Coastal area rehabilitation for climate change adaptation

The key role of mangroves in Nationally Determined Contributions

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WORKING PAPER 16

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Working Paper 16

DOI: 10.17528/cifor-icraf/008956

Jompa J and Murdiyarso D. 2022. *Coastal area rehabilitation for climate change adaptation: The key role of mangroves in Nationally Determined Contributions*. Working Paper 16. Bogor, Indonesia: CIFOR.

Translation of: Jompa J dan Murdiyarso D. 2022. *Rehabilitasi Kawasan Pesisir untuk Adaptasi Perubahan Iklim: Peran kunci mangrove dalam Nationally Determined Contributions*. Working Paper 12. Bogor, Indonesia: CIFOR.

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We would like to thank all donors who supported this work through their contributions to the CGIAR Trust Fund. A list of donors is available at: http://www.cgiar.org/about-us/our-funders/

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Executive summary

Mangrove blue carbon has significant climate change mitigation potential. This relates to the huge carbon stocks in mangrove ecosystems, which are 3–5 times higher than carbon stocks in protected tropical forests.

With a coastline of more than 90,000 km – the second longest after Canada–it is in Indonesia's interests to protect its coastal areas from climate change impacts, particularly as the majority of Indonesia's people live in vulnerable coastal areas. The high population densities in these areas require governments and communities to make the sustainable utilization of coastal areas a paradigm that must be continually mainstreamed. In addition to population pressures directly impacting coastal ecosystems, another threat is rising sea levels resulting from climate change. The enormity of the risks facing coastal areas makes them highly vulnerable.

Therefore, the existence and preservation of extensive coastal vegetation like mangroves and seagrasses are key to successful conservation and a nature-based solution to ongoing climate change. Regarding efforts to tackle climate change impacts, coastal ecosystems also present a huge opportunity for supporting Low Carbon Development (LCD) initiatives and Sustainable Development Goals (SDGs).

Positioning coastal area management in the Nationally Determined Contribution (NDC) is a smart move. The expectation is that coastal ecosystems, which are carbon rich and at the same time support the livelihoods of the majority of Indonesia's poor, can be managed wisely though the balancing of sustainable mitigation and adaptation measures according to direction under the Paris Agreement.

Coastal area rehabilitation/restoration needs to prioritize climate change adaptation. Therefore, the roles of coastal areas in overcoming rising sea levels, waves, coastal erosion, flooding, and inundation must be restored, so the resilience of communities, particularly fishing communities living in coastal areas, can be maintained or even enhanced.

Opportunities and challenges faced in mainstreaming coastal area and blue carbon mangrove ecosystems have been identified and should be anticipated when coastal areas are included in national strategies to achieve NDC targets. Coastal area resilience not only relates to physical aspects (abrasion, sedimentation, and flooding/inundation), but also community socioeconomic aspects and their supporting institutions. Therefore, information and funding flows must be transparent for all stakeholders, so adaptation agenda, decision making, and implementation can be carried out effectively, efficiently, and in a balanced manner.

This paper demonstrates efforts to bundle adaptation and mitigation measures to secure optimum outcomes in coastal area rehabilitation/restoration, as recommended in the Paris Agreement. It suggests adopting a responsive adaptation cycle so adaptive measures in these strategic coastal areas can commence immediately, and be monitored and evaluated. In this regard, emissions mitigation scenarios linked to adaptation measures can be considered to facilitate the achievement of 2030 NDC targets and SDG goals.

Foreword

Indonesia's large-scale mangrove rehabilitation programme has attracted the attention of many parties both inside and outside the country. This has happened in connection with the volume of work it entails and the time available for its implementation. A webinar was held on 31 March 2022 to ascertain public aspirations in relation to the programme. The webinar discussed three main topics: a long-term coastal region management strategy; coastal regions in climate change mitigation; and coastal regions in climate change adaptation.

This paper was prepared to outline opportunities for and challenges to positioning coastal area management as a priority agenda in climate change adaptation efforts. It also provides illustrations of prospective successes that could be achieved through several adaptation scenarios. Through these approaches, stakeholders can adapt by still considering anthropogenic factors and possible environmental changes as responses to interventions applied through the adaptation agenda.

Our hope is that all forms of initiatives offered in this paper can be developed in accordance with dynamics on the ground and the experiences of and lessons from stakeholders.

Jakarta, late July 2022

The editors

1 Introduction

Climate change adaptation is a logical response for humankind to build its durability in facing the consequences of climate change. IPCC (2022) indicated that adaptation together with mitigation measures constitute a combination of response systems in anticipating negative impacts and measures to overcome causes of climate change. Adaptation is undertaken to reduce vulnerability to the effects of climate change.

Due to high carbon saturation levels and carbon remaining in the atmosphere for hundreds of years, it will take time for Earth's temperatures to return to normal. Therefore, global warming will not only impact current generations, but many generations to come. Through adaptation measures, the expectation is that the capacity of humankind to face climate change can increase in parallel with its efforts to reduce the cause of global warming, namely greenhouse gas (GHG) emissions.

Of all impacts anticipated as a result of rising GHG emissions, one of the most significant is rising sea levels, which are expected to become increasingly problematic in years to come and pose a real threat to life in coastal areas. To date, domino effects observed from rising sea levels include erosion in coastal areas, damage to or loss of coastal ecosystems, losses of livelihood sources for coastal communities, and increased flooding in coastal cities and towns (Diposaptono et al. 2009).

These impacts are being exacerbated by anthropogenic activities with increasingly massive and destructive environmental impacts. In addressing this, the world's nations are preparing and implementing mitigation and adaptation strategies to reduce potential climate change damage, both ongoing, and damage predicted to occur in the future.

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In relation to this response, mitigation measures are generally focused on reducing GHG emissions. One of these measures is by utilizing the capacity of the Earth's vegetation to sequester carbon. Accordingly, in a coastal area context, rehabilitation and restoration of marine and coastal vegetation is one priority choice. Conversely, adaptation measures tend to focus more on efforts to enhance the ability of coastal communities to be more prepared, more resilient, and more proactive in responding to changes resulting from climate change. Changes that have already occurred show us that no matter how large or aggressive measures taken to reduce GHG emissions have been to date, changes in global climate cycles will still continue and become increasingly significant.

Therefore, effective adaptation strategies are required to increase the resilience of coastal areas. As impacts are global and oblivious to regional borders, every one of the world's nations, including Indonesia, is forced to play their part in efforts to tackle climate change.

Indonesia is the world's largest archipelagic state with a maritime area of 3,257,357 km². Located on the equator with a tropical climate and abundant natural resources, Indonesia has an important role to play in coastal area management in efforts to tackle climate change.

According to Law No. 27/2007, coastal regions are transition zones between terrestrial and marine ecosystems influenced by changes on land and at sea. As a tropical nation, Indonesia has 3,364,076 ha of mangroves (Direktorat Pendayagunaan Pesisir dan Pulau-Pulau Kecil 2021), 80% of which are in good condition, while an estimated 20% are in critical condition. Indonesia has approximately 150,693.16 ha of seagrass beds (Arifin 2018): around 4,409.48 ha in western Indonesia, and 146,283.68 ha in eastern regions of the country (Rosalina et al. 2022). With its extent of marine and coastal vegetation, Indonesia has huge potential in mainstreaming carbon capture and storage programmes. Coastal ecosystems like mangroves, seagrass beds, tidal marshes, and algae are able to capture and store blue carbon (Nellemann et al. 2009).

As a form of participation in the handling of global climate change, Indonesia has demonstrated its commitment by ratifying the Kyoto Protocol through Law No. 17/2004 on Ratification of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC). Then, in 2011 through Presidential Regulation No. 61/2011 on the National Action Plan for Reducing Greenhouse Gas Emissions (RAN-GRK), the Government of Indonesia committed to reducing GHG emissions unilaterally by 26% by 2020 and by 29% by 2030, and by 41% over the same period with external support (Indonesia 2011). Then, in September 2022, the government submitted Indonesia's enhanced NDC where GHG emissions reduction targets were increased from 29% to 31.89% unilaterally and from 41% to 43.20% with international support (Pemerintah Indonesia 2022).

Not long after the presidential regulation was passed, in 2015, Indonesia participated in COP 21 and ratified the Paris Agreement through Law No. 16/2016, which is intended to demonstrate commitments to curbing increasing global temperatures; encourage transparency in carbon calculations; and support adaptation and environmental degradation restoration efforts. In the same year, Indonesia submitted its first Nationally Determined Contribution (NDC) to UNFCCC. Five years later, Indonesia submitted its updated NDC to the same institution (Ministry of Environment and Forestry (KLHK) 2021).

The main strategies for achieving NDC adaptation targets by 2030 are:

1. Supporting economic resilience of at least 1.72% of gross domestic product (GDP) through a transformation to a low carbon economy, and food, water, and energy security;
2. Creating social and livelihood resilience of 0.32% of GDP through capacity development in various life systems;
3. Increasing ecosystem services and landscape resilience to 0.83% of GDP through an integrated landscape approach in the management of terrestrial, marine, and coastal ecosystems.

It is apparent from these three strategies that in regard to adaptation, it is important to create climate resilience in the form of socioeconomic, ecosystem, and landscape resilience (KLHK 2021).

The submission of these NDCs to UNFCCC signifies Indonesia's commitment and readiness to transition to Low Carbon Development (LCD) and mainstream a green economy. NDC documents elaborate strategies that will be applied, and enabling environments needed to meet emissions reduction targets, which increase in stages over set timeframes. These are to achieve the global goal of stopping average global temperatures increasing by 2°C and striving to limit them to 1.5°C above pre-industrial levels (KLHK 2021b).

Addressing Indonesia's commitment to transform towards environmentally friendly development through the conservation and rehabilitation/restoration of blue carbon areas, in 2017 the Ministry of National Development Planning/National Development Planning Agency (PPN/*Bappenas*) launched the LCD programme. The explicit objective of the programme as a climate change mitigation and adaptation measure, which constitutes a new paradigm in Indonesia's development, is to include GHG emissions reduction targets – together with interventions to preserve and restore natural resources – in policy planning.

The LCD policy has been internalized into the National Medium-Term Development Plan (RPJMN) 2019–2024, which constitutes part of the National Long-Term Development Plan (RPJPN) 2004–2024. It is expected to help Indonesia achieve its target of becoming a developed nation by 2045 as laid out in its *Visi Indonesia Maju 2045* vision. For that reason, RPJPN 2025–2044 should have content on coastal areas and blue carbon where a GHG emissions reduction of 43% is predicted, exceeding the set target of 41%.

Further, the government also announced a green economy (*Bappenas* 2019a), where LCD is predicted to be able to generate around 6% of GDP annually to 2045. A green economy – which constitutes part of the climate change adaptation strategy – is defined as an economy that is low carbon, resource efficient and socially inclusive.

2 Utilization of blue carbon in climate change adaptation

Coastal areas, which are transition zones between terrestrial and marine ecosystems, are vulnerable to various forms of change, both on land and at sea. During the 1970–2010 period, a progressive increase in sea temperatures by 0.11°C per decade caused sea levels to rise at an average of 2 mm year^{-1} (IPCC 2022). The Special Report on Global Warming of 1.5°C (IPCC 2018) states that various essential and unique ecosystems are under serious threat from climate change.

Climate change will increase atmospheric temperatures, change rainfall patterns, increase seawater surface temperatures, raise sea levels, increase ocean acidity, alter ocean currents, and increase incidence of extreme weather events, which will affect the existence of ecosystems, including those in coastal areas (IPCC 2018).

Rising sea levels can result in tidal floods, shortages of fresh water, coastal erosion, and even the disappearance of small islands. Meanwhile, for coastal cities and towns, rising sea levels also increase the vulnerability of road infrastructure, buildings, bridges, water structures, and other public facilities. All of these impacts will eventually affect human health and economic activities. Not only that, the tourism sector, including cultural artefacts and urban biodiversity, will also be affected by the above-mentioned negative impacts of climate change (Hunt and Watkiss 2011).

Coastal areas have different characteristics due to a dependence on marine natural resources among various economic players: fishers, fish farmers, fisheries product processors and marketers, and other economic players located on the coast. Considering the potential impacts of climate change in various

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regions in Indonesia, the segment of society deemed most at risk is rural communities, particularly those in coastal and small island areas (Sakuntaladewi and Sylviani 2014). Climate change will result in lower earnings, which in turn will result in economic pressures and social unrest in society.

The vulnerability of coastal areas in Indonesia is also caused by human activities, as evidenced by large-scale conversion of forests with no regard for sustainability; use of fossil fuels; conversion of mangroves in coastal areas; and massive ongoing destruction of coral reefs (Purnobasuki 2011; Mustaqim 2018).

Blue carbon ecosystems (mangroves, seagrass beds, and tidal marshes) cover a relatively small area compared with other marine and terrestrial ecosystems. However, they have huge capacity to store carbon, particularly in their sediments, and also have high net primary production (NPP) compared with terrestrial ecosystems (Larkum et al. 2006). Globally, mangroves are estimated to have carbon stock of 4–20 billion metric tons (Donato et al. 2011) and seagrasses of 0.4–0.8 billion metric tons (Fourqurean et al. 2012). Carbon stock in Indonesia's mangroves, which are the most extensive in the world at more than 3 million ha, reaches 3.14 billion metric tons (Murdiyarso et al. 2015). Combined with seagrass beds, total stock reaches 3.41 billion metric tons, or around 17% of global blue carbon (Alongi et al. 2016).

Since 2017, PPN/*Bappenas* has seriously and consistently addressed the important value of blue carbon, including through establishing the Indonesia Blue Carbon Strategy Framework. Also, in early 2019, the RPJMN 2020–2040 Technocratic Draft was finalized in which blue carbon conservation is included in the Priority Programme (PP): Low Carbon Development. This programme then focused on mangrove and seagrass bed inventories and rehabilitation/restoration activities in several regions of Indonesia (*Bappenas* 2019c).

Nevertheless, regulation modalities established by the government to facilitate the achievement of coastal area adaptation targets have not necessarily made the implementation of coastal area rehabilitation and restoration strategies any easier. Challenges in coastal area utilization include:

1. coastal ecosystem (mangrove and seagrass bed) degradation rates being higher than rehabilitation/restoration rates
2. limited information and accurate data on the status of blue carbon ecosystems
3. tenurial or land ownership conflicts
4. conflicting interests in use of regions for livelihoods
5. carbon stock quantification methods not being uniform
6. implementation of co-benefits and proceeds of blue carbon utilization for livelihoods
7. low capacity of local institutions in guarding and ensuring the preservation of rehabilitated/restored regions

Based on discussions during the webinar, a strengths, weaknesses, opportunities and threats (SWOT) analysis was conducted on the utilization of blue carbon in climate change adaptation. This analysis was laid out in a matrix of internal factors (S and W) and external factors (O and T), as illustrated in Table 1.

With this matrix, four coastal area management strategies were extracted by considering their opportunities and threats, as well as strengths and weaknesses. In other words, strategy choices should be adapted to actual conditions in the coastal areas being managed, as a strategy that suits one particular area may not be applicable in others.

Table 1. SWOT analysis on blue carbon utilization in climate change adaptation

Internal factors \ External factors	Opportunities (O)	Threats (T)
	1. Coastal areas can become centres for tourism 2. Coastal ecosystems can encourage coastal communities to improve economies	1. Land expanse in coastal areas is shrinking and veering towards beach degradation 2. No policies as yet on the enactment of beach conservation
Strength (S) 1. Extent of coastal areas influencing blue carbon absorption 2. Gross regional domestic product (GRDP) potential	Strategy 1 (S-O) Allocate spaces specifically for coastal area rehabilitation/ restoration and conservation activities so they can become ecotourism and eco-education areas	Strategy 2 (S-T) Provide coastal ecosystem management policies as protectors of beach ecosystems so the extent of coastal areas can be maintained or even grow
Weakness (W) 1. Conversion of coastal ecosystems to other forms of cultivation thereby reducing land area 2. No proper and structured management from institutions or from policies	Strategy 3 (W-O) Support the limitation of cultivation activities, especially for areas established in coastal regions, with institutional support and community empowerment	Strategy 4 (W-T) Enact strict policies from local governments or authorities to control conversion and conservation through outreach and giving incentives and disincentives for implementors

3 Utilization of blue carbon in Indonesia's NDC implementation

3.1 Coastal ecosystem rehabilitation/restoration

Mangrove and seagrass beds are vital ecosystems in coastal regions due to their high biodiversity. Mangrove forests are communities of tropical and subtropical coastal vegetation dominated by mangrove species able to grow and develop in muddy tidal areas. They have various functions and benefits that play important ecological, social, and economic roles in people's lives. Bearing in mind the importance of mangrove forests for human survival, and of preventing the further spread of mangrove forest degradation, a management plan is needed that considers their preservation and sustainability. Existing potential, both products and environmental services, must be used wisely and in a planned manner to provide human and development benefits (Chow 2017; Ellison et al. 2020).

Mangroves are some of the most productive and ecologically important ecosystems on earth. They are even considered one of the most efficient of all terrestrial and coastal ecosystems in terms of improving atmospheric carbon content and storing carbon in biomass and sediments (Hilmi et al. 2021). Mangroves can capture approximately 24 million metric tons of carbon every year (Alongi 2012).

Seagrasses are flowering plants with true leaves, rhizomes, fruits, flowers and roots, which grow in muddy, sandy, and rocky substrates, and live underwater. Seagrass beds play an important ecological role for living organisms, particularly as spawning and feeding grounds for fish (Fourqurean et al. 2012). Seagrass beds have multiple economic functions that play important roles in fisheries dynamics and the preservation of ecosystems and organisms, particularly for fish.

Photo by Aulia Erlangga/CIFOR-ICRAF

Seagrass beds also play an important function as carbon stores. Their relatively large long-term accumulation capacity gives seagrass beds an important role in carbon storage (Herr and Landis 2016). Seagrass bed ecosystems have the capacity to sequester and transport huge volumes of carbon from the atmosphere every day, and deposit it in sediments for long periods of time, meaning seagrasses are essential for the carbon sequestration service they provide.

Carbon absorption occurs through biological processes in the form of photosynthesis. In oceans, photosynthetic processes begin with microscopic plankton or vegetation that only lives along coastlines, such as mangroves, seagrass beds, or plants living in tidal marshes (Rahmawati 2011).

Coastal ecosystems, such as mangroves, seagrass beds, and tidal marshes, are natural sequesters that can absorb and store large volumes of carbon over long periods of time. Carbon stored in these coastal ecosystems is known as blue carbon (Macreadie et al. 2019). Research by the Ministry of Marine Affairs and Fisheries (KKP) over the last five years suggests Indonesia's seagrass beds have the potential to capture and store around 4.88 metric tons of carbon per hectare, or a total of 16.11 million tons annually. Meanwhile, mangrove ecosystems can absorb and store an average of 38.80 tons of carbon per hectare, or a total of 122.22 million metric tons annually (Ambari 2020).

Globally, mangroves can store 20 PgC with 70%–80% of this stored in the ground as organic carbon (Murdiyarso et al. 2014). Mangroves' sequestration of CO_2 is closely related to mangrove biomass; both aboveground biomass like trunks, branches, leaves, flowers and fruits; and belowground biomass like roots and soil. Soil in mangrove forests can store the most carbon.

Indonesia has climate change mitigation and adaptation goals with targets to reduce GHG emissions by 29% unconditionally and 41% with international assistance. Indonesia has around 3.3 million ha of mangroves. In addition to this extent, mangroves in Indonesia have potential as a nature-based climate solution (NBCS). As a special component of the NDC, mangroves have the potential to be an important asset in GHG emissions reduction (Atteridge et al. 2019). This is highly relevant for Indonesia bearing in mind it has the largest extent of mangroves in the world. In addition to providing an opportunity to fill gaps in emissions reduction programmes, this demonstrates Indonesia's active support for the marine sector as a focus of climate change mitigation and adaptation (Sidik et al. 2017).

3.2 Mitigation strategies

Considering provisions in Article 19 paragraph (1) of Law No. 25/2004 on the National Development Planning System, on 17 January 2020, President Joko Widodo (Jokowi) signed Presidential Regulation No. 18/2020 on the National Medium-Term Development Plan (RPJMN) 2020–2024. This RPJMN suggests a shift towards LCD, a paradigm shift towards a new green economy in Indonesia, with an expectation that low carbon development can create a country that is developed and independent, fair and democratic, and peaceful and united. The LCD policy initiative will be conducted to achieve *Visi Indonesia 2045* (*Bappenas* 2019a).

Steps that have already been undertaken in this direction include: imposing stricter licensing requirements for extractive and exploitative industries in coastal areas; integrating mangrove management policies into regional spatial plans; integrating coastal area management into climate change adaptation and NDC policies; encouraging green investments in coastal areas; implementing blue carbon socioeconomic values; preparing a technical planning document entitled, Indonesia: Long-Term Strategy for Low Carbon and Climate Resilience 2050; enforcing laws on coastal ecosystem protection and conservation; improving research quality; and developing a coastal ecosystem database. Carrying out mitigation now can reduce climate change impacts in the future.

3.3 Adaptation strategies

Climate change impacts that have already occurred and are felt by living creatures can no longer be avoided. Losses brought about by climate change impacts can reach trillions of rupiah, and not only impact the economy, but also other aspects of human life as well as ecosystems, including coastal ecosystems.

Preventing extreme impacts necessitates preventative and repressive strategies in controlling climate change. Such strategies involve adaptation and mitigation. Adaptation is a response to a stressor, as opposed to mitigation, which involves pre-empting challenges and taking steps to avoid threats, like reducing emissions or reducing flood impacts by constructing levees. There are many varying definitions of adaptation and mitigation. Adaptation according to this understanding veers more towards repressive measures, whereas mitigation can be carried out for preventative or repressive reasons (Wibowo and Satria 2015).

Adaptation is an effort to adapt oneself to an impact. In the context of climate change, adaptation is important as it is more local or contextual in nature and carried out reactively or anticipatively (Diposaptono et al. 2009). This means climate adaptation processes can differ from place to place, and relate to knowledge, experience, potential, and costs required. Adaptation is holistic where it reaches all associated social, economic, and ecological factors and government roles. Adaptation is not only beneficial for humans socially and economically, but also supports ecological preparedness in the process of adapting to changes that occur.

In contrast to adaptation in rural communities, which is generally sociocultural in nature, adaptation in urban areas is carried out by communities with government help and private sector support. Economic and infrastructure development in urban areas are an important part of helping communities and the ecological environment to reduce climate change impacts. However, urban poverty in coastal areas receives little attention and becomes a point of vulnerability that affects adaptation in urban coastal social and ecological systems.

The need for planning and implementation strategies in reducing climate change impacts is increasingly urgent. This is because climate change is difficult to control and because of its huge impacts, both now and in the future.

Understanding vulnerabilities resulting from climate change can become the foundation for building adaptation strategies. The aims of climate change adaptation are to sustain strong community economies; ensure food security; and protect community livelihoods and well-being by building resilience for impacted communities, as well as sectoral resilience like ecosystem, economic and livelihood system resilience (KLHK 2015).

The cycle of adaptation measures for coastal areas illustrated in Figure 1 shows that such measures should continually be monitored and evaluated. These are not one-off actions that immediately reach their targets due to the vulnerability of those targets and the highly dynamic strength of impacts. Consequently, adaptation measures always require adjustments when actions are ongoing.

According to Smit and Wandel (2006), there are two types of adaptation activities: autonomous-responsive/reactive adaptation; and planned-anticipative adaptation (see Table 2). Autonomous adaptation can be carried out by communities or governments as a response to conditions being experienced. Meanwhile, activities under planned adaptation require scientific studies relating to climate change scenarios to determine adaptation options. For coastal and marine areas, climate change adaptation involves combinations of reactive and proactive interventions in chosen adaptation sectors (World Bank 2011).

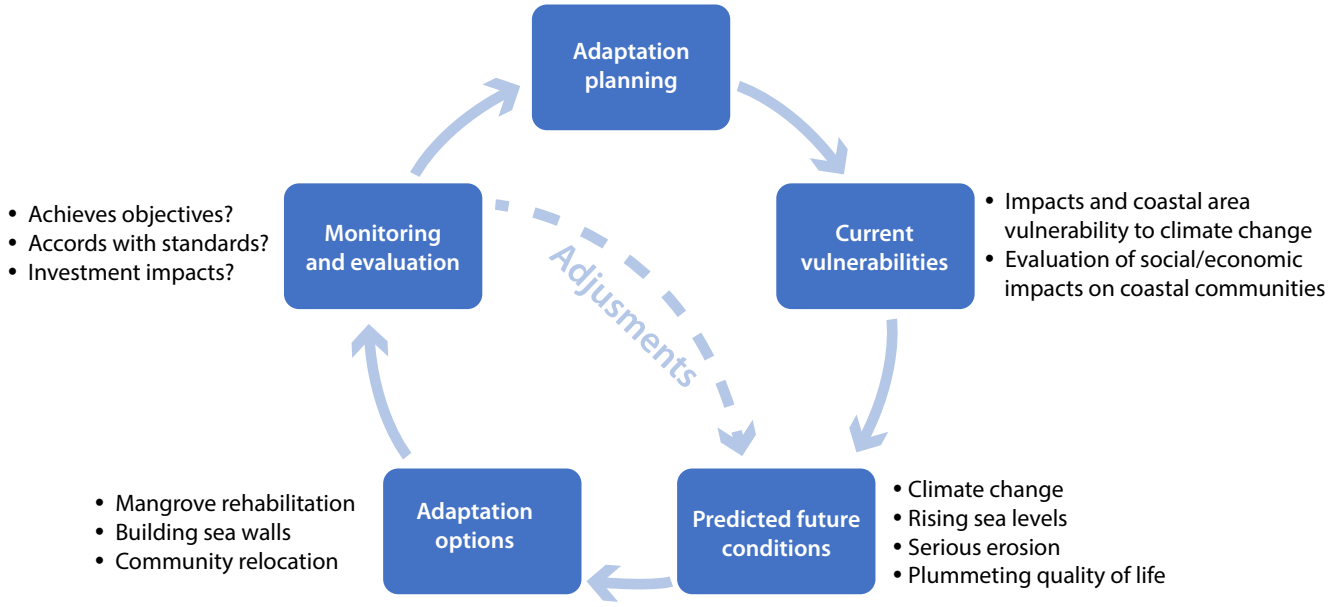

Figure 1. The adaptation cycle that should be applied in coastal areas where adaptation can be carried out if necessary

Emissions reduction and adaptation to the impacts of climate change are carried out through considerations for the functions of marine ecosystems. Integrated mangrove management covers:

1. enhancing protection efforts and expanding mangrove conservation regions
2. rehabilitating and restoring degraded mangroves
3. including protection efforts (avoided emissions) in the NDC
4. incentivizing systems for mangrove conservation payments like Reducing Emissions from Deforestation and Forest Degradation (REDD+), Payment for Environmental Services (PES), etc

Efforts to integrate the role of blue carbon in adaptation efforts should prioritize conservation and sustainable utilization in various areas. Then, as the country with the second longest coastline in the world, coastal and marine ecosystem roles in Indonesia's first NDC must be integrated into mitigation from the marine sector, and this has yet to be stated quantitively as there are many technical issues that must be carried out and still require comprehensive calculations and quantitative figures that can then be included in stages in the updated NDC (Rosyada et al. 2021).

Blue carbon has huge potential in supporting national programmes on carbon emissions reductions, food security and poverty eradication. However, management complexities and implementation capacity still need improving into the future. Sustainable management still requires coordination between ministries and other stakeholders.

A roadmap for coastal and marine ecosystem research has been developed in a framework of climate change control, but research outcomes have yet to be implemented. Key activities among them also relevant to adaptation strategies include: coastal community empowerment; increased community participation in monitoring; dissemination and assimilation of research results and development of marine and fisheries science and technology; development of marine, brackish water, and freshwater cultivation; development of marine and fisheries resources; empowerment of small island communities and facilitating integrated coastal region management; and improvement of marine and fisheries research resources capacity (*Bappenas* 2010).

Table 2. Climate change adaptation options for coastal/marine areas

Reactive/Responsive	Proactive/Anticipative
1. Protection of economic infrastructure	1. Integrated coastal zone management
2. Public awareness raising to increase protection of coastal and marine ecosystems	2. Better planning and determination of coastal zones
3. Construction of sea walls and beach reinforcement	3. Development of regulations on coastal protection
4. Protection and conservation of coral reefs, mangroves, seagrasses and beachside vegetation	4. Research on and monitoring of coastal areas and ecosystems

Source: Smit and Wandel (2006)

As a regulator, involvement of stakeholders and related ministries/institutions should begin with planning processes and policy intervention in the form of coastal region development integration and maintenance of coastal ecosystems. To develop blue carbon potential, government and stakeholders need to initiate policy, science and technology, sustainable financing, and outreach domains aimed at mainstreaming various initiatives and plans relating to blue carbon in Indonesia's development planning schemes, particularly those for coastal and marine ecosystems, in line with the LCD direction in RPJMN 2020–2024.

4 Stakeholder roles

Adaptation action involves all stakeholders with no one left behind, from the ministerial/agency (party stakeholder) level to regional governments, private sector initiatives, community groups, and the activities of international partners located in Indonesia. Contributions from these stakeholders then need to be reviewed comprehensively in action framework schemes.

4.1 Ministries/institutions

As the national focal point for UNFCCC, KLHK's support for and intersectoral cooperation with different stakeholders are essential in NDC implementation processes, as adaptation targets are not sector specific, but more about meeting basic needs for the survival and sustainability of community life in Indonesia. In addition, partnerships between the government and non-party stakeholders (NPSs) such as provincial, regency and municipal governments, private companies, non-governmental organizations (NGOs), academia and local communities need to be formed as NDC implementation requires support from various parties. NPSs are also mentioned in the Forestry and Other Land Uses (FOLU) Net Sink 2030 Operational Plan, meaning all stakeholders involved in tackling climate change (KLHK 2022).

Referencing the National Action Plan for Climate Change Adaptation (RAN-API) 2014, the government has already given mandates to 17 ministries and agencies to contribute in enhancing resilience to climate change impact risks. These institutions are expected to play active roles in mainstreaming climate change in various programmes and policies. In addition, it does not close the door on other ministries and agencies that might already have taken part in and contributed to supporting climate change action in Indonesia, but not been given a specific mandate to reduce GHG emissions, increase resilience, or lessen vulnerability.

Photo by Donny Iqbal/CIFOR-ICRAF

Government institutions must be able to collaborate in handling climate change. Cooperation between government institutions (KLHK, KKP, BRIN) can result in the formulation and preparation of policies relating to blue carbon development in Indonesia.

4.2 Non-party stakeholders

The Paris Agreement's recognition of non-party stakeholders (NPSs) is laid out in Section V of the Preamble to Paris Agreement Dec.1/CP.21 on the roles and action of NPSs, which under the agreement cover civil society organizations (CSOs), the private sector, academics, researchers and developers, regional governments, and financial institutions.

In collaborating with the Government of Indonesia, international NGOs must have licences from the Ministry of Foreign Affairs and then be established as partners in accordance with their focus field or area.

The utilization of blue carbon in climate change adaptation in coastal areas requires inter-sectoral coordination, as in addition to GHG emissions originating from various sectors, their impacts affect fields that are economic sources of development. Blue carbon issues involve multiple sectors, so require synergy between different institutions in building national commitments. The establishment of working groups or networks between the scientific community and national policymakers will provide forums for sharing lessons learned, while at the same time strengthening Indonesia's blue carbon framework. Successes in synergizing Indonesia's blue carbon with international blue carbon can be achieved with Indonesia taking an active role in international forums.

4.3 Funding

The world, including Indonesia, is vigorously encouraging low carbon development to minimize the impacts of climate change. To support this, Indonesia ideally requires annual low carbon development investments of IDR 306 trillion. This ideal investment figure is based on an analysis by PPN/*Bappenas* (LCDI 2020). Based on this analysis, LCD investment would ideally come from the government or state budget (APBN), and non-government parties such as private companies, state-owned enterprises, philanthropists, and other sources. Investment requirements for low carbon development are divided into two, based on their sources: government investment or funding of IDR 72.22 trillion (24%); and funding of IDR 232.56 trillion (76%) from non-government sources (LCDI 2020).

5 Recommendations

A rapidly changing world means multiple challenges confronting us, such as extreme climate impacts and Earth's rising temperatures, affecting food productivity significantly and increasing the risk of climate-related natural disasters. This highlights the importance of low carbon development and green economy for realizing a prosperous and sustainable future.

As the world's largest archipelagic nation, with the longest tropical productive coastline in the world, Indonesia is highly invested in sustainable development and utilization of resources in coastal areas.

After synthesizing and summarizing information from various references on the utilization of blue carbon in climate change impact adaptation measures, including consideration of the Government of Indonesia's ambitious programme to rehabilitate 600,000 ha of mangroves, and Indonesia's efforts to meet its NDC commitments, we present a number of recommendations based on different scenarios that warrant consideration:

5.1 Base scenario

This scenario works on the basic assumption that there are no new policies, but considers degradation. It reflects the continuation of historic economic, societal, climate, and environmental trends.

Under this scenario, various climate change impacts that will arise and affect coastal areas will require handling as usual without policy, strategy or programme interventions to control those impacts. Without such interventions, impacts arising will not only be linear in financial terms but may even be exponential. Further, the environmental services provided by coastal areas will plummet sharply over the increasingly short time remaining.

Photo by Aulia Erlangga/CIFOR-ICRAF

5.2 Moderate LCD scenario

This scenario covers the new low carbon development policy for 2020–2045 achieving the unconditional NDC target. It is consistent with Indonesia's efforts to achieve the unconditional climate target announced in the NDC, namely an emissions reduction of 31.89% by 2030 compared with the baseline (up from the earlier 29% by 2020).

Under this scenario, an estimated USD 14.8 billion in additional investment is required annually for 2020–2024 (around 1.15% of GDP), and USD 40.9 billion annually from 2025 to 2045 (1.39% of GDP) (*Bappenas* 2019b).

The achievement of Indonesia's unconditional NDC target requires rapid action, and full implementation of policies elaborated in this report on land and energy systems; there is no room to accommodate only one of a series of policies, or only to achieve partial and short-term targets. As all mitigation actions are oriented at domestic markets, stakeholders have no opportunities to interact with global market players. Therefore, adaptation capacity is not expected to develop.

5.3 High LCD scenario

This scenario is more ambitious than the moderate LCD scenario for 2020–2045 so it can achieve the conditional NDC target (*Bappenas* 2019b). It aims towards a 43% emissions reduction by 2030 compared with the set baseline, consistent with Indonesia's effort to achieve its conditional NDC emissions reduction target of 41% by 2030. Total GHG emissions fall from 2.14 $GtCO_2e$ in 2017 to 1.49 $GtCO_2e$ in 2030 (*Bappenas* 2019a). The fulfilment of this target depends on adequate and timely financial and other support from the international community. The achievement of this scenario will necessitate additional investment compared with the moderate scenario.

Total annual investment in this high LCD scenario averages: USD 22.0 billion (1.7% of GDP) for 2020–2024; and USD 70.3 billion (2.34% of GDP) for 2025–2045 (*Bappenas* 2019b). Achievement of the conditional NDC target requires efforts to bring about all measures in the moderate LCD scenario, with additional stepwise increases in restoration and forest protection actions, and reduced energy intensity and increased application of renewable energies to 2045 (*Bappenas* 2019a).

Under this scenario, stakeholders start to learn and increase their adaptation capacities, as adaptation is carried out by utilizing all mitigation opportunities. In such a way, mitigation actions are adaptive in nature.

5.4 LCD-Plus scenario

This scenario covers the high LCD scenario for 2020–2024, and the subsequent application of additional, more ambitious policies. It combines extra measures in the preparation of low carbon policies that begin around 2025, so emissions continue to fall to 2045 and beyond.

This fourth scenario necessitates a series of measures that have yet to be considered in the current RPJMN, such as: the introduction of a mechanism for setting carbon prices; a higher reforestation target; and policies to increase energy efficiency and reduce waste, especially through action at the city level. These measures will become part of a new generation of policies that will be implemented in the post-RPJMN 2020–2024 period, and require transformational changes in administrations, the private sector, and civil society in general.

Under this scenario, annual economic growth will be sustainable and average 5.6% by 2024, and 6.0% by 2045. By 2045, GDP is predicted to increase by USD 5.4 trillion; the poverty rate to fall to 4.2% (compared with 9.22% in 2019); 15.3 million jobs to be created; 16 million ha of forest loss to be prevented (from a 2014 baseline, and using the more than 1 million ha lost from 2009–2012 as a comparator); air quality to improve; living standards to increase; and regional and gender disparities to be resolved (*Bappenas* 2019b).

Many climate change adaptation measures are already being undertaken, and their policies already exist. However, based on climate risk analyses, many stages still need improving, including climate change impact analysis, and measures to strengthen coastal area climate change vulnerability studies/assessments. By improving these stages, the expectation is that community and state capacity to adapt can be built more effectively. In this regard, there are several adaptation options that could be chosen, as presented in Table 3.

Increasing national domestic earnings that constitute a reflection of earnings at various strata in society provides significant capital for increasing adaptation capacity. This capacity includes understanding problems, types of steps/actions taken, and setting priorities.

Table 3. Examples of climate change adaptation recommendations

No.	Indicator	Recommended adaptation options
1	Air temperatures, seawater surface temperatures	• Increasing the extent of mangrove conservation areas • Using climate stress-resistant seedlings (*Avicennia* sp., *Aegiceras* spp., *Aegiatilitis* spp., *Sonneratia* spp., *Osbornia* spp., *Lumnitzera* spp., *Laguncularia* spp., *Rhizophora stylosa*, *Ceriops*, and *Excocaria*) • Increasing availability of and ease of access to weather data and information, particularly in relation to coastal and marine areas associated with planning mangrove monitoring • Developing the capacity of coastal communities in cultivation with conservation, restoration and rehabilitation objectives • Conducting research and development on mangrove ecosystems specific to climate risk responses
2	Environmental carrying capacity	• Planning and spatial arrangement of coastal areas with climate change impact risks • Ensuring mutually beneficial co-management of regions • Strengthening of policies and law enforcement against illegal activities like illicit mining and regional spatial plan (RTRW) violations • Limiting the freeing up of land for development • Preparing mitigation steps in efforts to control abrasion/accretion
3	Population	• Limiting and regulating development in coastal areas • Maintaining balance between community livelihood resources and numbers of people • Preparing food resource distribution scenarios to vulnerable groups
4	Education level	• Preparing informal education for strengthening and risk acceleration • Preparing education schemes and schools accessible to coastal communities
5	Well-being level	• Capacity building for coastal communities on the management of resources originating from mangrove plants • Building cooperation with private parties in coastal area-based product distribution channels and sales • Facilitating ecosystem resilience-based ecotourism management

Source: Climate change document (KLHK 2021a) presented by Dra. Sri Tantri Arundhati in the Webinar on Coastal Zone Rehabilitation for Low Carbon Development on 31 March 2022

Adaptation approaches have developed to become more oriented towards developing resilience, with interventions to overcome causes of vulnerability resulting from climate change impacts; manage climate risks; and build adaptation capacity. KLHK (2020) in the NDC roadmap ambitiously targets climate change adaptation by building resilience and increasing adaptive capacity to reduce risks of loss resulting from climate change by around 2.87% (median value) of national GDP through economic, social, livelihood source, ecosystem and landscape resilience in meeting basic societal needs: food, water and energy with a landscape approach.

In line with the SWOT analysis presented in Table 1, various opportunities and challenges were encountered in preparing the NDC roadmap, as presented in Table 4. As adaptation measure planning in this table does not use climate change scenarios that can be adopted for Indonesia, estimated impacts are qualitative rather than quantitative, so impact reductions and resilience increases cannot be formulated quantitatively.

Table 4. Identification of challenges and opportunities in NDC roadmap preparation

	Challenges	Opportunities	Notes
Climate projection	Climate condition baseline analysis (2010)	Preparing a baseline based on 1991–2020 climate models	Consideration of earlier available climate projections
	Future climate scenario according with NDC targets (2030)	Climate scenarios needed for 2021–2050	More than one climate model is needed by considering future uncertainties
Impact analysis	The mandate of Article 21 of Law No. 32/2009, where ecosystem degradation and climate change become new criteria for environmental degradation	The need to separate analyses of climate change impacts from non-climate impacts	An impact model is needed that can separate climate impacts from non-climate impacts
	The mandate of Law No. 16/2016, where climate change control is a constitutional mandate under which every person has the right to live prosperously, to a home, to a clean and healthy environment, and to secure health services	Commitment needed to protect citizens' basic life needs from potential climate change impact risks	Climate change impact assessments need to be carried out on citizens' basic life needs (food, water, energy and health)
Strategy	Climate change management must become everyone's responsibility	The need for clear strategy direction at various levels	Strategies prepared that can be implemented down to the grassroots level
	Climate change adaptation must be mainstreamed down to the grassroots level in various areas of life	Development of a climate change one data policy	Needs to consider regional adaptation strategies, plans, and requirements
Funding	Poor climate change adaptation funding management capacity at the local level	The need for direction for and estimation of adaptation fund budgeting requirements	Adaptation funds need to be grouped into funds for governance and funds for adaptation action implementation

Source: KLHK (2020)

6 Closing

Adaptation measure planning is still a relatively new thing in Indonesia. Equally, including coastal area sectors remains a huge challenge. Nevertheless, in mitigation-based adaptation measures, these processes can be simplified and accelerated, and have multiple benefits, because by bundling the two together, current adaptation measures can reduce worse climate change impacts in the future.

A trial-and-error approach should be anticipated to increase stakeholder capacity. Adjustments should be made so anticipation of climate change impacts and changes in institutional capacity and the adaptation capacity of those institutions can be accommodated in revised action drafts.

Coastal areas are strategic systems in which to start all this, bearing in mind the urgency of problems and the potential benefits. These urgent problems relate to population densities and numbers of people impacted in these highly vulnerable ecosystems. Mitigation-based adaptation in coastal areas has far-reaching and significant financial impacts, bearing in mind the economic activities in these areas and the rich carbon these areas contain.

Photo by Rifky/CIFOR-ICRAF

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With a coastline of more than 90,000 km – the second longest after Canada – it is in Indonesia's interests to protect its coastal areas from climate change impacts. The continued existence and preservation of extensive coastal vegetation like mangroves and seagrasses is a nature-based solution for successful adaptation to climate change.

A coastal area rehabilitation/restoration agenda for climate change adaptation must be able to increase areas' resilience in overcoming rising sea levels, waves, coastal erosion, flooding and inundation, so the resilience of communities, particularly fishing communities living in coastal areas, can be enhanced. Communities' social cohesion, economic opportunities, and institutional capacity must also improve. Information and funding flows must be transparent for all stakeholders, so adaptation agenda decision making and implementation can be carried out effectively, efficiently and equitably.

This paper demonstrates efforts to bundle adaptation and mitigation measures to secure optimum outcomes in coastal area rehabilitation/restoration, as recommended in the Paris Agreement. It proposes adopting a responsive adaptation cycle so adaptive measures in these strategic coastal areas can commence immediately, and be monitored and evaluated. In this regard, emissions mitigation scenarios linked to adaptation measures can be considered to facilitate the achievement of 2030 Nationally Determined Contribution (NDC) targets and Sustainable Development Goals (SDGs).

Supported by:
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
based on a decision of the German Bundestag