Climateworks CENTRE

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

Sea of opportunity:

Ocean-based mitigation to support Indonesia's climate ambition

PHASE 1 SUMMARY REPORT

SEPTEMBER 2023

ACKNOWLEDGEMENT OF COUNTRY

We acknowledge and pay respect to the Traditional Custodians and Elders – past and present – of the lands and waters of the people of the Kulin nation on which the Climateworks Centre office is located, and all of the Elders of lands across which Climateworks operates nationally. We acknowledge that sovereignty was never ceded and that this was and always will be Aboriginal land.

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ABOUT US

Climateworks Centre bridges the gap between research and climate action. We are climate transition specialists, working in Australia, Southeast Asia and the Pacific with decision-makers who have the power to reduce emissions at scale. Climateworks Centre develops evidence-based solutions to accelerate emissions reduction in line with the global 1.5°C temperature goal and shared climate safety.

Co-founded by philanthropy and Monash University, Climateworks is an independent not-for-profit working within the Monash Sustainable Development Institute. To learn more about this work, visit www.climateworkscentre.org.

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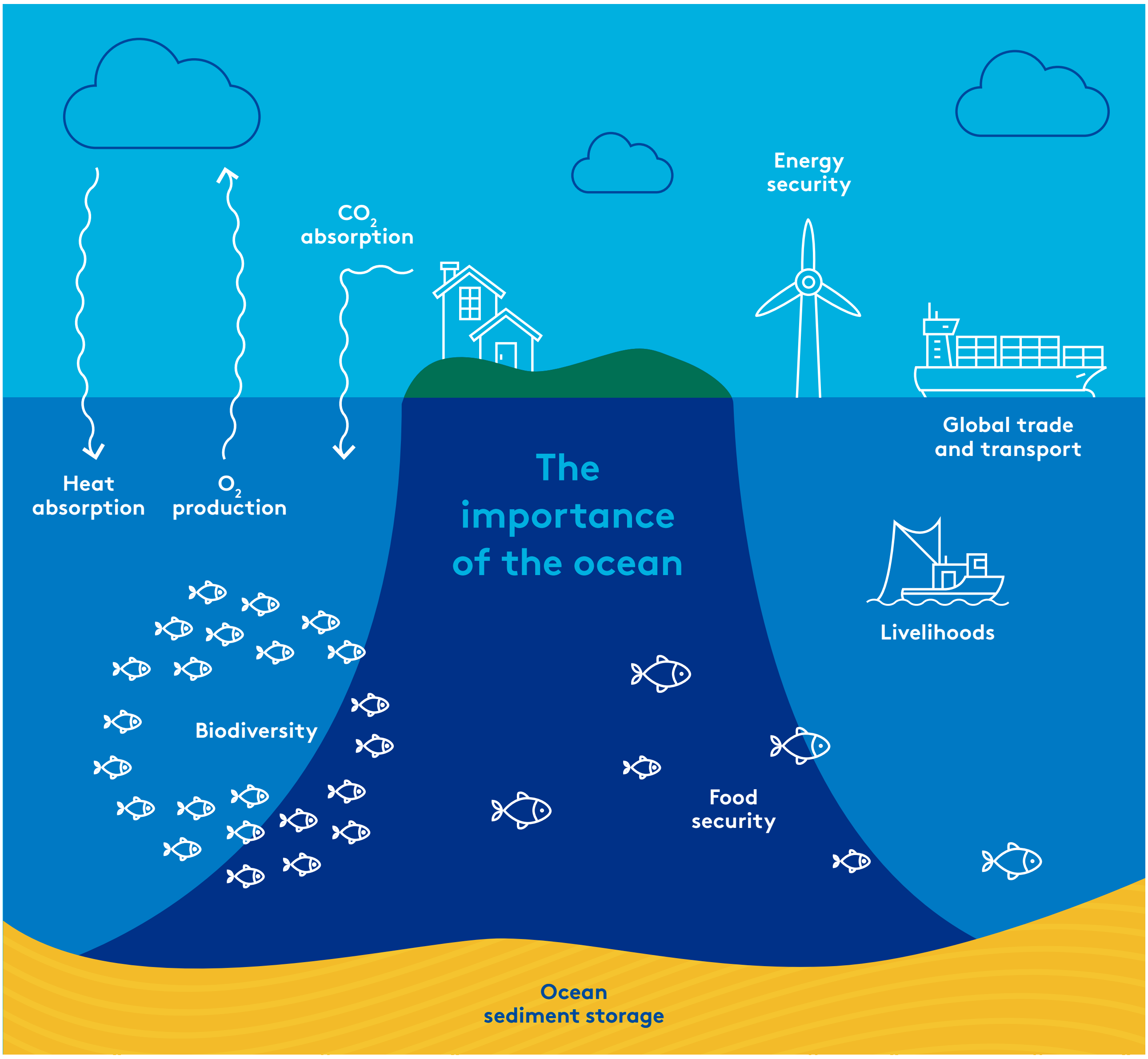
Summary

There is an urgent and recognised need to take action in order to limit the global mean surface temperature rise to 1.5 degrees Celsius above pre-industrial levels (IPCC 2018). However, the current mitigation ambitions of the signatories to the 2015 Paris Agreement remain insufficient to ensure we remain within that target.

For this reason, calls to consider ocean–climate action are accelerating, highlighting ocean-based action as a key opportunity to assist countries to meet and enhance their climate ambition.

The ocean houses 20 times more carbon than the atmosphere and terrestrial plants combined (Szopa et al. 2021), and absorbs approximately one-third of human-generated carbon dioxide and 93 per cent of anthropogenic heat (IPCC 2019). These interactions highlight the strong links between the atmosphere and the ocean, and the need for policy to reflect this relationship.



Source: Adapted from Oceano Azul Foundation n/a

The ocean–climate nexus recognises that while the ocean is vulnerable to impacts from increased greenhouse gases(GHG) in the atmosphere, it is also a key source of mitigation potential. Indonesia's coastal and ocean areas offer significant climate mitigation potential, drawing attention to the inclusion of ocean-based action in their forthcoming 'Second NDC' (nationally determined contribution), due in 2025.

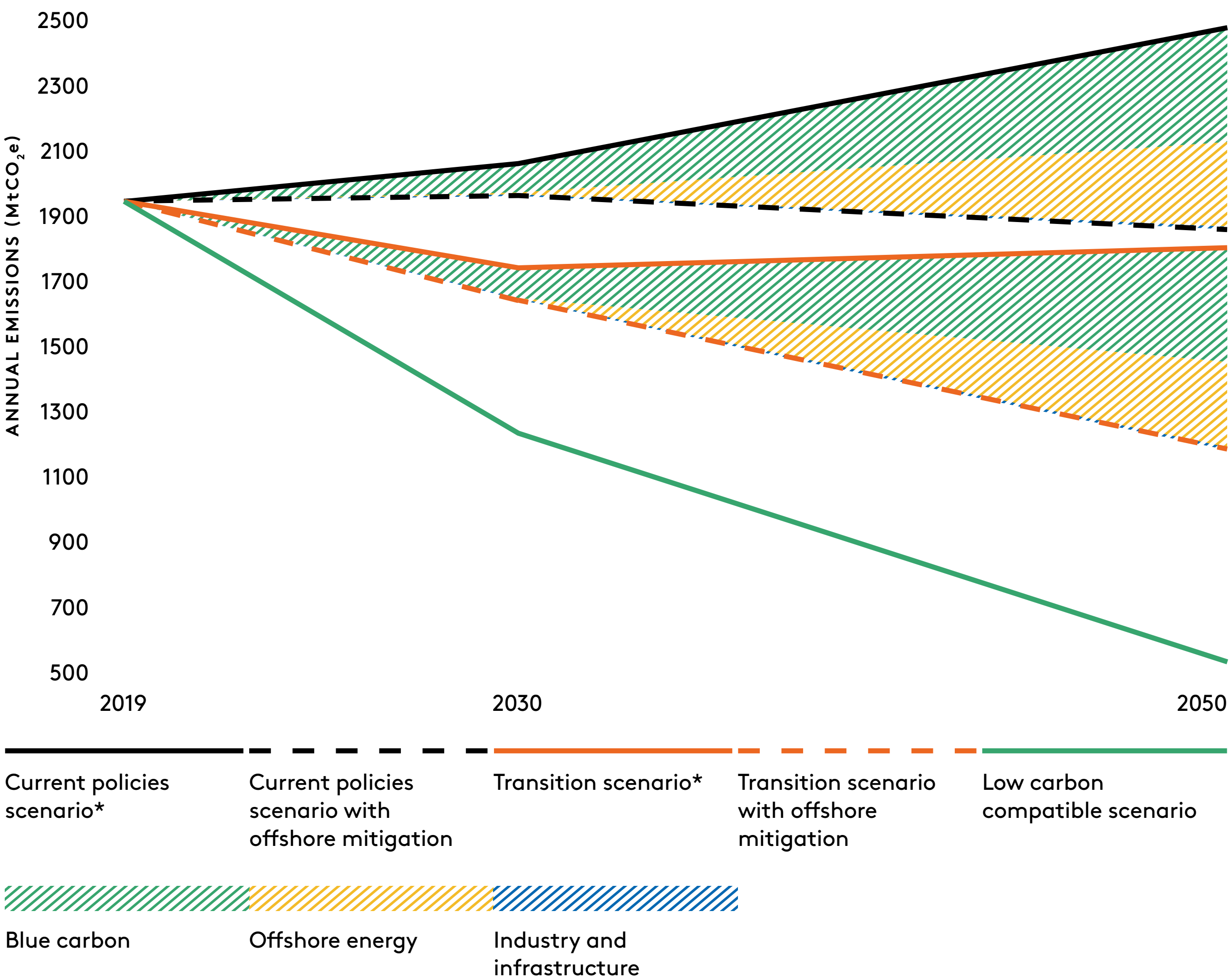
Recognising ocean–climate interrelatedness is the first step towards a sustainable blue economy that fosters biodiversity, culture, income generation and industry, conservation and innovation, as well as climate mitigation.

In order to include ocean-based climate action into Indonesia's 'Second NDC', this report investigates three sectors:

1. **blue carbon nature-based solutions**
2. **maritime industry and infrastructure**
3. **offshore renewable energy.**

These sectors demonstrate substantial potential for coastal and marine resources to contribute to Paris Agreement-aligned climate mitigation goals. If implemented in addition to the onshore mitigation plans that are specified in the Government of Indonesia's official 'Transition scenario' (Republic of Indonesia 2021), ocean-based mitigation could close the gap between this scenario and the more ambitious Paris-aligned 'Low carbon compatible scenario'. Our analysis shows this gap could be closed by 19 per cent in 2030 and 49 per cent in 2050 (Figure 1), recognising the significant contribution of ocean-based mitigation to Indonesia's goal of reaching net zero by 2060.

FIGURE 1: Contribution of ocean-based mitigation to Indonesia's net zero goal



**Note: The Government of Indonesia's current policies scenario and transition scenario have been adjusted to include emissions from seagrass degradation. Transition scenario is considered to include 8.9 $MtCO_2e$ of mitigation from mangroves in both 2030 and 2050. (Source: Republic of Indonesia 2021)*

The inclusion of ocean-based mitigation action in Indonesia's 'Second NDC' will strengthen the country's commitment to the maritime sector and enhance its efforts towards limiting global warming to 1.5 degrees. This report found that ocean-based mitigation can deliver the following impacts:

Mangroves **Seagrass**

The inclusion of seagrasses into NDC monitoring and reporting frameworks and the establishment of protection targets will reduce their degradation and destruction and has the potential to mitigate 17–60 $MtCO_2e$ per year by 2030. This adds to the already 32–41 $MtCO_2e$ of emissions mitigation per year projected for mangroves by 2030.

Domestic shipping and ports **Domestic maritime passenger transport**

The domestic maritime transport and shipping sector could mitigate 2.1–2.8 $MtCO_2e$ per year by 2030.

OTEC **Wind energy** **Tidal energy** **Wave energy**

Deployment of a mix of four offshore energy technologies – wave, tidal, offshore wind and ocean thermal energy conversion– could mitigate 0.83 $MtCO_2e$ per year by 2030 with rapid acceleration to 2050.

Seabed disturbance

The global seabed remains widely underexplored and unregulated, which means that seabed disturbance could potentially lead to the unaccounted release of a significant amount of carbon stored in the ocean seafloor.

Alongside climate mitigation, blue ecosystems hold the potential to reduce inequalities for minority groups and populations. Ocean-based activities like sustainable seaweed farming may enable livelihood diversification, alternative income generation and gender empowerment.

A more ambitious 'Second NDC' could also provide guidelines to enhance resilience, implement sustainable practices in industries and preserve the health of the ocean that forms the lifeblood of countless coastal communities. By aligning on-the-ground actions with the NDCs, Indonesia can foster sustainable development, ensure the well-being of its people, and safeguard the future of their diverse and precious marine resources.

The opportunity: Indonesia's annual emissions mitigation potential by 2030 and 2050

Indonesia's blue ecosystems and ocean-based sectors hold the potential to close the gap towards net zero, with blue carbon ecosystems and offshore renewable energy presenting key opportunities for net zero aligned pathways.

		$MtCO_2e/yr$	
		2030	2050
BLUE CARBON	Mangroves	32 – 41	41 – 59
	Seagrasses	17 – 60	86 – 298
	Seaweed farming	0.15 – 0.22	0.44 – 0.66
INDUSTRY AND INFRASTRUCTURE	Domestic maritime transport, shipping and ports	2.1 – 2.8	5.7 – 8.1
	International shipping and ports	10.3 – 13.9	28.3 – 40
OFFSHORE RENEWABLE ENERGY	Tidal energy	0 – 0.38	0.59 – 0.96
	Wave energy	0 – 0.13	0.81 – 4.6
	Ocean thermal energy conversion (OTEC)	0	0 – 76
	Wind energy	0 – 0.32	2.1 – 180
	TOTAL DOMESTIC ANNUAL EMISSIONS MITIGATION:	51 – 105	136 – 627

Note: An exponential decay function was used to calculate seagrass emissions mitigation.

Introduction

This report assesses the mitigation potential of coastal and ocean areas and their contribution to Indonesia’s 'Second NDC', and suggests mechanisms for including the ocean in the forthcoming NDC. In addition to examining mitigation potential, it also provides details of key relevance to decision makers such as enabling and economic factors, scientific gaps and the likely flow-on effects.

This summary report was prepared by Climateworks Centre to demonstrate the value and impact of Indonesia’s ocean-based climate mitigation. The findings presented in this report are the result of the Southeast Asia Framework for Ocean Action in Mitigation (SEAFOAM) project.

The report aims to contribute to the conversation on ocean-based climate mitigation and provide insights on the interplay between climate action, ocean protection and the broader sustainable development goals.

Read more details on the research and findings in the SEAFOAM Phase 1 Technical Report available on the Climateworks website.

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.

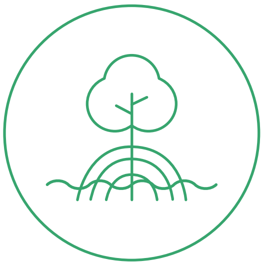
Indonesia's blue carbon is globally significant, housing 17 per cent of the world's mangrove and seagrass forests (Alongi et al. 2016). However, rates of decline of mangroves and seagrasses could have a significant impact on the country's emissions profile.

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



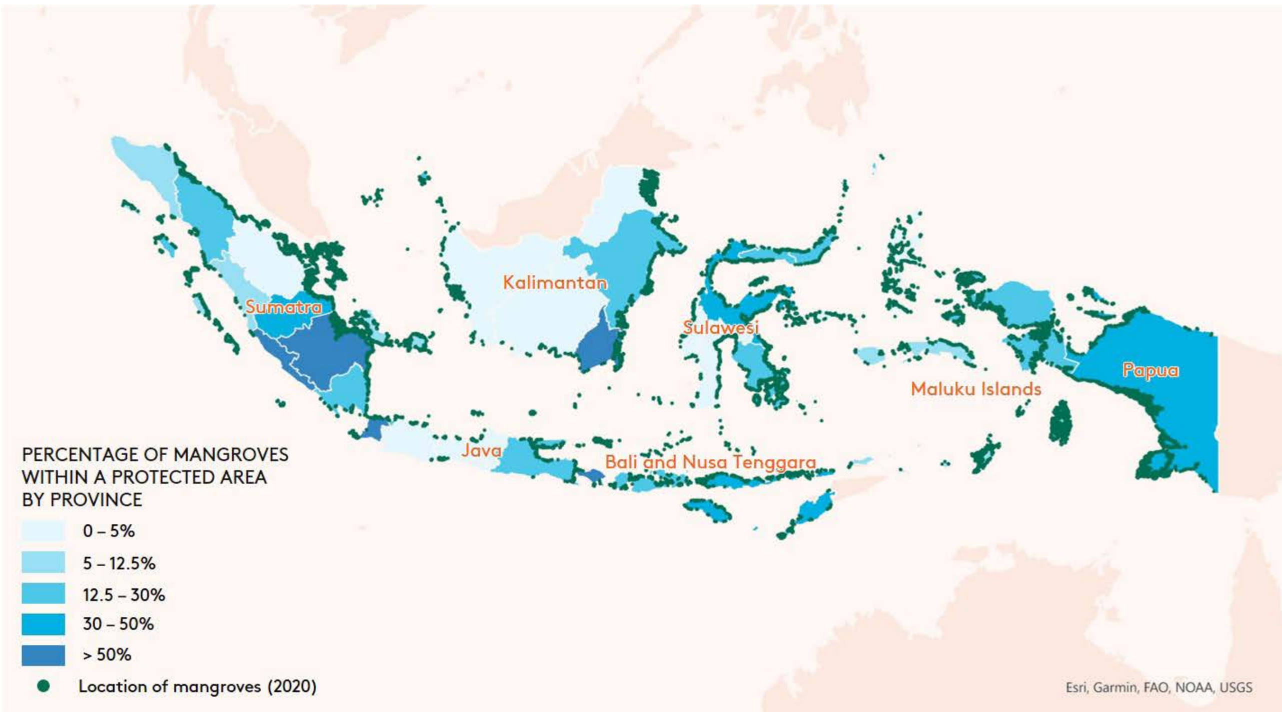
Mangroves act as critical long-term carbon sinks. Their ecosystems also provide a multitude of environmental and societal benefits such as protection against storm surges and tsunamis for coastal regions, habitats for biodiverse coastal species, ecotourism activities, wood production and a local source 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.

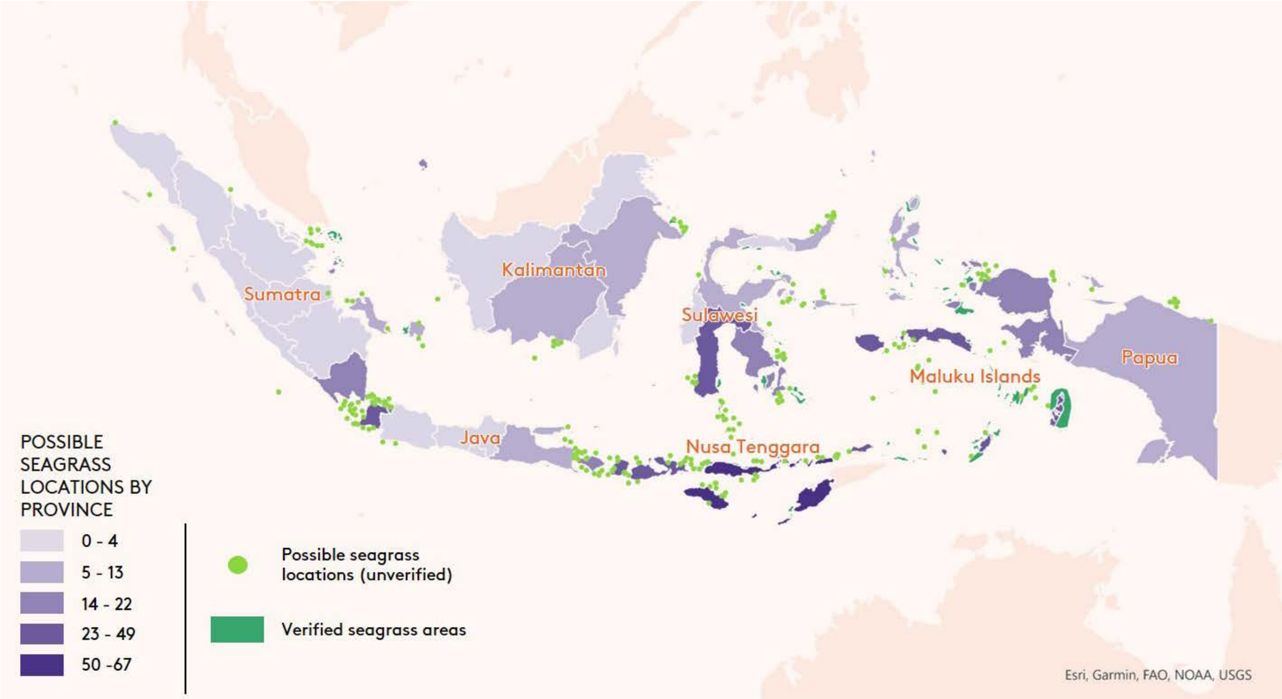
Globally, the role of blue carbon ecosystems in climate change mitigation has focused on mangroves as a carbon sink, and prioritised their protection and restoration. In contrast, seagrass ecosystems have received insufficient recognition, research and regulation.

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.

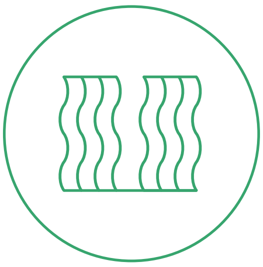
Indonesia's Second NDC – targets for inclusion

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



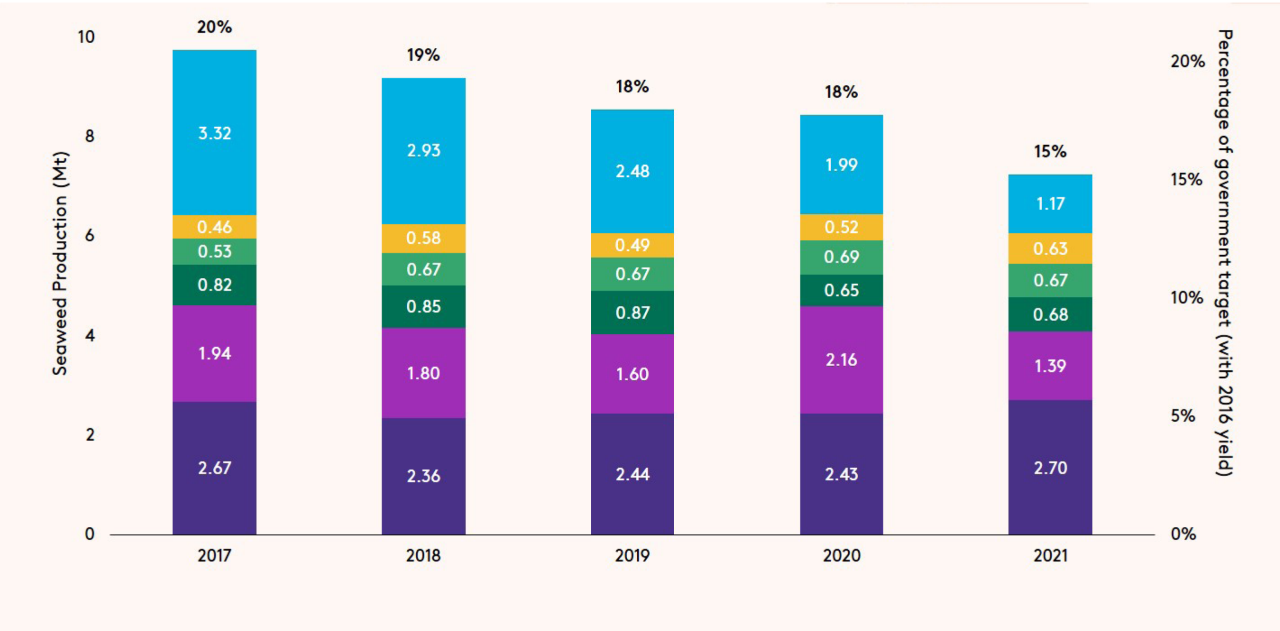
Seaweed ecosystems absorb carbon which is exported to the deep ocean where, if undisturbed, can be stored for long periods of time. The term seaweed refers to red, green and brown macro-algae ecosystems.

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.

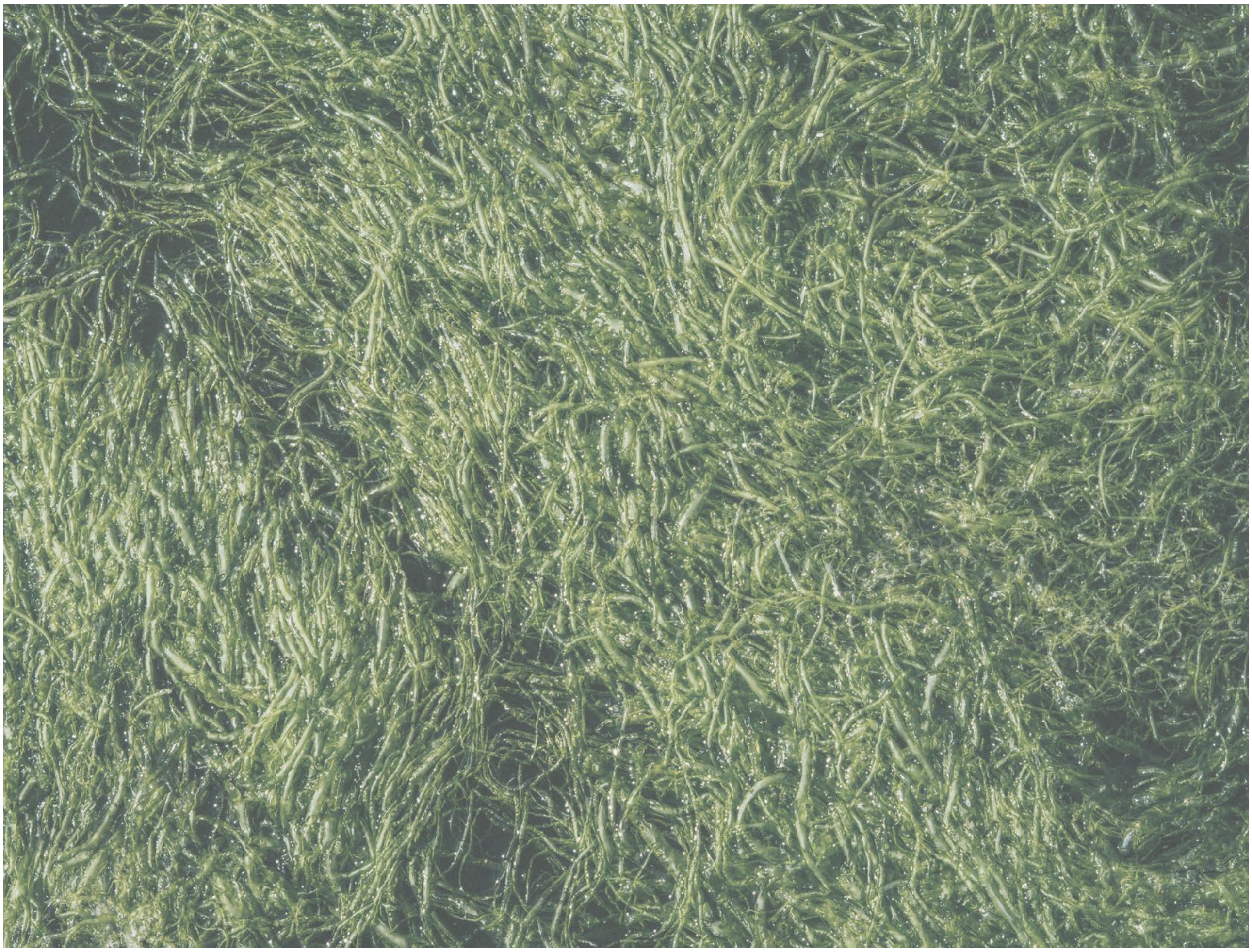
Indonesia's Second NDC – targets for inclusion

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).



Industry and infrastructure

The ocean is the primary passage for international trade, as well as providing a means of domestic freight and passenger travel. Maritime transport is of particular importance to Indonesia, a country consisting of thousands of inhabited islands.

Internationally, Indonesian territory occupies a strategic position for important trade routes between the Indian Ocean, Pacific Ocean and South China Sea. The most significant route is the Straits of Malacca, through which a third of global trade passes and estimated to be the most emissions-intensive trade route in the world (Wang et al. 2021).

These trade routes contribute to the high levels of air pollution that occur within the Indonesian territory. However, Indonesia also has a unique opportunity to lead a transition to a low-emissions future for the international shipping industry.

<table>
<tr><th>Industry and infrastructure: action and impact</th><th>2025</th><th>2030</th><th>2050</th></tr>
<tr><td>Domestic maritime passenger transport</td><td>+ Implement a route-specific analysis and commit to priority routes for electrification.
+ Develop an accurate and disaggregated inventory for the maritime transport sector.
+ Set a specific target for maritime passenger transport emissions reduction.</td><td rowspan="2">+ Reduce GHG emissions as an average across domestic maritime passenger transport by at least 20 per cent, striving for 30 per cent, compared to 2008 levels.
+ Transition 5 per cent of the domestic fleet to alternative fuel sources.
+ Identify and commence the transition toward the electrification of at least one suitable high-impact maritime passenger route.</td><td rowspan="2">+ In line with international targets, achieve net zero emissions across domestic maritime passenger transport and shipping.</td></tr>
<tr><td>Domestic shipping and ports</td><td>+ Explore low carbon emitting fuels for domestic shipping.
+ Commit to improvements in energy efficiency across the domestic fleet.
+ Develop an accurate and disaggregated inventory for the domestic shipping sector.
+ Set up a specific target for domestic shipping emissions reduction.</td></tr>
<tr><td>International shipping and ports</td><td>+ Transition to low-emission fuel production and bunkering.
+ Establish green shipping partnerships.</td><td>+ In line with international targets, reduce GHG emissions from international shipping by at least 20 per cent, striving for 30 per cent, compared to 2008 levels.</td><td>+ In line with international targets, achieve net zero emissions.</td></tr>
<tr><td>Seabed disturbance</td><td>+ Undertake an assessment of the extent of seabed disturbance from fisheries and other industries, as well as fisheries and industrial maritime vessel emissions.
+ Formulate and enforce stronger regulations on sand mining and limit sea sand exports.</td><td>+ Enhance knowledge on seabed carbon storage and release.
+ Enhance knowledge of artisanal fishing practices and facilitate conversion of those activities linked to seabed disturbance.</td><td>+ At least 50 per cent of seafloor protected via marine protected areas (MPAs) expansion.</td></tr>
</table>

Domestic shipping and maritime passenger transport are of particular importance to the more remote and disadvantaged areas of Indonesia. The five provinces most reliant on sea trade in Indonesia are concentrated in the remote east of the country (BPS 2022a; Zen and Yudhistira 2021). In recognition of this, the government introduced the Maritime Highway initiative and Sea Toll program, which subsidise maritime logistics and passenger transport between larger, more economically developed islands and smaller islands (BPK 2015).

Domestic shipping is an integral part of the economy and around five per cent of national transport emissions come from this sector. Domestic shipping emissions are likely to increase as economic growth continues in eastern Indonesia and the government pursues increased connectivity programs to the more remote areas of the country. This may be exacerbated by an imbalance in the flow of goods to these locations.

Passenger transportation by ferry is also vital to Indonesia. In 2021, there were 10 million more domestic trips by boat than journeys made by plane (DEPHUB 2021). Indonesian transport decarbonisation efforts would benefit from including domestic shipping and maritime passenger transport emissions reduction targets and policy commitments in its NDC.

Domestic maritime passenger transport

Domestic maritime transport is a key contributor to the economy. In Asia, the ferry industry supported 73,000 jobs and directly contributed US$3.3 billion to the region’s GDP in 2019 (Oxford Economics 2021). Indonesian maritime passenger transport is a key enabler of the movement of people between islands. In 2021, 74 million passenger journeys were made across Indonesian waters, compared with 64 million passenger journeys by aeroplane (DEPHUB 2021).

In an effort to reduce emissions from transportation, Indonesia's NDC has specified an increase in the use of biodiesel blends (Republic of Indonesia 2022b). The Indonesian government retains control of diesel supply across the country, and in February 2023, mandated an increase in the blend of biodiesel from 30 to 35 per cent (Rahmanulloh 2023).

Many vessels operating in the maritime passenger transport sector operate on diesel, and a large portion of this sector is impacted by this emissions reduction policy.

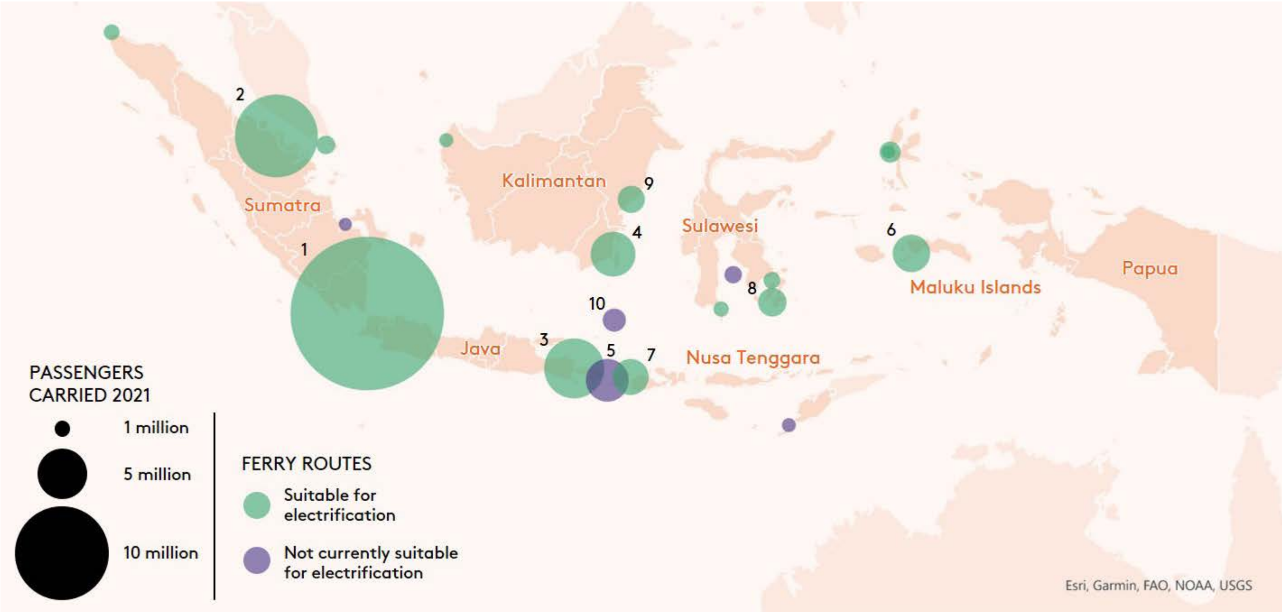
A focus on low-emission production as well as use is needed in relation to the adoption of biofuels. Biodiesel in Indonesia is derived from palm oil, and while its use may lead to reduction in transport sector emissions, there are concerns that the expansion of palm oil production actually drives a net increase in emissions from land use change (LPEM FEB UI 2020; Yasinta and Karuniasa 2021). Moreover, additional measures are needed for those vessels that operate on fuels other than diesel.

It is estimated that in 2018, the combined emissions from passenger ferries and mixed purpose ferries equalled 0.9 per cent of Indonesia’s 2019 transport emissions (Abhold et al. 2022). If the emissions from these vessels could be reduced in line with International Renewable Energy Agency (IRENA) decarbonisation pathways, this would achieve a reduction of 0.38–0.51 $MtCO_2e$ annually by 2030 and 1.0–1.5 $MtCO_2e$ annually by 2050.

Electrification is the most promising solution for vessels operating on routes that regularly call at a port. The electrification of ferries is a mature technology and is operational in a number of countries including across Southeast Asia, where significant developments have occurred in passenger vessel electrification. Figure 6 shows major ferry routes with the potential for electrification.

In addition to the opportunity for decarbonised transport, ferry electrification provides the added benefits of eliminating pollution from ferry operation, reduced journey times and reduced noise, resulting in improved passenger satisfaction. Furthermore, electric vessels have been found to lower underwater noise, thus reducing negative impacts of the sector on marine life (Parsons et al. 2019).

FIGURE 6: Commercial ferry routes in Indonesia (data for 10 most travelled maritime routes in 2021)



(Source: DEPHUB 2021)

Note: The map shows the location and level of traffic of major passenger ferry routes in Indonesia, highlighting routes that have technical potential for electrification.

In Indonesia, domestic maritime passenger transport has clear pathways for decarbonisation. Options to reduce maritime passenger transport sector emissions range from the near total elimination of emissions through electrification supported by renewable energy sources, to the introduction of lower emissions fuels.

Indonesia's Second NDC – targets for inclusion

NDC category:	Sub-sector mitigation target	Sub sector non-GHG targets
Targets for inclusion:	+ Reduce GHG emissions as an average across domestic maritime passenger transport by at least 20 per cent (striving for 30 per cent) by 2030, by at least 70 per cent (striving for 80 per cent) by 2040 as compared with 2008 levels, with a goal of net zero emissions by 2050.	+ Transition five per cent of domestic fleet to alternative fuel sources by 2030. + Identify and commit to the electrification of high impact suitable maritime passenger routes.

Current targets and mitigation strategies for the transport sector are primarily based on energy efficiency measures which aim for 15,197,000 electric vehicle units and the adoption of low carbon emitting fuels such as Compressed Natural Gas fuelled public transport. However, these policy measures are focused on land transport, and there is a need for the inclusion of specific emissions mitigation targets for domestic maritime passenger transport. The most relevant major mitigation strategy is an increase in the use of low-emission and sustainably sourced biodiesel blends with the aim of reducing the lifecycle emissions of fuel usage.

Domestic shipping and ports

Indonesia comprises over 17,000 islands, and due to this geography, domestic shipping is a key part of the economy. Around five per cent of national transport emissions come from the domestic shipping sector. In 2021, almost four million tonnes of domestic cargo were unloaded at Indonesian ports, with eight of Indonesia's 34 provinces relying on the sector for over 60 per cent of their trade with other provinces (Figure 7).

Indonesia aspires to become the 'global maritime fulcrum', a policy which has driven growth in the number of ships built and expansion of port infrastructure. However, almost all vessels built or registered in Indonesia are designed to use diesel or other fossil fuels. As the international shipping industry transitions to alternative low-emissions fuels, there is the risk that high cost retrofits will be required to avoid these vessels becoming stranded assets.

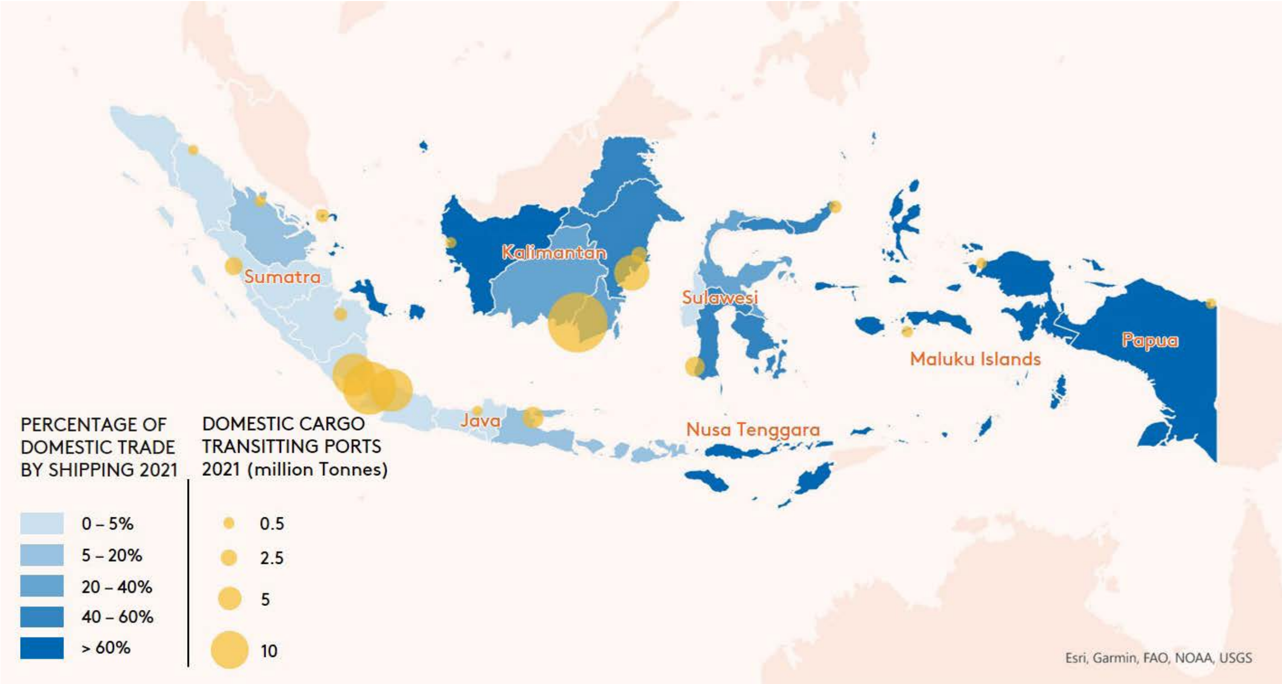
Notwithstanding Indonesia's heavy reliance on domestic shipping, there is a lack of monitoring and reporting frameworks. There is also a lack of detailed data on emissions related to domestic shipping activities, which limits data analysis and the assessment of decarbonisation solutions.

As with domestic passenger freight transport, the government's key decarbonisation strategy is the increased use of biodiesel blends. However, many other options exist for the decarbonisation of this sector, including energy efficiency improvements and a transition to low-emissions fuel and energy sources. There is also scope for energy efficiency improvement in the Indonesian domestic shipping fleet. A study found that 26–78 per cent of oil tankers could meet international energy efficiency regulations through engine technology improvements, weather rerouting and solar panels (Budiyanto et al. 2022).

Operational measures, such as slow steaming and weather routing can have a significant impact. Reducing vessel speed could achieve emissions reductions of 19–23 per cent (Ichsan 2019). Better route design can lead to emissions reduction across the whole transport sector; for example, a new freight shipping route between Java and Sumatra could avoid 24 ktCO_2e annually by reducing the distance higher emitting or lower capacity vehicles travel on land (Arianto et al. 2022).

Low-emissions energy supplies can be used to aid sector decarbonisation with vessels using electricity from the grid while docked or tug boats using batteries charged from the grid. A consortium has announced plans to manufacture e-tugs in the Asia–Pacific region with construction occurring at a shipyard facility in Batam, Indonesia (The Maritime Executive 2022). These decarbonisation solutions could be applied in-country as well as exported to the region, providing the additional benefit of promoting Indonesian manufacturing and investment opportunities.

FIGURE 7: Indonesia's domestic shipping and ports



(Sources: BPS 2022a; 2022b)

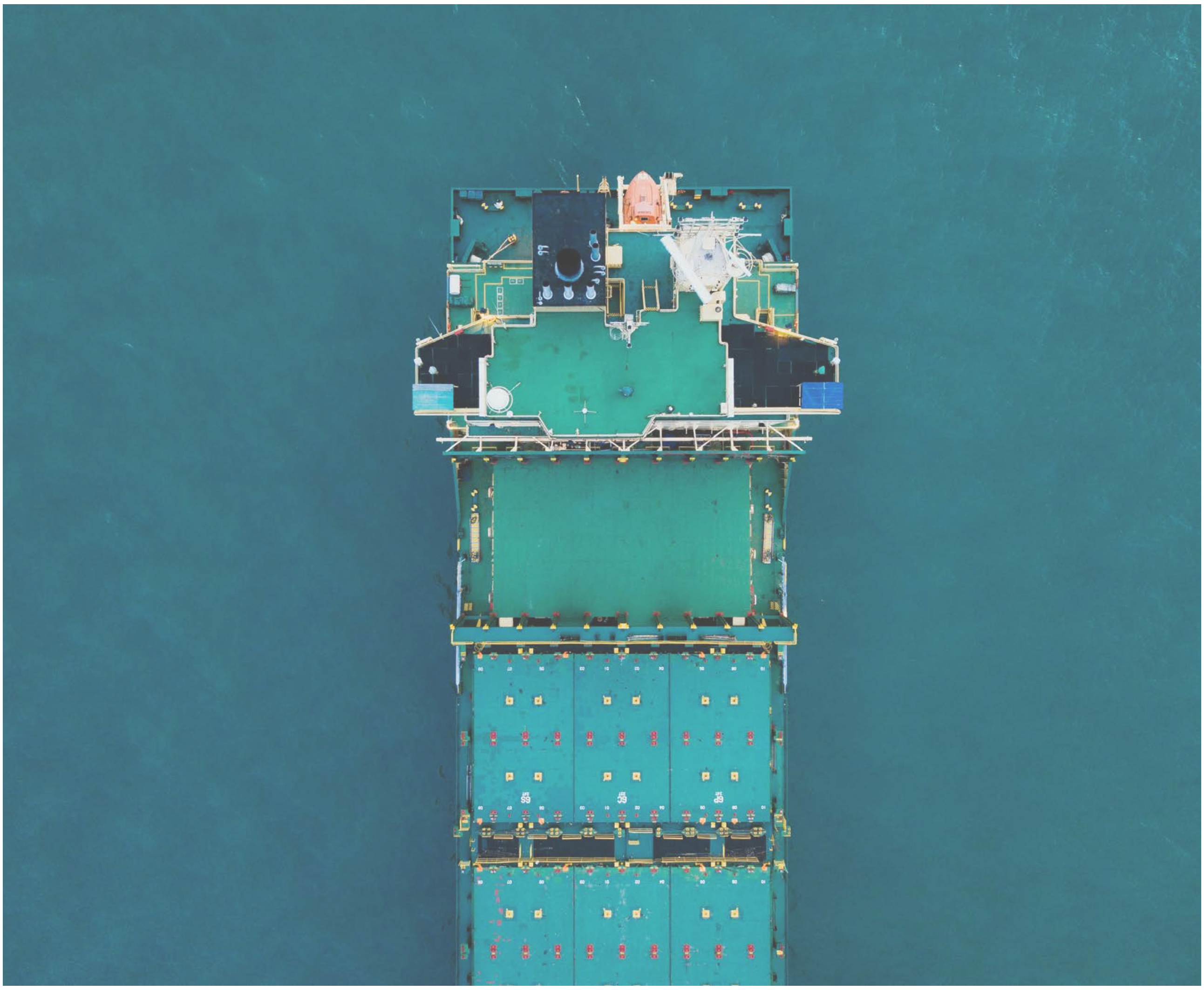
Note: Percentage of domestic trade conducted by shipping for Indonesian provinces and cargo loaded/unloaded at 20 strategic ports.

Domestic shipping is a key part of Indonesia's economy. If emissions from this sector were reduced in line with IRENA decarbonisation pathways, they would achieve a reduction of 1.9–2.6 $MtCO_2e$ annually by 2030 and 5.2–7.4 $MtCO_2e$ annually by 2050.

Indonesia's Second NDC – targets for inclusion

NDC category:	Sub-sector mitigation target	Sub sector non-GHG targets
Targets for inclusion:	+ Reduce GHG emissions as an average across domestic shipping by at least 20 per cent (striving for 30 per cent) by 2030, by at least 70 per cent (striving for 80 per cent) by 2040 as compared with 2008 levels, with a goal of net zero emissions by 2050.	+ Transition five per cent of domestic shipping fleet to alternative fuel sources by 2030. + Identify shipping routes for the deployment of low net production and low-emissions alternative fuels.

This is an opportunity for Indonesia to become a world leader in increasing global ambition to reduce the sector's GHG emissions. A target at least as ambitious as the International Maritime Organization's (IMO) should be set for the domestic maritime freight sector. This would be well supported by a commitment to the transition of 5 per cent of domestic shipping fleet to alternative fuel sources by 2030.



International shipping and ports

The international shipping industry is a key part of Indonesia's economy. In 2021, goods worth US$223 billion were exported from Indonesian ports (BPS 2022b), equivalent to about 19 per cent of the country's GDP that year (UNCTAD 2022) (Figure 8). Indonesia is the third largest supplier of seafarers in the world, with the sector providing employment for around 900,000 Indonesians (UNCTAD 2022). International shipping is regulated by the IMO, not the Paris Agreement. Indonesia's active involvement within this forum will be important for decarbonising and securing a low-emissions future.

In 2018, GHG emissions from Indonesia's maritime exports were estimated to be 25 $MtCO_2e$, while imports contributed 13 $MtCO_2e$, together representing 3.6 per cent of international shipping emissions globally (UNCTAD 2022).

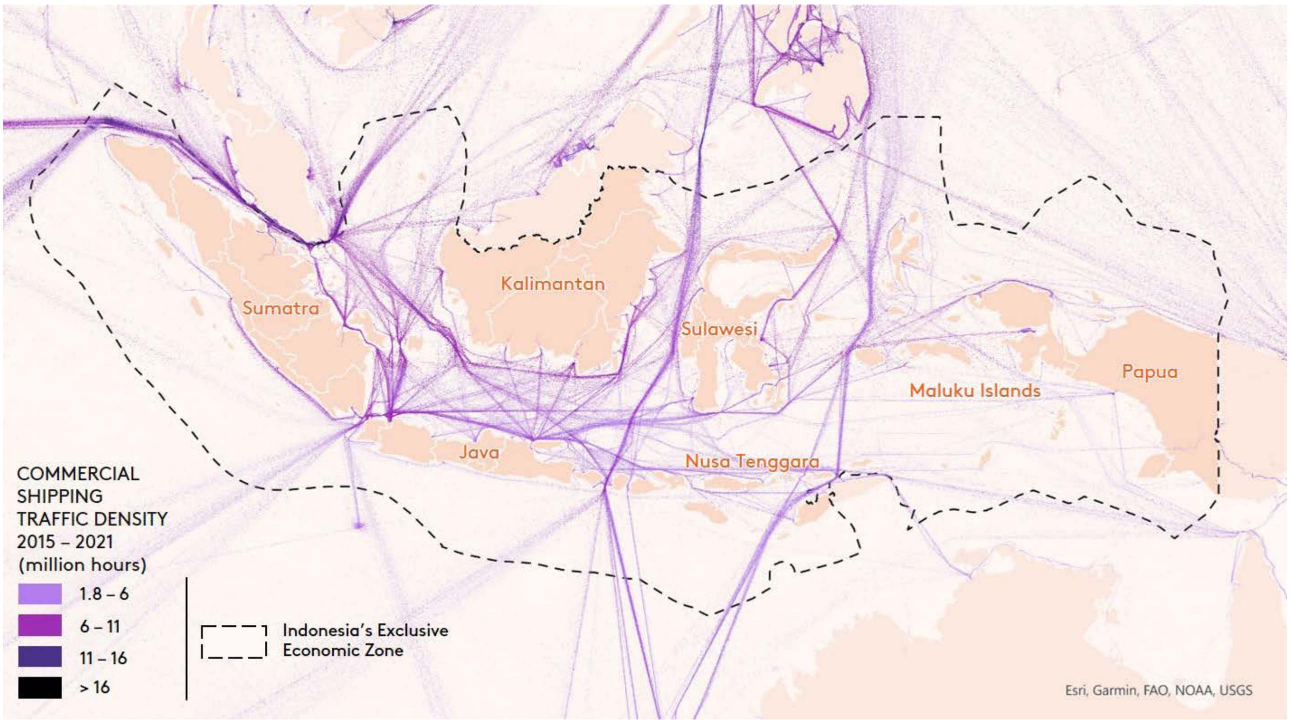
Reducing emissions from international shipping activities in line with IRENA 2021 targets would achieve an annual emissions reduction of 10.3–13.9 $MtCO_2e$ by 2030 and 28.3–40 $MtCO_2e$ by 2050.

The shipping sector is heavily reliant on fossil fuels such as diesel, heavy fuel oil and marine gas, with low-emissions alternatives at early stages of commercial readiness. Vessels have an operational lifespan of between 30 and 50 years, meaning that many existing vessels will require costly retrofits. The cost of upgrades to onshore infrastructure to support the transition to a decarbonised shipping sector are high. In spite of these challenges, a global movement towards international shipping decarbonisation is slowly progressing.

To become a hub for international maritime trade and leverage its unique strategic position, Indonesia must develop facilities to produce and supply low-emissions alternative fuels such as hydrogen and ammonia. The concept of Green Shipping Corridors (DfT UK 2022) aims to facilitate partnerships between multiple ports, operators and other stakeholders to accelerate emissions reductions and ensure that vessels can continue to operate on important trade routes. Engagement with this could attract investment from the shipping industry and provide new funding to assist with the development of renewable energy resources and the decarbonisation of Indonesia's energy system (Smith et al. 2021).

Indonesian ports can also act to reduce their own emissions impact. In a 'green port' (Arof et al. 2021), indicators are used to consider environmental impacts across a variety of areas including air quality, water quality, waste management, dredging activities and port development. Individual ports have the ability to reduce emissions and control environmental impacts within their waters through the control of fuel types, measures preventing discharge of wash water, the prioritisation of ships based on environmental performance (International Transport Forum 2018), and the use of technology systems to reduce ship waiting and turnaround times. Once docked, vessel emissions can be reduced through 'cold ironing', where vessels are connected to an onshore power source, rather than the use of onboard auxiliary engines for power (Zis 2019).

FIGURE 8: Commercial shipping traffic density in Indonesia and surrounding areas 2015-2021



(Sources: Marine Regions 2019; World Bank 2023)

Note: International shipping is integral to Indonesia's economy with maritime exports valued at 19 per cent of Indonesia's GDP leaving the country in 2019. The sector is intrinsically linked to the energy sector and decarbonisation plans between the two sectors have the potential to be mutually beneficial.

Indonesia's Second NDC – targets for inclusion

International shipping emissions are not included in Indonesia's national accounts. Under international shipping plans, Indonesian commitments should align with internationally agreed targets to reduce GHG emissions by at least 20 per cent (striving for 30 per cent) by 2030 and by at least 70 per cent (striving for 80 per cent) by 2040, as compared with 2008 levels. These progressive targets would support a strengthened goal of net zero emissions by 2050.

Seabed disturbance

The seabed is one of the most significant stores of carbon on the planet, with nearly twice as much carbon stored in the sediment of the seabed than in soil on land.

However, the global seabed remains widely underexplored, hampered by both inaccessibility and governance complexities. The resulting scientific uncertainties and gaps in knowledge mean that the impacts of seabed disturbance are often overlooked, which leads to the unaccounted release of carbon stored in the ocean seafloor.

The most common activities associated with sedimentary carbon disturbance are bottom trawling, dredging and various forms of seabed mining. Few regulatory safeguards are in place for these activities, which means there is scope for improvement across the entire process from assessment, to management, implementation and monitoring.

Discussions about Indonesia's seabed have largely focused on mining, shipping and fishing activities. More recently, the seabed has been recognised as a significant carbon sink through sequestration by blue ecosystems such as seaweed and kelp (Hurd et al. 2022). New marine protected areas may need to consider seabed carbon storage as a key part of the conservation imperative (Atwood et al. 2020; Howard et al. 2017).

Bottom trawling

Seafood is a major source of nutrition for people, particularly in Southeast Asia where fish contribute to a large portion of dietary protein. Harmful fishery practices, however, have severe negative consequences on the environment. Bottom-trawling is a globally dominant fishing practice that involves dragging weighted nets along the seafloor to catch fish (He et al. 2021).

Analysis based on data from Sea Around Us (2019) on bottom-trawled fish catch in Indonesia's three Exclusive Economic Zones areas – Central, Eastern and Indian Ocean – shows that during the period of 2010–2019, around 1.04 Gt of CO_2 emissions resulted from bottom-trawling activities.

Seabed mining and dredging

Shallow water mining creates seabed disturbance due to its intensity and the practices used, such as dredging, which severely alter seabed ecosystems.

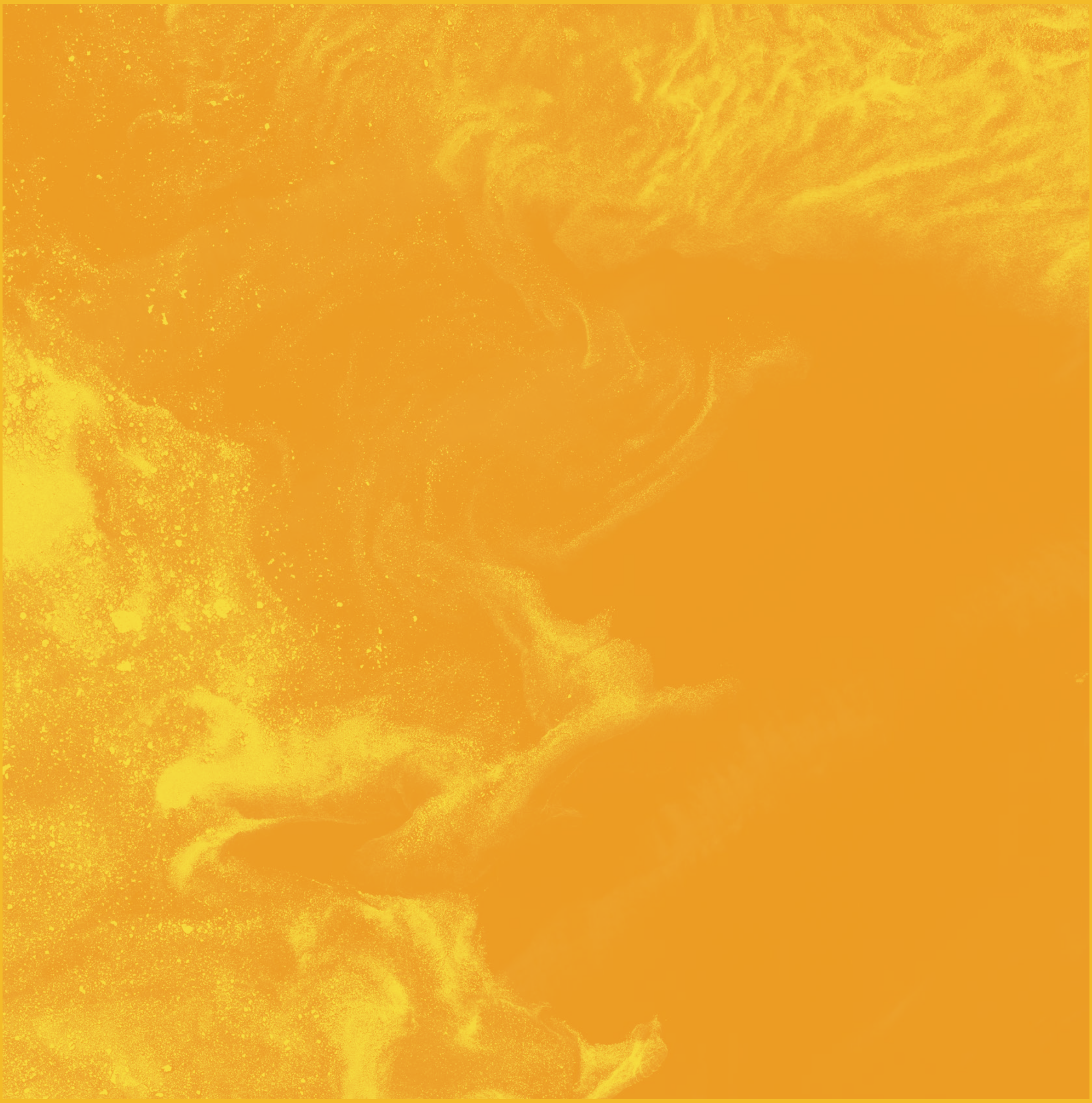
Operations in shallow waters in Indonesia appear considerably under-regulated. Tin is one of the key minerals extracted in seabed mining activities and Indonesia also has an industry in more traditional sand mining.

To date, Indonesia has not participated in international seabed management activities. Seabed governance is of critical importance for an archipelagic nation such as Indonesia, and national seabed regulations are still undergoing formulation (Widiastuti 2022).

Indonesia's Second NDC – targets for inclusion

Indonesia's 'Enhanced NDC' does not contain any existing commitments to limit seabed disturbance.

The formulation and implementation of strong regulations on sand mining is critical, as well as limitations on sea sand exports. There is also the need to fill the substantial knowledge gaps on seabed carbon storage, release and flux, as well as further understand the extent of artisanal fishing practices, particularly those linked to seabed disturbance. With an increased understanding, seabed disturbance would be a future area for inclusion in a new Ocean Use and Ocean Change sector in Indonesia's NDC.



Offshore renewable energy

Over the past 30 years, Indonesia's population has increased by more than half, with energy demand increasing by around 237 per cent. Although population growth is expected to slow, electricity demand is forecast to grow by 4.9 per cent annually by 2030, in line with Indonesia's ambition to become the world's fifth-largest economy by 2045.

Indonesia's 'Enhanced NDC' commits to expanding renewable energy generation. Offshore renewable energy could play a key role in supplying this growing energy demand as well as in Indonesia's just clean energy transition.

The marine environment has the potential to provide multiple sources of clean energy through offshore wind farms as well as renewable ocean energy. This latter category includes wave energy, tidal energy, and ocean thermal energy conversion (OTEC). Deployment of renewable offshore energy offers the same low-emissions advantages as onshore, but without the requirement for land.

Offshore renewable energy: action and impact	2025	2030	2050
Offshore renewable energy	+ Conduct further research to enable parameter setting and science-informed site selection. + Advance the inclusion of offshore renewable energy as part of the energy mix in Indonesia.	+ Commit to institutionalise energy equity, particularly in remote locations and energy-impoverished communities. + Commit to incorporate grid infrastructure upgrades to the national planning strategy. + Ensure government financial support for renewable energy is at least equal to, and where possible higher than, fossil fuel-based energy subsidisation and support.	+ Achieve grid-ready infrastructure, installed and operative across the country. + Achieve sustainable, equitable energy distribution and access.
Tidal energy	+ Conduct research and site-based feasibility studies for tidal stream deployment and impacts of tidal technologies. + Establish parameters and procedures for the selection and approval of offshore tidal facilities, stressing the need for rigorous environmental impact assessments.	+ Deploy pilot tidal energy projects in at least three locations in Indonesia.	+ Achieve institutionalised and regulated offshore tidal facilities.
Wave energy	+ Conduct feasibility studies for pilot deployment in identified locations.	+ Pilot deployment providing commercial readiness of wave energy technologies.	+ Achieve sustainable, widespread use of wave energy technologies.
OTEC	+ Explore production of zero-emissions fuel or electricity generation from OTEC alongside rigorous environmental impact assessments.	+ Pilot deployment providing significant grid infrastructure upgrades in the lead up to 2050.	+ Achieve pilot deployment and prospected expansion.
Wind energy	+ Explore and facilitate low-speed and high-speed wind technology and infrastructure, bearing in mind potential locations and their interactions with vulnerable ecosystems.	+ Deploy offshore high wind infrastructure in West Java and South Sulawesi.	+ Produce 30 per cent of eletricity from offshore wind.

With its archipelagic geography, many coastlines and island channels, Indonesia has the opportunity to leverage the power of the ocean to enhance renewable energy generation. The theoretical potential of offshore wind is many times over the country's current total energy consumption level (Bosch 2018, IEA 2020a).

Offshore technologies, particularly tidal and OTEC are very predictable, meaning that they can complement onshore wind and solar technologies to provide a stable, resilient and continuous low-emissions energy system. Many potential wave energy sites are located near high energy demand areas, helping to fill the gap required to meet rising energy demands.

Apart from emissions reduction opportunities through renewable energy generation, the development of an offshore renewable energy sector also supports socio-economic benefits such as job creation and security, improving the livelihoods of rural communities and providing opportunities for increased private-public partnerships and the development of regional and local supply chains (Quirapas and Taeihagh 2021). Offshore energy also helps to address issues of energy access and equity for remote communities. It reduces reliance on fossil fuel imports, and in so doing, reduces communities' vulnerability to price fluctuations and other events affecting trade, such as pandemics and geopolitical conflicts.

Tidal energy

Tidal energy harnesses the changes in height of seawater due to the tides. Its key advantage over other renewable resources is that it does not depend on weather.

The two most common types of tidal generators are tidal stream and tidal barrage. Tidal stream turbines are placed in narrow straits where tidal current velocity is accelerated and work in a similar way to wind turbines. Tidal barrages use a wall to create a tidal reservoir where water is trapped at high tide and released through turbines to generate electricity.

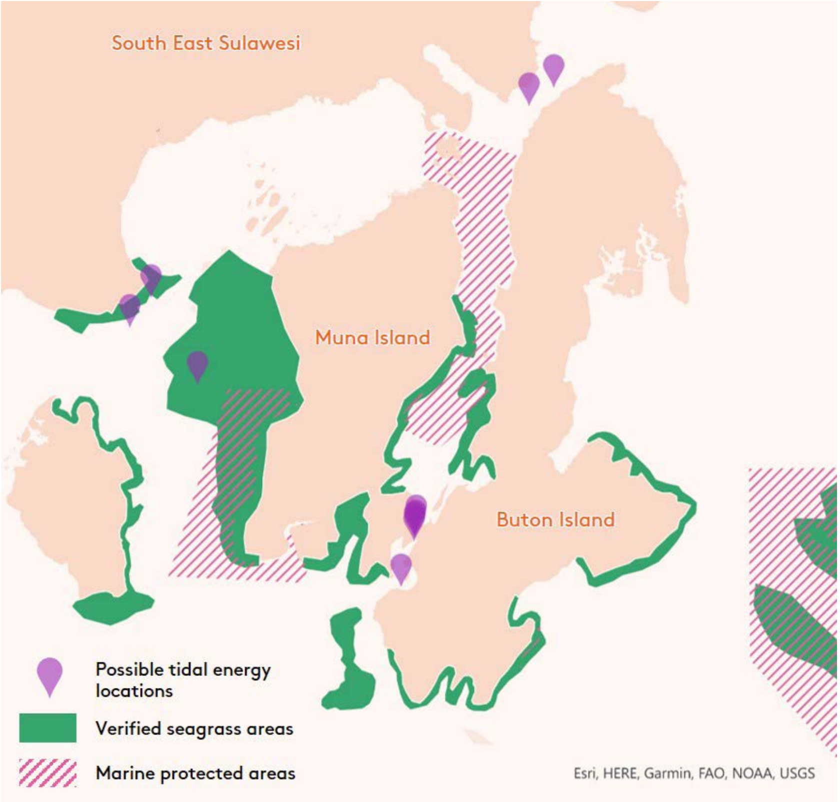
Tidal stream technology is still in the early stages of commercialisation but shows potential as a means of harnessing tidal energy with a much smaller impact on the environment than tidal barrages. There are environmental concerns regarding tidal stream technology which require careful consideration. These concerns include the impact on sediment distribution, which could affect seagrass meadows (Frid et al. 2012).

Indonesia's many islands and narrow straits possess strong tidal currents in many locations. This potential has led to interest from project developers, with the national power company, PLN, forming a partnership with British tidal energy company SBS International to conduct a feasibility study for the deployment of tidal energy in the Larantuka and Boleng straits.

The transition to renewable energy, in particular offshore, is often limited by cost competitiveness rather than technological readiness.

Of the 24 potential sites for the deployment of tidal stream devices, 11 were found to fall within a MPA or be in close proximity to a verified seagrass bed and are therefore not recommended for use in these locations. Of the 13 sites which were deemed to not have a negative environmental impact, 10 sites were found to be economically viable, with nine of these sites found around Buton Island in the province of South East Sulawesi (Figure 9).

FIGURE 9: Tidal stream sites around Buton Island in the province of South East Sulawesi



(Sources: Protected Planet 2023; Ribal et al. 2017; Sudo et al. 2021)

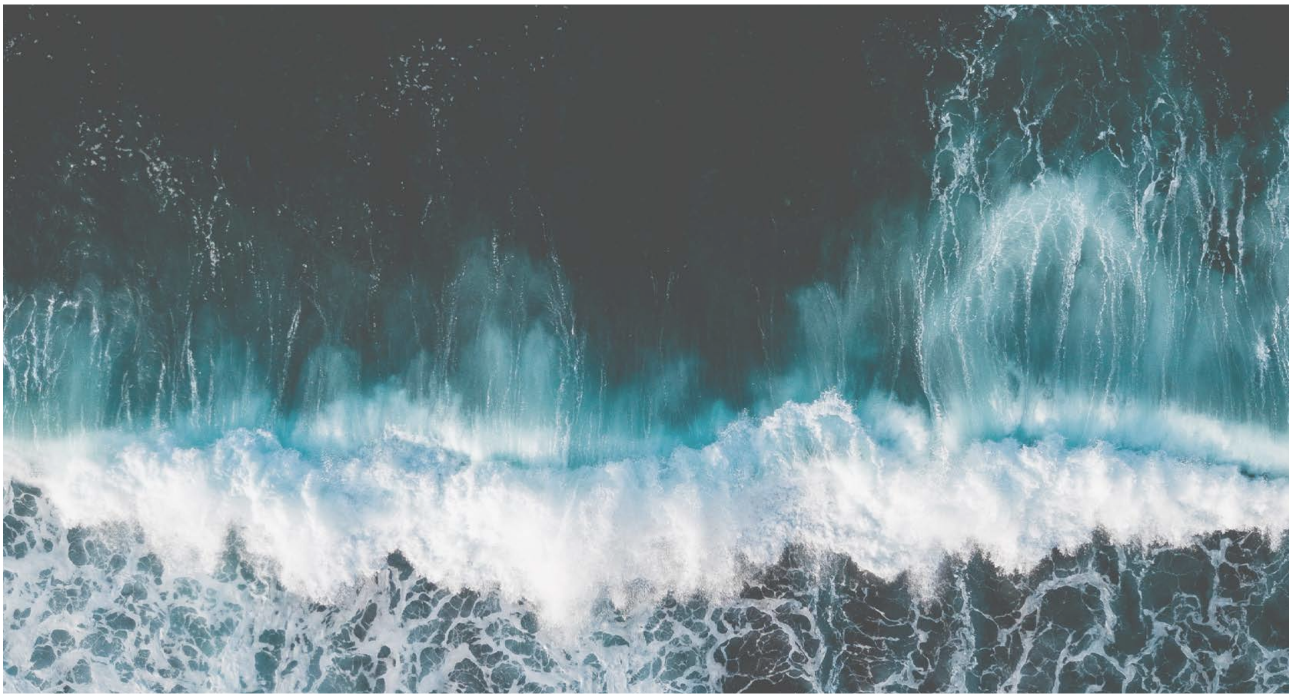
Note: Tidal stream sites with no currently identified environmental concerns could provide emissions mitigation of 0.85 $MtCO_2e$/year. Those sites which were also identified as being economically viable could provide 0.38 $MtCO_2e$/year, contributing to 0.16 per cent of Indonesia's electricity demand in 2030.

Indonesia's Second NDC – targets for inclusion

NDC category:	Sub-sector mitigation target	Sub sector non-GHG targets
Targets for inclusion:	+ Renew commitment to, and accelerate adoption of, current renewable energy targets.	+ Specify and increase use of ocean-based renewable energy potential, including tidal.

In Indonesia's 'Enhanced NDC', the main mitigation strategy for the energy sector is the expansion of renewable energy generation, primarily focused on geothermal, hydropower, solar PV, onshore wind, biomass and biofuel. Offshore renewable energy has yet to be considered as a viable source of renewable energy in Indonesia's 'Enhanced NDC'.

There is a need to research tidal stream deployment at appropriate locations as well as the impacts of tidal energy technology on Indonesia's blue carbon and other sensitive ecosystems. Feasibility studies for deployment in identified locations could confirm that tidal energy could be both economically viable without having an adverse environmental impact. There is the opportunity to set ambition for offshore renewable energy which includes tidal and commit to identifying appropriate sites for offshore tidal facilities.



Wave energy

Harnessing the power of waves to provide electrical energy is not a new concept. European countries have led the development of wave technologies, driven by the high wave energy densities in the Atlantic Ocean.

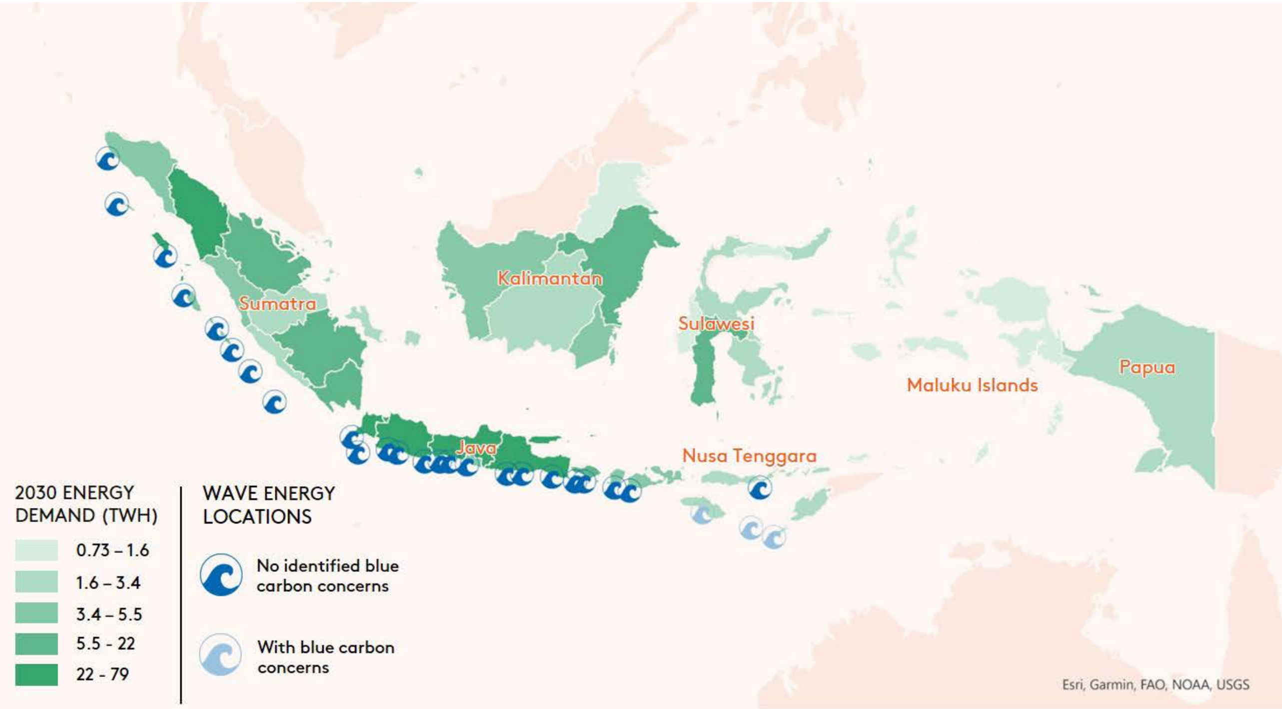
Similarly, the Indian Ocean possesses high energy waves which offer an excellent opportunity for Indonesia's major population and energy demand centres on the islands of Java and Sumatra (Figure 10). The national power company, PLN, has committed to explore the commercial and technical aspects of the deployment of wave energy. Many potential wave energy locations are situated near areas of high energy demand, which suggests that wave energy could be used to meet rising energy needs if properly connected to grid infrastructure.

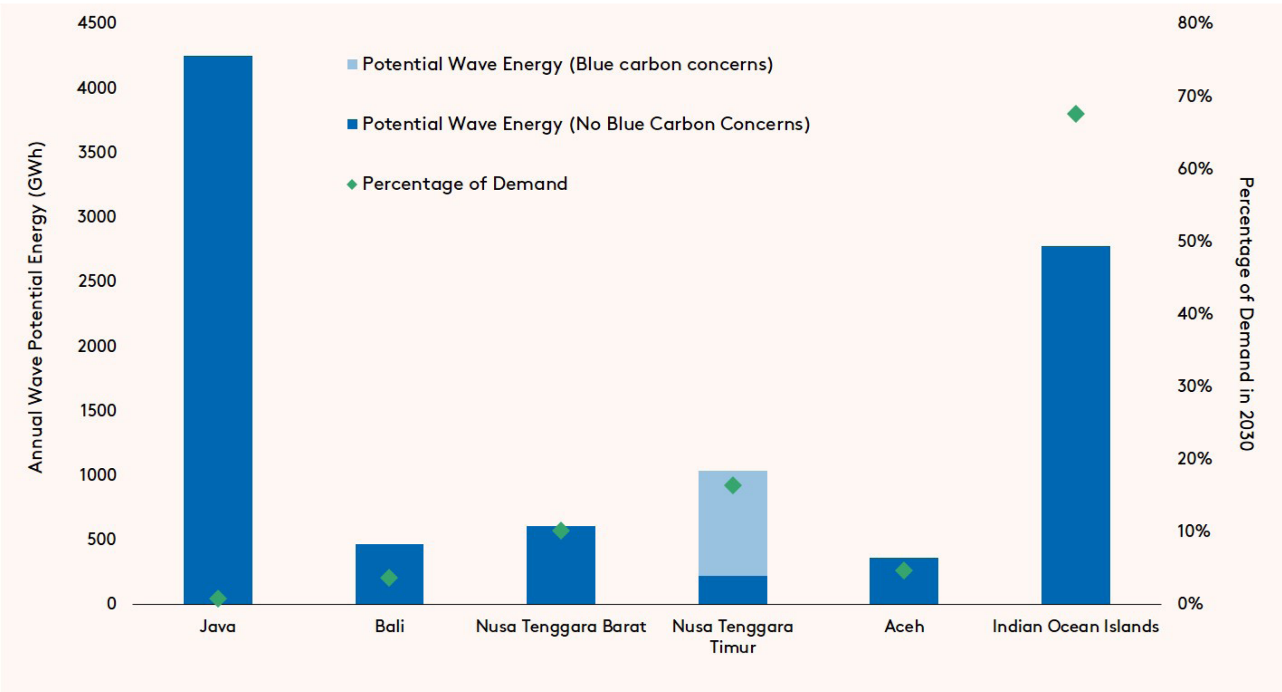
One of the advantages of wave technologies is that their environmental impacts are relatively limited. In fact, subsea structures can in some cases provide artificial reefs which enhance local biodiversity. Nearshore and onshore wave energy devices can also dampen storm surges and waves, so as to reduce erosion and provide protection to coastal communities.

Wave energy in Indonesia presents promising initial results with an estimated potential total wave power as high as 2–3 TW (Badriana et al. 2021) – utilising just three per cent of this would be equivalent to Indonesia's installed capacity in 2021 (International Trade Association 2022). Wave energy projects can provide a significant impact in terms of renewable energy generation share and hence emissions mitigation, as well as addressing issues around energy security, exposure to fuel price volatility and low electrification rates. Wave energy could also reduce the logistical need to transport fuels such as diesel to the islands to provide power.

Just under 30 semi-remote sites have been identified that could have a significant impact as pilot projects. Small islands that are often off-grid and rely heavily on diesel generators offer an ideal location for the deployment of pilot projects. Such projects are of vital importance in demonstrating to both government and financiers the scale and viability of such installations as well as to build up expertise in the operation of such facilities, providing Indonesia with a potential leadership role in the region.

FIGURE 10: Potential wave energy sites are largely in close proximity to areas of high energy demand





(Sources: IEA 2022a; Rizal and Ningsih 2020; Rizal et al. 2019; Triasdian et al. 2019)

Note: While potential for wave energy is significant, it is unlikely that widespread deployment of the technology will be possible by 2030. This is due to a lack of commercial readiness and shortage in expertise. However, deployment of pilot projects could accelerate progress towards deployment of commercial scale generation. One possible location for such deployment is at Enggano Island in the Indian Ocean, this would mitigate 0.13 $MtCO_2e$ annually.

Indonesia's Second NDC – targets for inclusion

NDC category:	Sub-sector mitigation target	Sub sector non-GHG targets
Targets for inclusion:	+ Renew commitment to, and accelerate adoption of, current renewable energy target.	+ Specify and increase use of ocean-based renewable energy, including wave energy, with commitment and priority given to the operationalisation of a pilot project.

In Indonesia's 'Enhanced NDC' the main mitigation strategy for the energy sector is the expansion of renewable energy generation, primarily focused on geothermal, hydropower, solar PV, onshore wind, biomass and biofuel. Offshore renewable energy has yet to be included as a viable source of renewable energy in Indonesia's 'Enhanced NDC'.

There is the need to deploy pilot projects in high impact and accessible locations, which will further the expansion of this technology to remote and off-grid islands and allow for accelerated deployment of commercial scale generation. To this end, Indonesia would benefit from the setting of ambition for the offshore renewable energy sector, which includes wave energy.

Ocean thermal energy conversion (OTEC)

OTEC is a technique that uses the temperature difference between cold deep-sea water and warmer surface water to drive a low-pressure turbine to produce electricity (Faizal and Ahmed 2011). It is particularly suitable for tropical areas where the surface water temperature remains almost uniform throughout the year.

OTEC is not currently used on a commercial scale due to high capital costs, ranging from US$4000 to US$8000 per kW (Adiputra et al. 2020; Koto 2016). However, the large capacities available from the technology, and its ability to provide a base load that reduces the requirement for backup generation, make it a promising technology for the future.

OTEC is most economical at a large scale. It is becoming cost-competitive against baseload power generation such as geothermal and coal, suggesting that OTEC's potential in Indonesia could be to provide continuous energy throughout the year and support more intermittent forms of energy supply such as solar and wind.

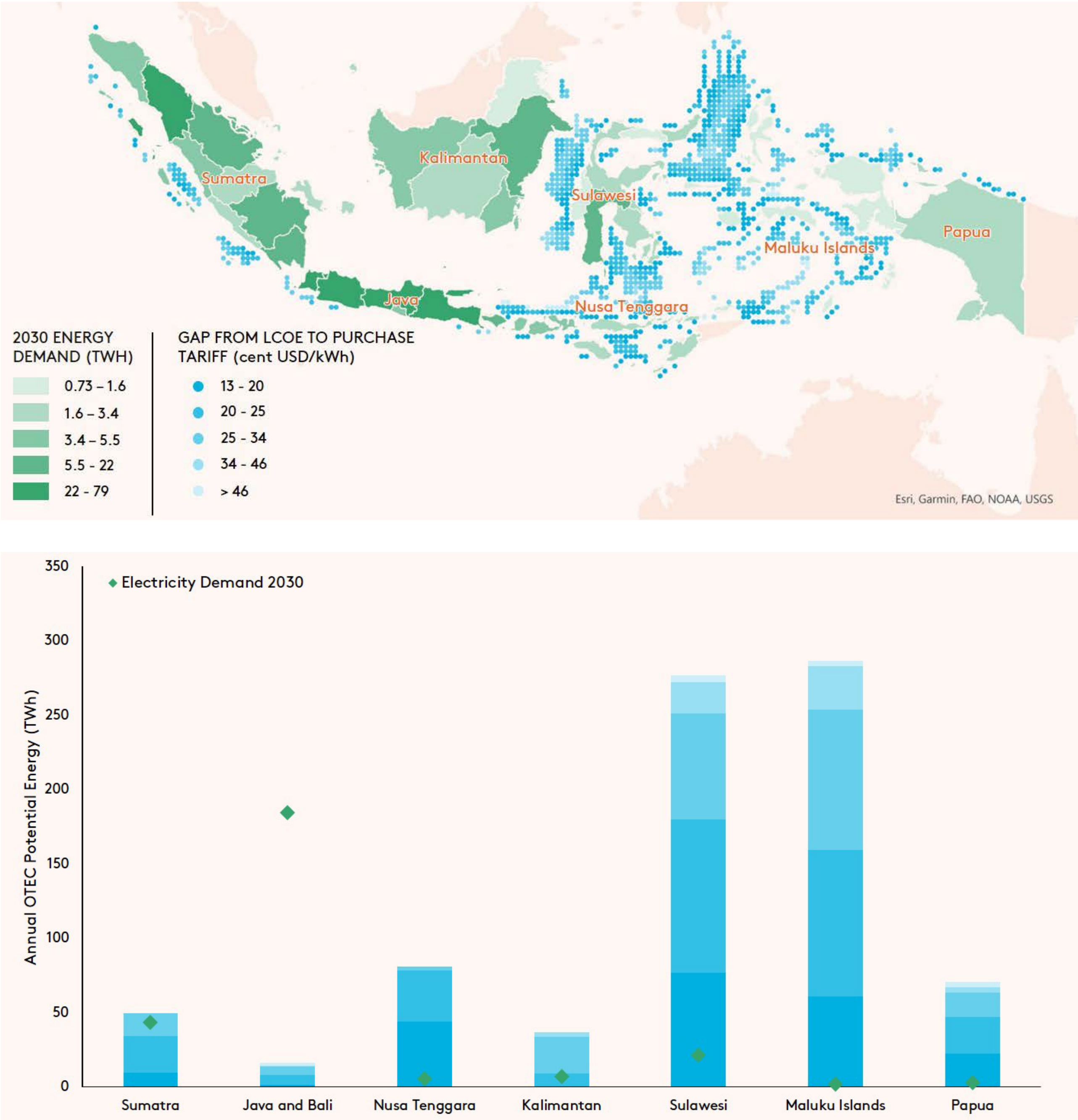
For OTEC to reach commercial scale, development must accelerate in the same way that wind and solar has in recent years. The supply chain for developing such plants needs to be fast-tracked, including large-scale production of the pipes required to transport water in the system. Policy and investment support are also needed (Langer et al. 2022a).

Much of Indonesia's ocean territory has potential for the deployment of OTEC, with the exception of the Java Sea and the Arafura Sea (Figure 11). There is huge potential, with around one thousand possible locations across Indonesia for the deployment of 100 MW capacity systems.

Although OTEC could provide significant emissions mitigation, concerns remain with regard to environmental impacts. The technology reduces the surface temperature of the ocean whilst increasing temperatures in deeper water. The consequences of this are largely unknown, but could be profound, potentially resulting in increased mixing of surface and deep waters, resulting in carbon dioxide stored in the ocean being released to the atmosphere.

Continued research and development could contribute to the reduction of costs and mitigation of the potential environmental impacts in order to accelerate widespread use of the technology.

FIGURE 11: Potential sites for OTEC deployment across Indonesia



(Sources: Langer et al. 2021; IEA 2022a)

Note: Provinces such as Maluku, North Sulawesi, Papua and West Papua have more than 1000 MW of OTEC capacity closest to being economically viable with Levelised Cost of Energy (LCOE) in the range of US$0.13–0.15 kWh, and emissions reduction potential of around 3.91 $MtCO_2e$ in 2023.

Provinces such as Maluku, North Sulawesi, East Nusa Tenggara, North Maluku, Papua, West Papua, West Sulawesi, South East Sulawesi and Central Sulawesi have more than 5500 MW of OTEC capacity with an LCOE in the range of $US0.15–0.17/kWh, with the highest potential in Maluku, North Sulawesi and East Nusa Tenggara, and emissions reduction potential of around 7.84 $MtCO_2e$ in 2030.

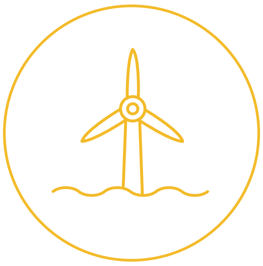
Indonesia's Second NDC – targets for inclusion

NDC category:	**Sub-sector mitigation target**
Targets for inclusion:	+ Renew commitment to, and accelerate adoption of, current renewable energy target.

In Indonesia's 'Enhanced NDC', the main mitigation strategy for the energy sector is the expansion of renewable energy generation, primarily focused on geothermal, hydropower, solar PV, onshore wind, biomass and biofuel. Offshore renewable energy has yet to be considered as a viable source of renewable energy in Indonesia's 'Enhanced NDC'.

There is a need to explore the production of zero emissions fuel or electricity from OTEC as well as explore the deployment of OTEC in the most economically viable locations.

Offshore wind



Offshore wind is currently the most sustainable source of energy generation, accounting for the lowest comparative lifecycle GHG emissions (Williams et al. 2022). While offshore wind holds the most immediate potential for Indonesia, it is not yet central to Indonesia's energy transformation plan.

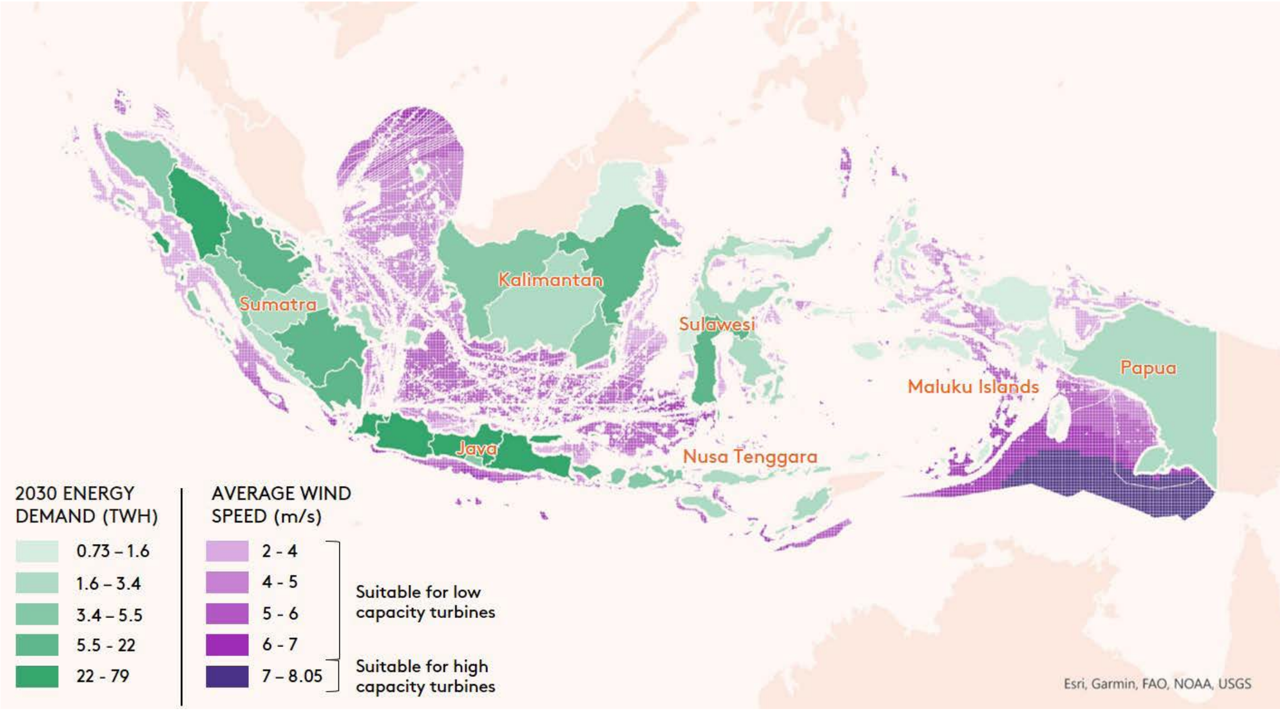
However, Indonesia's Blue Economy Development Framework does recognise offshore wind energy as one of the key emerging sectors. Recent developments include a memorandum of understanding (MoU) signed during the G20 summit in 2022 in Indonesia for the development of an integrated offshore wind energy and green hydrogen production facility (Pers 2022).

Multifaceted institutional barriers currently impede offshore wind development in Indonesia. These include barriers related to regulatory uncertainty, institutional uncertainty for investors due to energy development plans regularly changing, governance issues related to contracting, and the exclusion of wind farm capacity in generation infrastructure planning (Simanjuntak 2021).

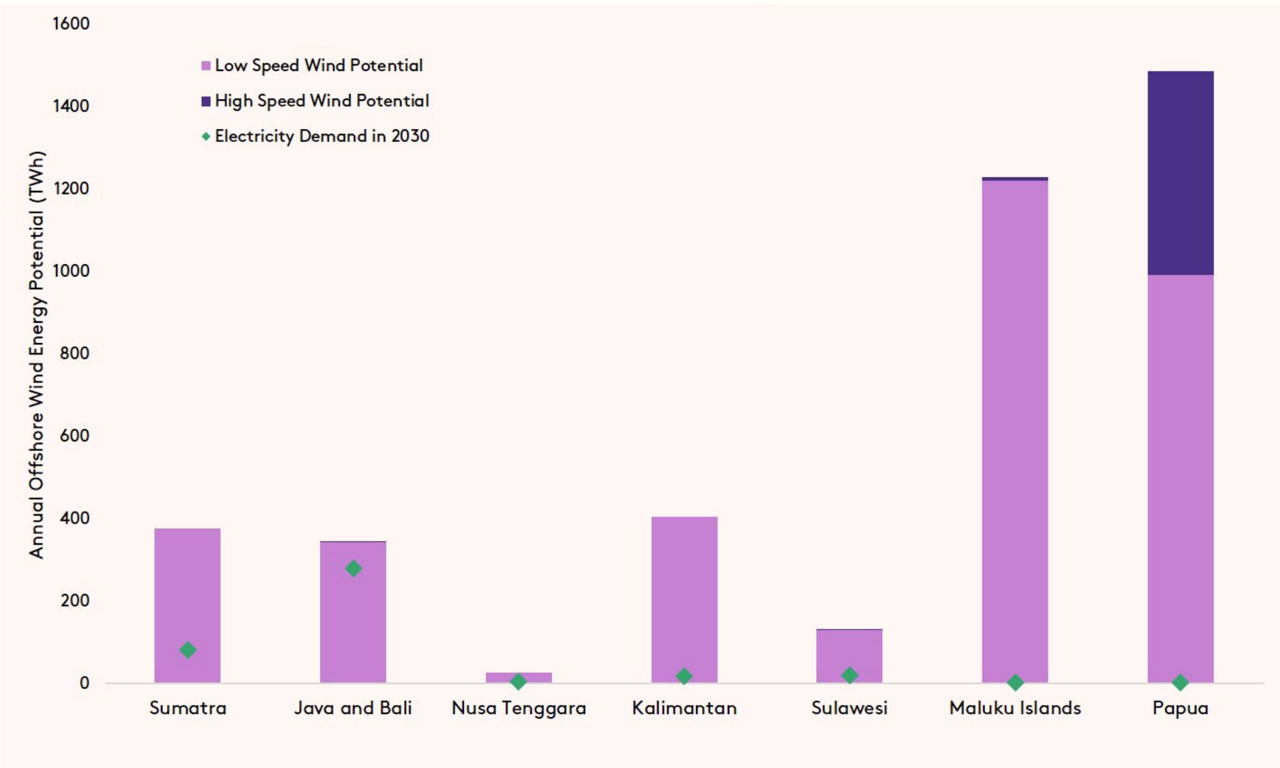
Implementation of specialised turbine designs such as vertical axis wind turbines that can run at wind speeds as low as 2 m/s (to up to 65 m/s) may be suited to Indonesia (Hidayat 2022). These are lighter and operate in all wind directions. They also have lower noise levels, lower incidence of bird collisions and lower cost of production compared to standard horizontal axis wind turbines.

Environmental impacts from offshore wind are lower compared to other offshore energy technology types. However, it should be noted that floating devices have hydrodynamic interactions with the potential to disturb wave patterns and impact on reproductive and migratory habits of marine life, food availability and nutrient distribution (Mendoza et al. 2019). Devices fixed to the ocean floor also have the potential to modify sediment transport patterns and limit or sometimes eliminate marine habitat. Options to mitigate some of these impacts are available and their codesign and application should be a priority.

FIGURE 12: Average wind speed distribution across Indonesia and projected electricity demand by 2030 by province



Note: Average wind speed is based on ERA-5 at 100 m as it offers the highest resolution, both geospatially and temporally.



(Sources: IEA 2022a; Langer et al. 2022b)

Note: Indonesia has several higher wind speed areas (reaching 7–8 m/s) along the coasts of West Java, Maluku, Papua and South Sulawesi that are suitable for deployment of high capacity high wind speed turbines, although commercial turbines are generally deployable in areas with wind speeds upwards of 6 m/s (ESMAP 2022).

Indonesia’s average wind speed is 4 m/s, making it also suitable for further research into wind turbines designed for low wind speeds (See Figure 12 for average wind speeds). The offshore regions of 26 provinces could be harnessed for low capacity offshore wind generation. This would be particularly useful in high-demand provinces such as East, West and Central Java, South Sulawesi, South Sumatra, Lampung and Bali.

Indonesia’s Second NDC – targets for inclusion

NDC category:	Sub-sector mitigation target	Sub sector non-GHG targets
Targets for inclusion:	+ Renew commitment to, and accelerate adoption of, current renewable energy target.	+ Increase renewable energy use across ocean and coastal environments initially with the establishment of offshore wind installations. + Ensure competitive subsidisation programs are in place.

In Indonesia's NDC, the main mitigation strategy for the energy sector is the expansion of renewable energy generation, primarily focused on geothermal, hydropower, solar PV, onshore wind, biomass and biofuel. Offshore renewable energy has yet to be considered as a viable source of renewable energy in Indonesia’s 'Enhanced NDC'.

There is the need to prioritise the development of an offshore, low-speed wind industry and explore the production of zero-emissions fuel or electricity production from offshore wind. There is also the opportunity to set targets for offshore wind deployment as part of Indonesia’s renewable energy goals and deploy high capacity turbines in high wind locations.

Conclusion

There is an urgent need for increased action to provide the greatest chance of limiting global warming to 1.5 degrees. The ocean offers a huge and largely untapped opportunity for countries to meet and raise their climate ambitions. Under the Paris Agreement, NDCs provide a vehicle to strengthen the articulation of and progress in ocean-based climate action. This report demonstrates how ocean-based mitigation and blue nature-based solutions can contribute to a net zero future for Indonesia and the world.

NDCs offer a mechanism for the integration of goals related to sustainable development, ocean resource management and climate. To date, however, there is no template for what this could look like at the national level. By taking a sectoral approach, this report highlights the opportunities and challenges present when moving beyond land-based action into systematic ocean-based climate action. It suggests a framework for the inclusion of such ocean-based action both within existing NDC sectors, where appropriate, and through the creation of a new 'Ocean Use and Ocean Change' sector where needed.

The ocean is too important not to protect – and too powerful not to utilise.

The opportunities presented in this report illustrate the wealth of technological innovations and nature-based solutions emerging in the maritime space. These form part of an emerging broader global conversation that aims to strengthen government responsibility and accountability related to coastal and marine areas and their biodiversity.

The findings in this report present an important opportunity for Indonesia. Leadership on ocean inclusions in their forthcoming 'Second NDC' could help solidify the country's role as a global leader in the maritime sphere and enhance Indonesia's position as a Global Maritime Axis. This is supported by Indonesia's regional leadership in coordinating international pledges, progressing blue sustainable economy planning, and promoting a just energy transition under a climate agenda. The findings from this report illustrate that the emissions reduction opportunity is clear:

Ocean-based climate action could enable Indonesia to bridge the gap to their net zero pathway by 49 per cent in 2050.

To achieve this, action needs to begin now.

The first step is leveraging Indonesia's Second NDC to:

+ Set explicit emissions mitigation targets, and protection and restoration strategies for mangroves and seagrasses to secure the longevity of these ecosystems by 2030, facilitated through the addition of an 'Ocean Use and Ocean Change' sector in the NDC to trace emissions and related commitments.
+ Set a decarbonisation target for domestic shipping and maritime passenger transport that is in line with the IMO strategy, and establish a plan to transition the sector towards electrification and alternative fuel sources by 2030.
+ Clearly articulate a commitment to pursue offshore renewable energy as an important part of the country's energy mix by 2050, and take immediate action towards developing a robust offshore energy industry through large pilot projects.

These steps establish the foundations for further action. Clear communication and explicit commitments must then be followed by policies and measures that create an enabling environment. These include:

+ robust and transparent carbon monitoring and reporting systems
+ a specific marine planning process that encompasses all maritime sectors and users, and includes consideration of the co-benefits and social implications of planning decisions
+ targeted establishment of marine protected areas that prioritise mangrove and seagrass ecosystems
+ implementation of energy efficiency and low-carbon fuels for domestic shipping
+ investment in feasibility studies (including grid and technical readiness, economic production opportunities, alignment with industrial expansion, and energy equity analysis) to further the deployment of offshore renewable energy.

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For a full list of References see the SEAFOAM Technical report available on the Climateworks Centre website.

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