whom the value of mangroves is non-existent (Mukherjee *et al* 2014). To provide an incentive for the preservation and sustainable use of these ecosystems, Payment for Ecosystem Services (PES) schemes can be used to place a value on those services that are valuable to local communities.

The wealth of services provided by mangroves and other coastal ecosystem makes them well-suited for such schemes. One estimate for the annual economic value of mangrove loss from aquaculture came to US$4-17 billion (Mukherjee *et al* 2014), and this likely underestimated the value to local populations of a number of benefits. Notably, the same study showed that carbon sequestration does not rank highly in terms of economic value or expert-based valuation. Numerous other ecosystem services are more important for local communities: food, livelihoods, construction materials and coastal protection provide essential life support services, and it is these services that should be driving the protection of coastal ecosystems.

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