Climateworks CENTRE

Southeast Asia Framework for Ocean Action in Mitigation (SEAFOAM) project

Blue carbon

Blue carbon and marine nature-based solutions have become a core component of climate mitigation over the past decade.

One of the main drivers for the inclusion of coastal and marine ecosystems in climate mitigation is their ability to sequester carbon – both in their biomass and soil – over long periods of time. Blue carbon ecosystems refers to those vegetated coastal and marine ecosystems with capacity to capture and store carbon. The protection of blue carbon is of key importance because damaged or degraded ecosystems can alter from a GHG sink to a source of carbon dioxide, methane and nitrous oxide (Hiraishi 2013, Oreska et al. 2020, Vanderklift 2019).

Alongside conservation and restoration activities, blue ecosystems hold the potential to reduce inequalities, particularly for women and young people. They create opportunities for participation and further sustained inclusion via training activities (for example, mangrove restoration and sustainable seaweed farming), access to finance and the creation of women-led cooperatives.

Blue carbon: action and impact	2025	2030	2050
Mangroves **Seagrasses**	+ Establish specific emissions reduction targets and mitigation strategies to be included in the next NDC. + Establish and clearly define a sixth sector for 'Ocean Use and Ocean Change' in Indonesia's NDC reporting.	+ Achieve a protection rate of 50 per cent of mangrove and seagrass ecosystems. + Prevent all conversion of mangroves to other land uses.	+ Achieve thriving blue ecosystems and communities with verifiable emissions mitigation. + Achieve a healthy and stable blue economy supporting, and supported by, mangrove and seagrass ecosystems.
Seaweed	+ Set a specific target for expanding seaweed production in line with national planning and environmental assessments. + Set parameters and improve best practices for seaweed cultivation. + Improve mapping of wild and cultivated seaweed. + Enhance monitoring and reporting systems of seaweed plots.	+ Achieve a production target of 453,000 ha of seaweed cultivation. + Improve data and processes for seaweed farming. + Improve carbon accounting and monitoring for wild and cultivated seaweed.	+ Achieve thriving wild and cultivated ecosystems and sustainable sea farming practices. + Seaweed products replace carbon-intensive, land-based production of food and fuels.

Indonesia's blue carbon is globally significant, housing 17 per cent of the world's mangrove and seagrass forests (Alongi et al. 2016). However, rates of decline of mangroves and seagrasses could have a significant impact on the country's emissions profile.

By avoiding mangrove deforestation and degradation and implementing restoration and reforestation, Indonesia could mitigate 41 MtCO_2e annually, with total mitigation to 2030 reaching 256 MtCO_2e (Arifanti et al. 2022a). Additionally, reducing seagrass degradation could mitigate 17–60 MtCO_2e emissions annually by 2030. In terms of seaweed farming, if Indonesia was able to achieve 30 per cent of the projected 1.5 million hectares of seaweed cultivation potential by 2030, it is estimated that the emissions mitigation would be 0.15–0.22 MtCO_2e per year.

Whilst Indonesia's emissions accounting currently includes mangroves, the full potential of seagrasses is yet to be considered as either a source of emissions or as a carbon sink. Overall, enhanced efforts are needed to better integrate blue carbon ecosystems into Indonesia's 'Second NDC'.

More recently, the development of the Indonesia Blue Carbon Strategy Framework (IBCSF) presents an important step to streamline governance efforts in blue carbon and bring together what have historically been separate ecosystem categories, such as mangroves and seagrasses, under one definition (Sidik et al. 2023). It also provides an opportunity to remedy information gaps and more clearly understand the climate value of blue carbon, while aiming to improve national monitoring, reporting and verification systems. Success will require financial support and enhanced governance, as well as stronger links between local communities and national policy outcomes.

Mangroves

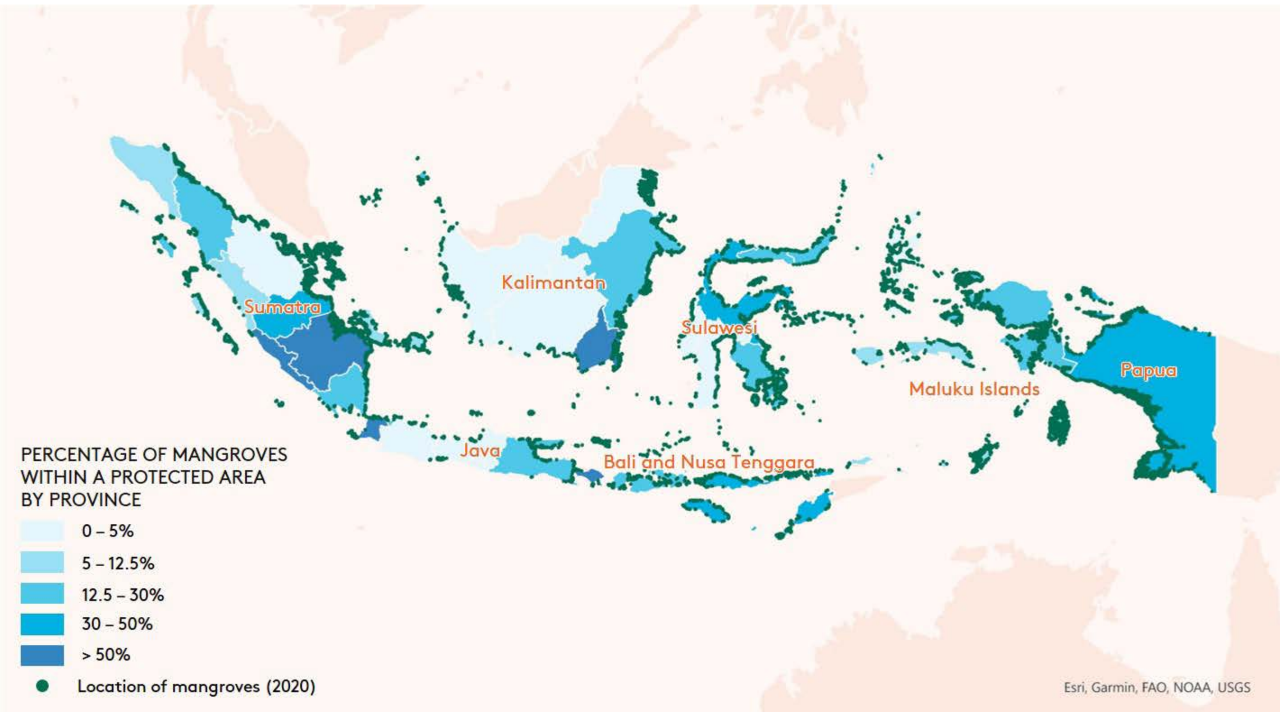
Mangroves act as critical long-term carbon sinks. Their ecosystems also provide a multitude of environmental and societal benefits such as protection against storm surges and tsunamis for coastal regions, habitats for biodiverse coastal species, ecotourism activities, wood production and a local source of nutrition (Arifanti et al. 2022b). Despite their importance, mangroves are subject to degradation and are a target of deforestation worldwide.

Mangroves in Indonesia are extensively monitored and mapped, with the Ministry of Forestry and Environment (MoEF) estimating coverage of 3.3 million hectares in 2022 (MoEF 2021a). Figure 2 shows the locations of mangroves in Indonesia as of 2020.

Indonesia is home to about 22 per cent of global mangroves (Giri et al. 2011); however, in the past three decades, approximately 800,000 hectares have been lost (Sasmito et al. 2023). Between 2009 and 2019, 6.3 per cent of mangroves were deforested, while 2.7 per cent experienced degradation (MoEF 2021b) (Figure 3). Degradation and deforestation are mainly a result of land use changes and coastal and infrastructure development.

Mangroves are currently listed in the Food and Land Use section of Indonesia's NDC which means they are grouped with terrestrial forests and contribute to land-based emissions reporting and mitigation strategies. There are currently no mangrove-specific emission reduction targets.

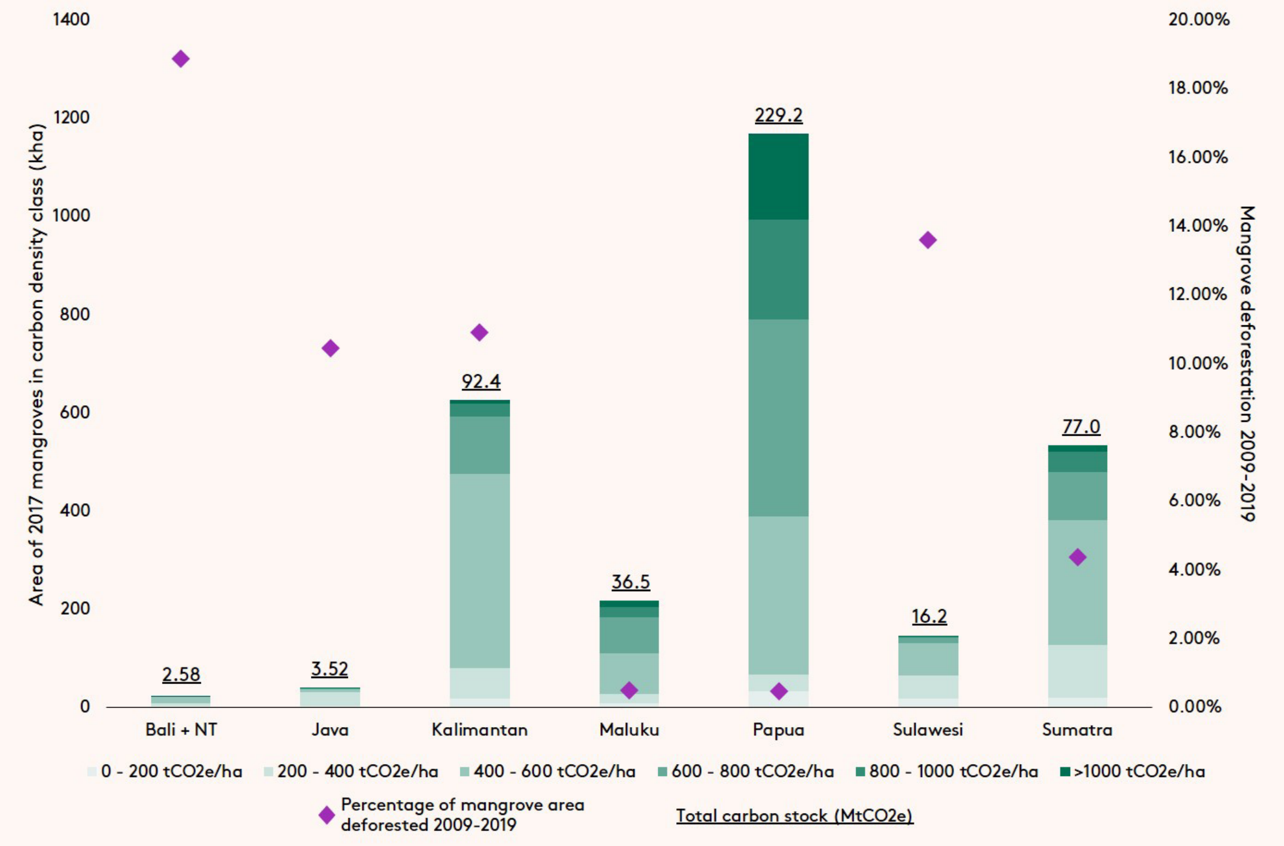
FIGURE 2: Locations of mangroves in Indonesia as of 2020 with percentage of mangroves in marine protected areas per province



(Sources: Protected Planet 2023; Global Mangrove Watch 2023; Simard et al. 2019)

Note: Mangroves are concentrated along the coastline of Indonesia's major islands. The provinces of North Kalimantan, Riau, North Maluku and Central Java have the lowest percentage of mangroves that fall within protected areas. This is significant given that the greatest potential for emissions gains from mangroves is through the protection of existing sites, while reforestation is beneficial over a longer timeframe (Arifanti et al. 2022a).

FIGURE 3: Key areas of mangrove presence and deforestation in Indonesia



(Sources: data derived from MoEF 2021a; Sanderman 2017; Simard et al. 2019)

Note: Kalimantan is an area of importance for mangroves in Indonesia, subject to a deforestation rate of 19 per cent between 2009–2019. The current protection rate is 18 per cent coverage, which is low in comparison to Indonesia's national average of 27 per cent. By comparison, Papua has a large area of carbon-dense mangroves with a low historic deforestation rate and no indication of shift.

Indonesia's Second NDC – targets for inclusion

NDC category:	Sub-sector mitigation target	Sub sector non-GHG targets
Targets for inclusion:	+ Reduce 32–41 $MtCO_2e$ of annual emissions from mangroves by 2030.	+ Protect 39,000 ha per year to achieve a total mangrove protection rate of 50 per cent by 2030. + Prevent all conversion of mangroves to other land uses by 2030.

By actively addressing deforestation and degradation of mangroves, Indonesia has the potential to mitigate 32 $MtCO_2e$ annually, with total mitigation to 2030 reaching 256 $MtCO_2e$ (Arifanti et al. 2022a). Emissions reductions are highly dependent on effective protection to ensure that mangroves forests are not converted to other land uses.

An overarching action is the inclusion of mangrove accounting and emissions within a new 'Ocean Use and Ocean Change' sector in Indonesia's 'Second NDC'. This will allow for clear demarcation of the boundary between other forests and mangroves, and provide for the inclusion of offshore emissions without alteration of historic land use, land-use change and forestry (LULUCF) ecosystem baselines.

Seagrasses

Indonesia's seagrasses are a key ecological, social and economic asset in the context of climate change mitigation.

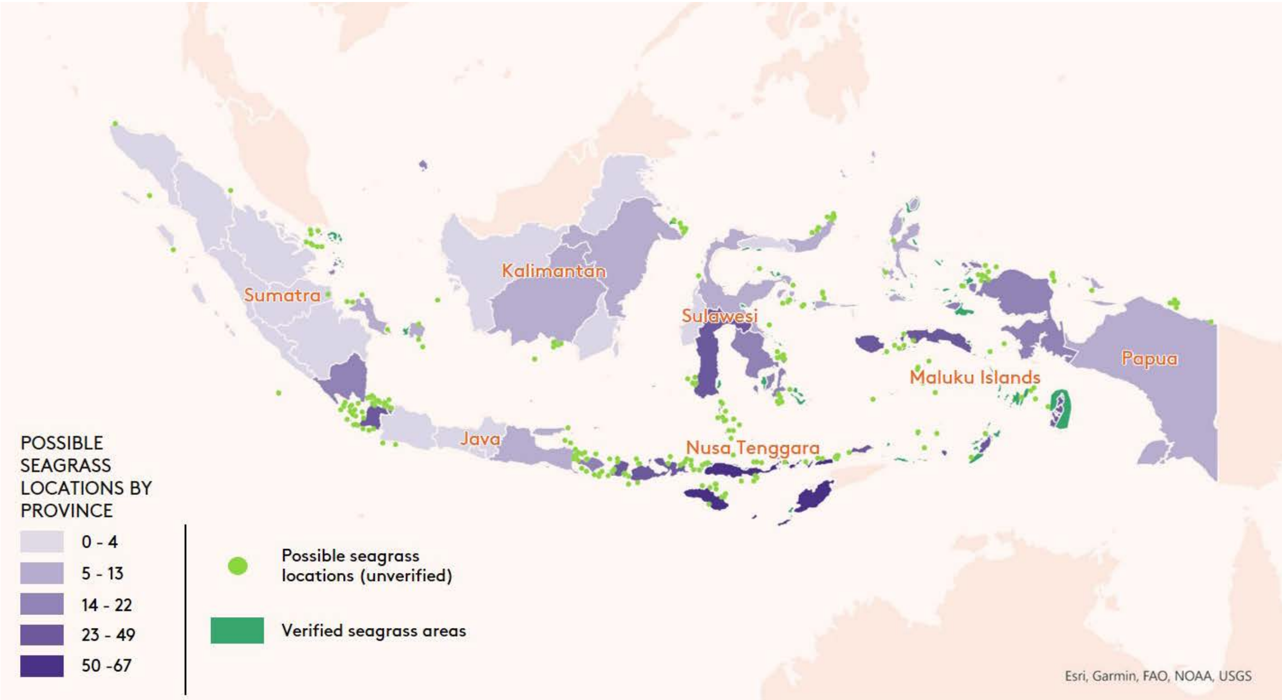
Globally, the role of blue carbon ecosystems in climate change mitigation has focused on mangroves as a carbon sink, and prioritised their protection and restoration. In contrast, seagrass ecosystems have received insufficient recognition, research and regulation.

Seagrasses sequester carbon dioxide from the atmosphere and act as a carbon sink, with biomass, seabed and subsoil storage capabilities. They also provide economic value through enhanced fisheries productivity and the reduction of coastal erosion. Indonesia's seagrasses also have high conservation value through the support of species richness, including for vulnerable populations such as dugongs and turtles. Figure 4 shows the extent and concentration of seagrass meadows in Indonesia.

Across Southeast Asia, seagrass ecosystem degradation is estimated to be around 4.7 per cent per year over the past 20 years (Sudo et al. 2021). Seagrass degradation is primarily caused by coastal development, water pollution and stresses on the ocean as a result of climate change (Sudo et al. 2021). Additional causes of seagrass loss in Indonesia include land reclamation, deforestation, seaweed farming, sand and coral mining, overfishing, poor water quality, garbage dumping and direct disturbances such as anchoring.

It is estimated that by reducing their degradation, Indonesian seagrasses have the potential to mitigate 17–60 MtCO_2e per year by 2030. The application of the correct protection measures would also create a range of economic, environmental and social co-benefits.

FIGURE 4: Seagrass meadows extent and concentration in Indonesia (by province)



(Sources: Sudo et al. 2021; Sjafrie et al. 2018; IUCN 2018)

Note: This map highlights the significant portion of locations where data is still tentative and which may be historical locations.

Indonesia has committed to the Convention on Biological Diversity '30×30' goal, aiming to protect 10 per cent of its waters by 2030. Leveraging this commitment could enable the coordination of current conservation goals with climate mitigation targets.

Current best practice targets encourage the protection of 50 per cent of global seagrass meadows by 2030 and restoration of 90 per cent of loss by 2050 (Buelow et al. 2022). The application of these best practice targets by Indonesia would show leadership and provide critical protection.

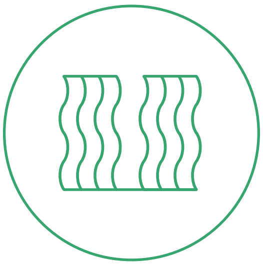
Indonesia's Second NDC – targets for inclusion

NDC category:	Sub-sector mitigation target	Sub sector non-GHG targets
Targets for inclusion:	+ Reduce 60 $MtCO_2e$ of annual emissions from seagrasses by 2030. + Achieve a total seagrass protection rate of 50 per cent by 2030.	+ Protect at least 8,600 ha per year of seagrasses.

Seagrasses are currently not represented within Indonesia's 'Enhanced NDC'. As a result, the full extent of blue carbon has yet to be considered as either a source of emissions or as a potential carbon sink, leaving a significant gap within national GHG inventory accounting and climate ambition and policy. The creation of a new 'Ocean Use and Ocean

Change' sector in the NDC will enable accounting for, transparency around and prioritisation of blue ecosystems and the inclusion of offshore emissions without altering historic LULUCF ecosystem baselines.

Seaweed



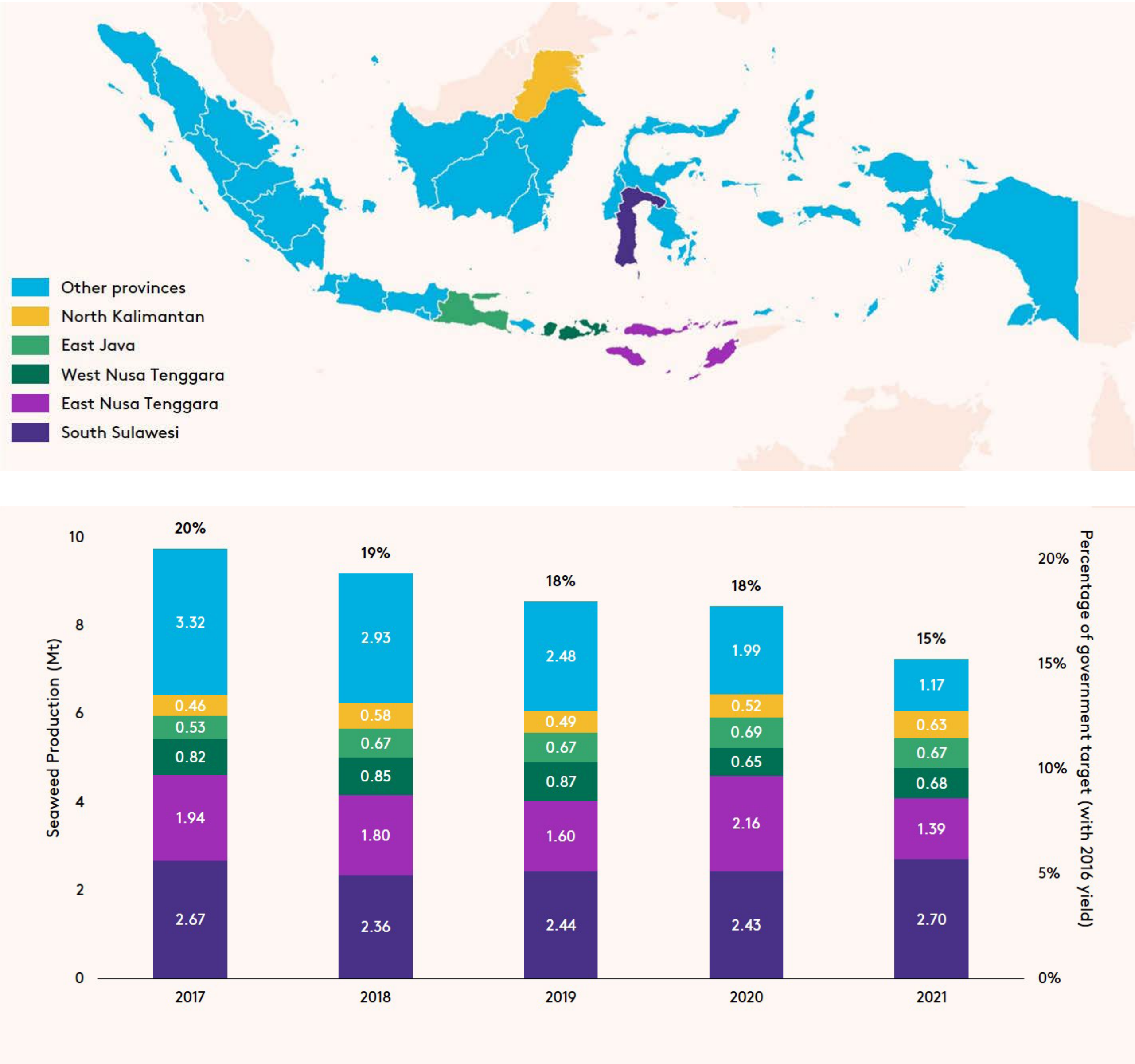
Seaweed ecosystems absorb carbon which is exported to the deep ocean where, if undisturbed, can be stored for long periods of time. The term seaweed refers to red, green and brown macro-algae ecosystems.

Seaweeds help regulate ocean acidification and minimise deoxygenation, among other ecosystem services including carbon sequestration – the latter is currently being studied given the unknowns regarding the extent of carbon stored and its permanence. Additionally, seaweed holds mitigation opportunities as a low-carbon alternative to high emitting products including as a food source, as a substitute for synthetic fertilisers, as biofuel and as a livestock feed replacement leading to reduced bovine methane emissions.

The Indonesian Government has deemed seaweed farming a growing sector with a calculated potential of 1.5 million hectares for cultivation (BPK 2019). Indonesia also plans to increase its domestic seaweed processing capacity and improve cultivation practices and access to disease and climate change resistant seeds. However, if closely located, cultivated seaweed ecosystems may pose a threat to established seagrass meadows and, thus, to the carbon sequestration potential of seagrasses. The magnitude of the impact will depend on seaweed abundance, attachment type and size (Thomsen et al. 2012).

If Indonesia was able to achieve 30 per cent of the 1.5 million hectares cultivation potential by 2030, it is estimated that the emissions mitigation would be 0.15–0.22 $MtCO_2e$ per year; if 90 per cent of the cultivation potential was achieved by 2050, the estimated emissions mitigation would be 0.44–0.66 $MtCO_2e$ per year. Emissions mitigation remains deeply dependent on seaweed farming scalability and market uptake. Figure 5 breaks down Indonesian seaweed production by province.

FIGURE 5: Seaweed production in Indonesia, by province



(Sources: BPK 2019; BPS 2021)

Note: Seaweed production to date compared to the Indonesian Government's calculated potential of 1.5 million ha for seaweed cultivation.

Seaweed farming expansion will require clear guidelines that consider production advice, practices, site selection, and seeds as well as clarity on the potential interactions with vulnerable blue carbon ecosystems like seagrass meadows. There is a need for strong policies and procedures to minimise the chance of perverse outcomes from such developments.

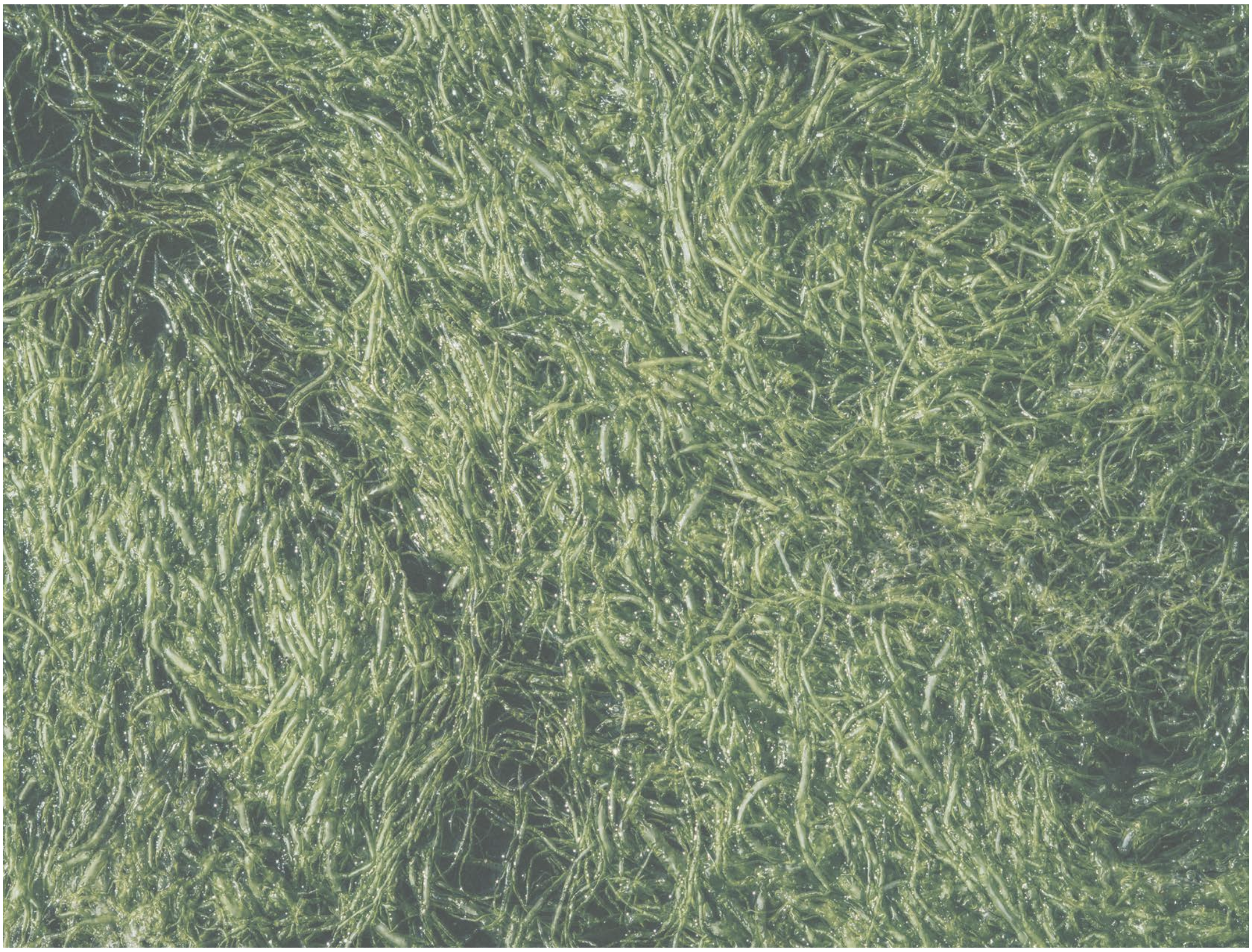
Indonesia's Second NDC – targets for inclusion

NDC category:	Sub-sector mitigation target	Sub sector non-GHG targets
Targets for inclusion:	+ High uncertainty in mitigation potential – target to be reviewed as scientific information improves.	+ Expand cultivation area of seaweed to 453,000 ha by 2030 – 30 per cent of the government's current calculated cultivation potential.

The inclusion of seaweed as a form of blue carbon remains tentative, and confidence in its sequestration abilities and permanence will require further investigation.

Due to these uncertainties, wild seaweed forests and cultivated seaweed are not currently mentioned in Indonesia's NDCs. Their inclusion is further hampered by inconsistencies in monitoring, quantification and verification standards (Rose and Hemery 2023).

Furthermore, seaweed carbon sequestration potential is also dependent on scale and linked to high-quality seeds, best practices, suitable production costs and market variations, as well as more contentious considerations regarding offshore cultivation (Ross et al. 2023).



References

BLUE CARBON

Alongi D, Murdiyarso D, Fourqurean J, Kauffman J, Hutahaean A, Crooks S, Lovelock C, Howard J, Herr D, Fortes M and Pidgeon E and Wagey (2016) 'Indonesia's blue carbon: a globally significant and vulnerable sink for seagrass and mangrove carbon,' *Wetlands Ecology and Management*, 24(1):3–13, doi:10.1007/s11273-015-9446-y.

Arifanti VB, Kauffman JB, Subarno, Ilman M, Tosiani A and Novita N (2022a) 'Contributions of mangrove conservation and restoration to climate change mitigation in Indonesia,' *Global Change Biology*, 28(15): 4523–4538, doi:10.1111/gcb.16216.

Hiraishi H, Krug T, Tanabe K, Srivastava N, Jamsranjav B, Fukuda M and Troxler T (2013) *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*, IPCC, https://www.ipcc.ch/site/assets/uploads/2018/03/Wetlands_Supplement_Entire_Report.pdf.

Oreska M, McGlathery K, Aoki L, Berge A, Berg P and Mullins L (2020) 'The greenhouse gas offset potential from seagrass restoration', *Science Reports*, 10:1-15, doi:10.1038/s41598-020-64094-1.

Sidik F, Lawrence A, Wagey T, Zamzani F and Lovelock C (2023) 'Blue carbon: A new paradigm of mangrove conservation and management in Indonesia,' *Marine Policy*, 147:105388, doi:10.1016/j.marpol.2022.105388.

Vanderklift M, Marcos-Martinez R, Butler J, Coleman M, Lawrence A, Prislan H, Steven A and Thomas S (2019) 'Constraints and opportunities for market-based finance for the restoration and protection of blue carbon ecosystems,' Marine Policy, 107:1–6, doi: 10.1016/j.marpol.2019.02.0010.

MANGROVES

Arifanti VB, Kauffman JB, Subarno, Ilman M, Tosiani A and Novita N (2022a) 'Contributions of mangrove conservation and restoration to climate change mitigation in Indonesia,' *Global Change Biology*, 28(15): 4523–4538, doi:10.1111/gcb.16216.

Arifanti VB, Sidik F, Mulyanto B, Susilowati A, Wahyuni T, Subarno, Yulianti, Yuniarti N, Aminah A, Suita E, Karlina E, Suharti S, Pratiwi, Turjaman M, Hidayat A, Rachmat HH, Imanuddin R, Yeny I, Darwiati W, Sari N, Hakim SS, Slamet WY and Novita N (2022b) 'Challenges and Strategies for Sustainable Mangrove Management in Indonesia: A Review,' *Forests, Trees and Livelihoods*, 13(5):695, doi:10.3390/f13050695.

Giri C, Ochieng E, Tieszen LL, Zhu Z, Singh A, Loveland T, Masek J and Duke N (2011) 'Status and distribution of mangrove forests of the world using earth observation satellite data,' *Global Ecology and Biogeography: A Journal of Macroecology*, 20(1):154–159, doi:10.1111/j.1466-8238.2010.00584.x.

Global Mangrove Watch (2023) *Mangroves Worldwide, Global Mangrove Watch*, https://www.globalmangrovewatch.org/?activeLayers=mangrove_extent&category=distribution_and_change&zoom=3.0961178338339037.

Ministry of Environment and Forestry, Republic of Indonesia (MoEF) (2021a) *Persentase Penutupan Hutan 2021 [Percentage of Forest Cover 2021], Ministry of Environment and Forestry*, https://nfms.menlhk.go.id/.

—— (2021b) *Land Cover Recalculation, Ministry of Environment and Forestry*, https://nfms.menlhk.go.id/statistic.

Protected Planet (2023) *World Database on Protected Areas (WDPA), Protected Planet*, https://www.protectedplanet.net/en/thematic-areas/wdpa?tab=WDPA.

Sanderman J (2017) 'Global mangrove soil carbon: dataset and spatial maps', doi: 10.7910/DVN/OCYUIT, Harvard Dataverse, V4, UNF:6:KdgZjEsAGV1VOL82caK6JQ== [fileUNF]

Sasmito S, Basyuni M, Kridalaksana A, Saragi-Sasmito M and Lovelock C and Murdiyarso (2023) 'Challenges and opportunities for achieving Sustainable Development Goals through restoration of Indonesia's mangroves,' *Nature Ecology & Evolution*, 7(1):62–70, doi:10.1038/s41559-022-01926-5.

Simard M, Fatoyinbo T, Smetanka C, Rivera-Monroy V, Castaneda E, Thomas N and Van der stocken T (2019) 'Global Mangrove Distribution, Aboveground Biomass, and Canopy Height,' ORNL DAAC, doi:10.3334/ORNLDAAC/1665.

SEAGRASSES

Buelow CA, Connolly RM, Turschwell MP, Adame MF, Ahmadia GN, Andradi-Brown DA, Bunting P, Canty SWJ, Dunic JC, Friess DA, Lee SY, Lovelock CE, McClure EC, Pearson RM, Sievers M, Sousa AI, Worthington TA and Brown CJ (2022) 'Ambitious global targets for mangrove and seagrass recovery,' *Current Biology*, 32(7):1641-1649.e3, doi:10.1016/j.cub.2022.02.013.

International Union for Conservation of Nature (IUCN) (2018) *Protected planet report 2018: tracking progress towards global targets for protected areas*, International Union for Conservation of Nature, https://portals.iucn.org/library/node/48344.

Sudo K, Quiros TEAL, Prathep A, Van Luong C, Lin H-J, Bujang JS, Ooi JLS, Fortes MD, Zakaria MH, Yaakub SM, Tan YM, Huang X and Nakaoka M (2021) 'Distribution, Temporal Change, and Conservation Status of Tropical Seagrass Beds in Southeast Asia: 2000–2020,' *Frontiers in Marine Science*, 8, doi:10.3389/fmars.2021.637722.

SEAWEED FARMING

Badan Pusat Statistik, Republic of Indonesia (BPS) (2021) *Produksi Perikanan Budidaya Menurut Provinsi dan Jenis Budidaya (Ton), 2021 [Aquaculture Production by Province and Type of Cultivation (Tons), 2021], BPS*, https://www.bps.go.id/indicator/56/1509/1/production-of-aquaculture-by-province-and-type-of-cultivation.html.

Rose DJ and Hemery LG (2023) 'Methods for Measuring Carbon Dioxide Uptake and Permanence: Review and Implications for Macroalgae Aquaculture,' J*ournal of marine science and engineering*, 11(1):175, doi:10.3390/jmse11010175.

Ross F, Boyd P, Filbee-Dexter K, Watanabe K, Ortega A, Krause-Jensen D, Lovelock C, Sondak C, Bach L, Duarte C, Serrano O, Beardall J and Tarbuck P and Macreadie (2023) 'Potential role of seaweeds in climate change mitigation,' *The Science of the Total Environment*, 885:1–15, doi:10.1016/j.scitotenv.2023.163699.

The Audit Board, Republic of Indonesia (BPK) (2019) *Presidential Decree No.33, BPK*, https://peraturan.bpk.go.id/Home/Details/108806/perpres-no-33-tahun-2019, accessed 12 April 2023.

Thomsen MS, Wernberg T, Engelen AH, Tuya F, Vanderklift MA, Holmer M, McGlathery KJ, Arenas F, Kotta J and Silliman BR (2012) 'A meta-analysis of seaweed impacts on seagrasses: generalities and knowledge gaps,' *PloS one*, 7(1):e28595, doi:10.1371/journal.pone.0028595.

For further information please contact:

DR SALI BACHE
Ocean and international policy Lead
sali.bache@climateworkscentre.org

GUNTUR SUTIYONO
Country Lead, Indonesia
guntur.sutiyono@climateworkscentre.org

Climateworks Centre
Level 27, 35 Collins Street
Melbourne Victoria 3000
Wurundjeri Country

Published by Climateworks Centre, September 2023

This fact sheet presents findings from the SEAFOAM Summary Report.

This publication can be downloaded at: www.climateworkscentre.org

Co-founded by philanthropy and Monash University, Climateworks Centre is an independent not-for-profit working within the Monash Sustainable Development Institute.