Resilience of Ecosystem-Dependent Coastal Communities for SDG 14 in Indonesia

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1. Introduction

The UN Sustainable Development Goals (SDGs) recognise that current models for economic growth are insufficient for sustainable and equitable development for all global citizens within the planet's resource and climatic limitations. The SDGs, agreed by all parties of the UN General Assembly, are an international commitment to improve the outcomes of economic development for people and planet. The implementation of the Sustainable Development Goal 14 - to conserve and sustainably use the oceans, seas, and marine resources for sustainable development - requires global action towards the protection, conservation, restoration, and sustainable management of coastal ecosystems.

Indonesia, as an archipelago state with the longest coastal line in the tropical region (ca. 108.000 kilometers) is very suitable for habitat of coastal ecosystems with the largest mangroves (3.1 Mil Ha) and seagrass (3 Mil Ha) ecosystems on earth (Giri et al., 2011; KLHK, 2015) (Figure1). This amount is equivalent to 23% of the world's mangrove ecosystems of a total area of 16.53 million Ha. From the entire mangrove area in Indonesia, it is known that 48%are in good condition, while the rest area about 52% is in medium-poor condition (KLHK, 2015). It was recorded 202 mangrove species (Kusmana, 2009).

Figure1. Map of Indonesia and the distribution of Mangrove Ecosystem based on satellite image. (Giri et al., 2011; KLHK, 2015)

2. The importance of a healthy mangrove ecosystem in Indonesia

Mangrove is one of the most productive and biologically diverse coastal ecosystems on the planet. They deliver incredible ecosystem services that play a critical role in supporting human well-being through climate regulation, disaster risk reduction, food security, and poverty reduction. Costanza et al., (2014) once calculated the economic valuation of a mangrove ecosystem, be it by bringing value in the production of goods or services and estimated that a mangrove’s value could be up to US$ 193.843 per hectare/year. With good mangrove ecosystem conditions, this vegetation is able to contribute at least USD 1.5 billion annually only from fishery to the national economy (MMAF, 2015). Local communities harvest shrimp, eel, clam, crab, sea snail and a variety of fish species from mangrove ecosystem, providing both income and food for families. Mangrove wood is sold for the paper pulp business, as well as for charcoal production, wood chips and firewood. These products are harvested at both small and large scales, contributing to local livelihoods and national exports. Furthermore, Intangible benefits of mangrove ecosystems include social and cultural functions. Mangrove ecosystem support religious and spiritual values, as well as recreational and aesthetic values for ecotourism (FAO, 1994) and (UNEP, 2014).

However, the importance of mangrove ecosystem for mitigation and adaptation global climate change is remaining neglected in International dialogue such us in UNFCCC, mostly due to the lack of available scientific data and less attentions in comparison with another sectors such us forestry and agriculture (Hutahaean, 2012). Although its role in national and global climate change mitigation strategies, mangrove ecosystem contains more than 5 times as much mean carbon per hectare (3.14 billion metric tons of carbon - PgC) as land based tropical forests (Alongi et al., 2016). By preventing mangrove deforestation, Indonesia can meet a quarter of the 26% emission reduction target by 2020 (Murdiyarso et al., 2015). In addition, several studies revealed that mangroves with a minimum thickness of 100 meters inland can reduce high waves between 13% and 66%. This condition can reduce the risk of erosion and disasters caused by ocean waves or tsunamis.

Unfortunately, current conditions show that mangrove is facing a major challenge of land conversion, tourist industry and coastal pollution. Indonesia has one of the fastest rate of mangrove destruction in the world with a rate of 0,3 % or about 9330 Ha annually (Giri et al., 2011). This equates to 0.05 million hectares (Mha) out of the total 0.84 Mha annual deforestation in Indonesia (Margono et al., 2014; KLHK 2015), due to land conversion for various interests such as aquaculture ponds, settlements, plantations, industry and coastal/port infrastructure. In addition, another general problem related to the community's low understanding of the mangrove and overlapping policies at the national to regional levels. At the regional level, deforestation remains substantial across Southeast Asia, with more than 100,000 ha of mangrove ecosystem lost between 2000 and 2012 (Figure 2). Approximately 2% of the mangroves present in Southeast Asia in 2000 were lost during the period, at an average rate of 0.18% per year (Richards and Friess, 2016)

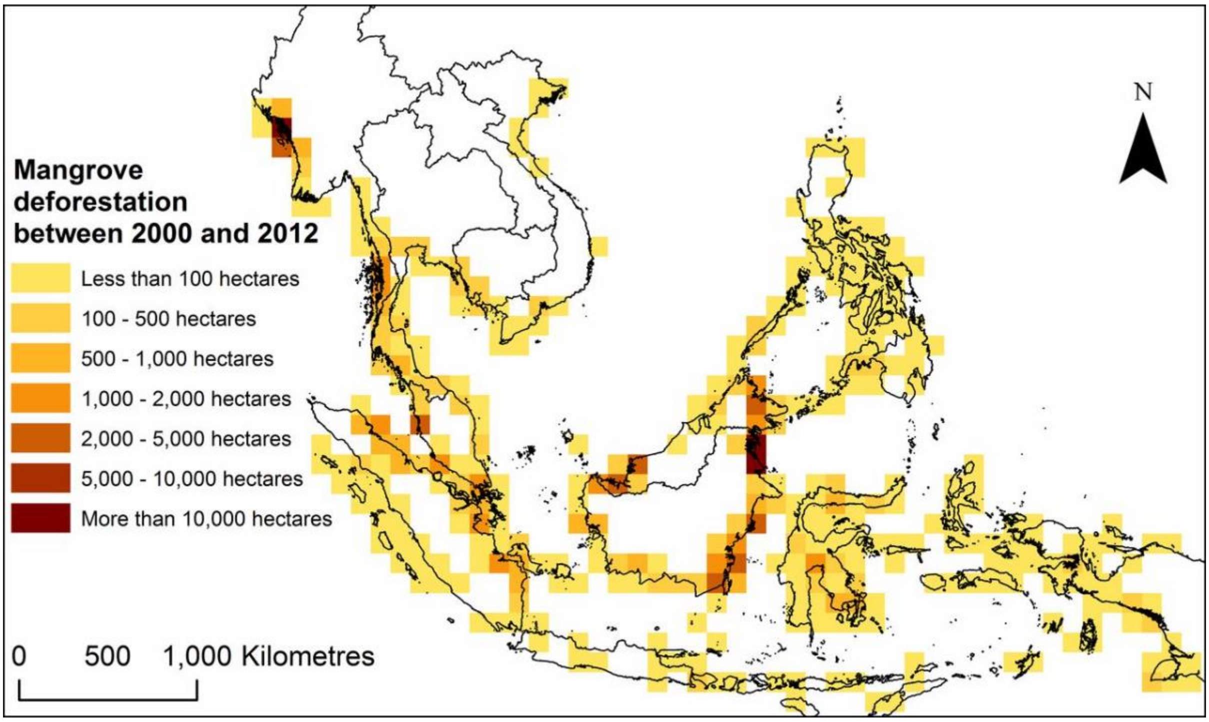

Figure 2. Image of mangrove deforestation in South East Asia 2000-20012. There is considerable spatial variation in the degree of deforestation, with hotspots in Myanmar, Indonesian and Malaysia (Richards and Friess, 2016).

3. The Carbon Stock in Mangrove Ecosystems

Although the mangrove ecosystem may seem to account for a small percentage of the overall global beach and reef areas, it is a highly productive ecosystem, even when compared to other ocean ecosystems. On average, the primary productivity level of a mangrove ecosystem (NPP) is on par with tropical rainforests (Alongi, 2009), and could absorb the most CO_2 emissions out of any other ecosystems (Mcleod, 2011). Twilley et la's study in 1992 calculated the global mangrove ecosystem's primary productivity level to be at 280 TgC/year based on rate of fallen leaves and wood/timber production.

Many other studies have continued to show the mangrove ecosystem's capability in absorbing and storing large amounts of organic carbon in sediments, whilst maintaining a high level of primary productivity rate and trapping particles through its complex system of roots (Alongi, 2012). On average, the accumulation of organic carbon in the mangrove ecosystem's sediment reaches 24 Tg C/year (Twilley *et al.,* 1992; Jennerjahn & Ittekot, 2002; Duarte *et al.,* 2005).

Yet, almost half of the mangrove ecosystem's NPP is exported to the greater beach region to support the natural food chain in these areas. In Alongi's 2014 research NPP reached around 46 Tg C/year, or the rough equivalent of 11% of the total terrestrial carbon input for the seas. The remaining carbon that is not exported is consumed by benthic zone animals and experiences decomposition by microorganisms and becomes sediment later on (Duarte and Cebrian, 1996).

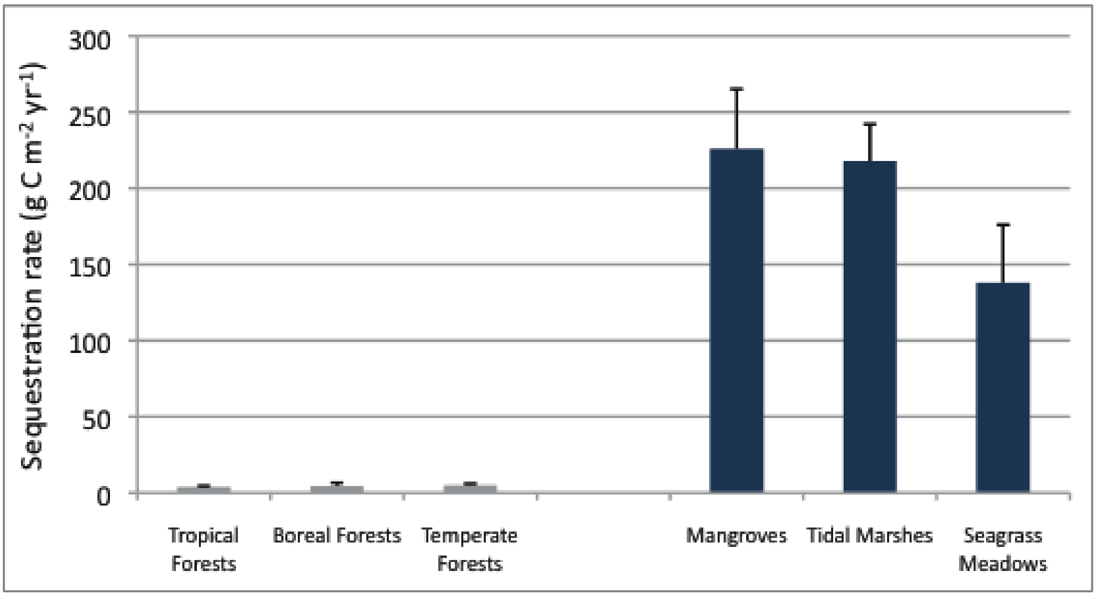

Figure 3: Annual mean carbon sequestration rates for blue carbon ecosystems per unit area compared to terrestrial forests (error bars indicate standard error). The annual sequestration rate for a given ecosystem is the quantity of CO2 removed from the atmosphere and/or ocean and trapped in natural (McLeod et al. 2011)

Although mangroves are so beneficial to the environment and the surrounding population, even from a socioeconomic perspective, the mangrove ecosystem keeps degrading throughout the country. Indonesia experiences around 9,388 hectares of mangrove forest destruction every year, or 0.3% of its total mangrove ecosystem.

In 2011, McLeod et al. published research that shows beach vegetation could absorb much higher levels of atmospheric CO_2 than land vegetation (*Fig. 3)*. Out of all the various beach plants, the mangrove ecosystem has the capability to absorb the highest levels of CO_2 in comparison to tropical rain forests, salt marshes and sea grass meadows.

Further than that, mangrove forests absorb CO_2 and stores it as organic carbon in biomass and sediments. Total amount of carbon that is above ground per unit area is equal to the forest ecosystem on land (Donato *et al.,* 2011, *Fig. 4*). Yet organic carbon that is below ground has a higher composition than those that is above ground, wherein the ratio of carbon that is below ground and above ground is much higher when compared to the same ratio in a tropical forest ecosystem (Donato *et al.,* 2011; Alongi, 2014). In several local mangrove regions in preservation areas, the amount of carbon that is stored in the sediment is very high, reaching up to several meters under ground. Globally, the mangrove ecosystem has a carbon stock of 1083 MgC per hectare, which is higher than tropical forests (241 MgC/ha), seagrass meadows (408 MgC/ha), brackish marsh (593 MgC/ha) and sea grass fields (142 MgC/ha) (Alongi, 2014).

The total organic carbon that is stored within a mangrove ecosystem can vary depending on the geography of the area and the unique species composition of the mangrove vegetation itself. IUCN (1993) showed that species composition and the mangrove ecosystem's characteristics depend on multiple factors, including weather, the shape of the beach or reef areas, the distance between the tidal waves and the availability of fresh water. Hence, a mangrove ecosystem's distribution pattern and accumulation can be complex and affect all biochemical processes within that ecosystem. (Jennerjahn & Ittekkot, 2002). Other supporting factors, such as a strong ecosystem structure, forest density and mangrove species composition, salinity and nutrition levels, benthic activities and microbiology and changes in usage are important things to consider in controlling the carbon dynamics within a mangrove ecosystem.

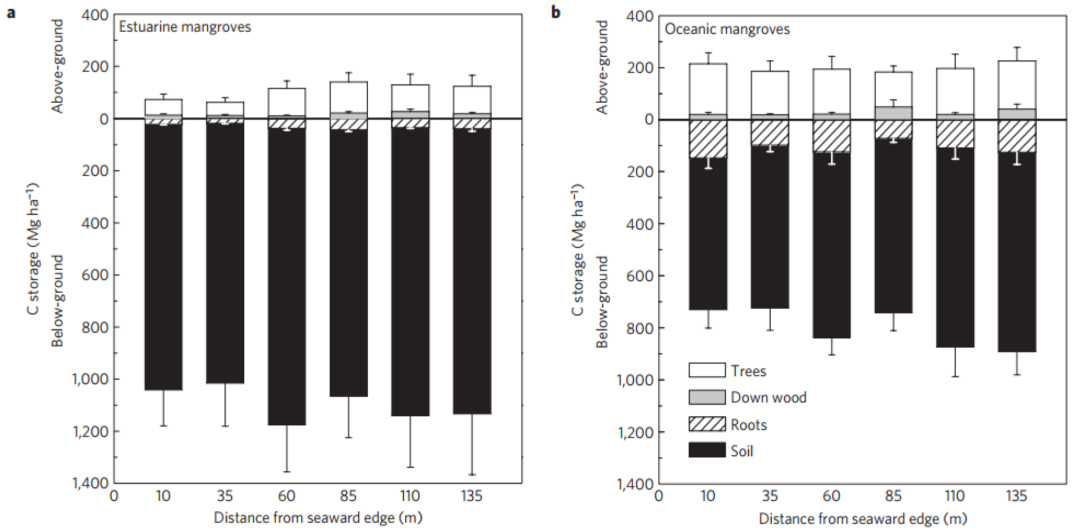

Figure 4: Above and below ground Carbon in Indo-Pacific mangroves ecosystem, assessed by distance from the seaward edge. a, Estuarine mangroves situated on large alluvial deltas. b, Oceanic mangroves situated in marine edge environments. Donato et al., 2011

4. The socioeconomic importance of mangrove ecosystem

To determine the value of a mangrove ecosystem, we could evaluate the ecological and socioeconomic benefits of each biotic and abiotic component within that ecosystem. Many researchers, including Suzana dkk (2011), Saprudin & Halidah (2012) and Nahib (2011) have evaluated the economic value of a mangrove ecosystem through observing the direct and indirect benefits that a mangrove forest brings to the local population. The direct benefits could include the sales value of wood as building material and firewood, the mangrove's economic contribution in the fishing industry (as a place to cultivate fish, shrimp and crab farms) and the value of its leaf and fruits. Indirect benefits may include the mangrove's function in protecting beaches, which is calculated based on replacement costs of creating a breakwater structure, and the biodiversity within that ecosystem (*Fig 5*).

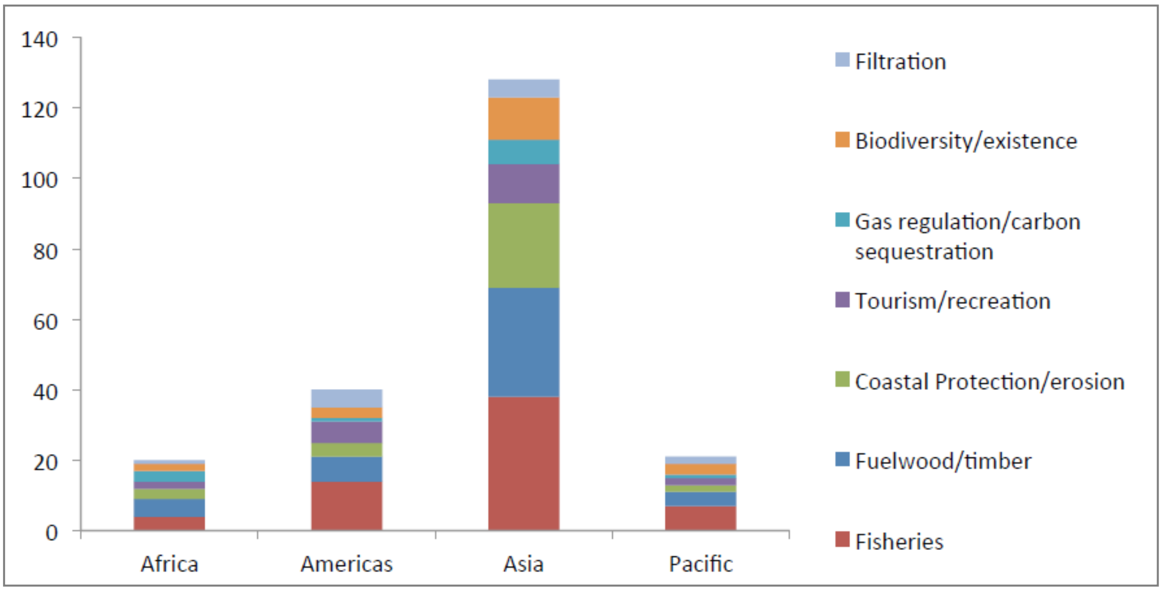

Figure 5. The benefit of mangrove ecosystem in several regions. As for Fisheries, firewood and coastal protection are the main benefit of mangrove ecosystem in all regions (Costanza et al., 2014).

Costanza et al., (2014) once calculated the economic valuation of a mangrove ecosystem, be it by bringing value in the production of goods or services, and estimated that a mangrove's value could be up to US$ 193.843 per hectare/year. If one uses this latter estimation, the potential economic value of Indonesia's mangrove ecosystem could then reach US$ 602.852 million/year. Especially in Asia, the main benefits of a healthy mangrove ecosystem are in the fishing industry, timber and wood and as a natural protectant to beach areas.

In early 2010, the mangrove ecosystems ability to absorb and store carbon in biomass and sediments were considered as part of a Payment for Ecosystem Services (PES) scheme as carbon credit (Pendleton et al, 2012; Siikamäki et al, 2012). Its value as a carbon credit continued to grow in accordance with the decline of its contribution to the fishing industry (Fig. 6) (Vegh et al., 2014).

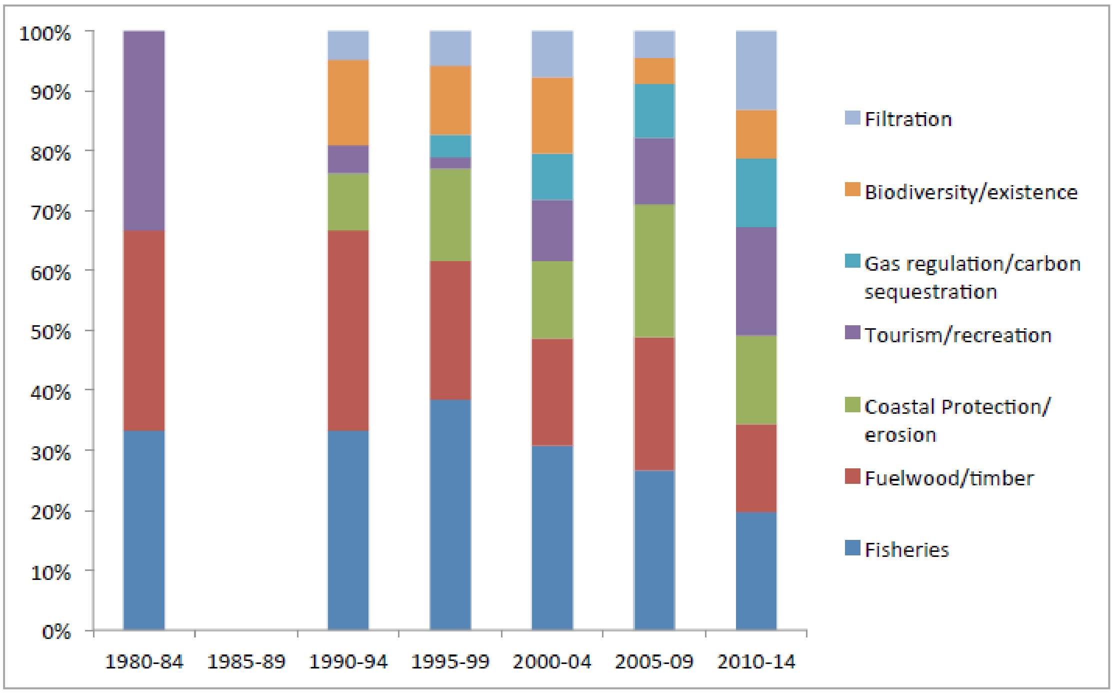

Figure 6. Number of Mangrove Ecosystem Services Values by Year. Mangrove ecosystem service valuation increased around the turn of the 21st century, but with one notable exception, it has decreased since 2000. Although the number of valuations has generally increased the proportion on fisheries and fuel wood have decreased (Vegh et al., 2014).

Hence, economic valuation could be an effective argument to help maintain this ecosystem (Ullman et al, 2012). Jerath et al (2016) calculated the value of stored carbon per unit area of a mangrove ecosystem in Everglades, Florida, U.S.A., and that amounted to US$ 13.859 – 23.728/hectare. But such calculations on the economic value of stored carbon within Indonesia's mangrove ecosystems are still very limited. So, if we utilized the same calculation method and estimations, then we could estimate that the economic value of stored carbon in Indonesia's mangrove ecosystem could be in the range of US$ 43.102-73.794 million.

The overwhelming benefits that mangrove ecosystems could bring to Indonesia have encouraged federal and local governments to pursue sustainability projects in partnership with private institutions, businesses and citizens at large. This widespread movement started gaining traction especially after the Earth Charter Declaration in 1982. Some of these projects is in East Sumatra, Kaimana, and North coast of Java and are considered to be the largest mangrove conservation projects to this day. The conservation project involves the development of shrimp farming whilst utilizing mangrove forests to become the key to maintaining the sustainability of the local shrimp industry. Hence, the project marries the concept of conservation with economic growth, making this particular effort compelling to all parties involved. Creating such initiatives that show the clear relationship between ecosystem conservation and economic development is still a challenging task, especially for many developing countries. As the world moves forward with the 2015 Paris Agreements, which outlines a clear goal to reduce global warming by 1.5 – 2 degrees Celsius above pre-industrial levels by 2020, developing countries must now create more financially compelling sustainability projects to help reach this goal and curb global warming. But we are confident that we can continue to develop such projects, as Indonesia has moved forward with these efforts, both in larger and smaller scale conservation projects, before many developed countries even adopted the concept of the importance of sustainability through the 2015 Paris Agreement.

Another example of Indonesia's early conservation efforts include rehabilitating a beach area through a reclamation and rejuvenation of the local mangrove forests by creating an ecotourism project that is focused on showcasing the mangrove ecosystem. Unfortunately many of these projects have faced technical and political hurdles, hence they have not produced the most optimal results. Yet, the fact that Indonesia has initiated such ecotourism projects since 2010 is quite a significant effort itself. Further, government regulations and participation towards conserving mangrove ecosystems have positively impacted the local community's preservation efforts, too. For example, through effective public and private partnerships they have rehabilitated two to four million mangroves in North Java, West Sumatra and South Sulawesi. These partnerships have also attempted to introduce other benefits to creating a sustainable mangrove ecosystem by developing the honeybee industry in mangrove forests, creating food products from mangroves and ecotourism (*Fig.7*).

Figure 7. The benefit of mangrove as food products, rich of biodiversity and ecotourism (CI-Indonesia courtesy).

These initiatives help support the local economy, hence the government must also create legislations that will further the development of such projects, especially since Indonesia is one of the countries participating in the 2015 Paris Agreements to help curb global warming.

5. Related Policies on Coastal Resilience in Indonesia.

The government plays an important role in mainstreaming coastal resilience in Indonesia particularly related to climate change, considering that it involves different government institutions and various stakeholders. Integrated policies and coordinated institutional arrangements will create coastal resilience governance that benefits the people and contributes positively to the environment.

In global context, Indonesia supports the UNFCCC (United Nations Framework Convention on Climate Change), not only as part of its global responsibility, but also because of a realization that as an archipelagic state, Indonesia is particularly vulnerable to impacts of climate change. Furthermore, Indonesia is also one of the top contributors to carbon emissions from forest land use change, forest fire, industry, transportation, etc. The government's formal support for the global treaty takes for as Law No. 6 of 1994 on the Ratification of the United Nations Framework Convention on Climate Change. This law confirms Indonesia's active participation alongside other members of international community in preventing rising atmospheric concentrations of greenhouse gases.

The signatories to the UNFCCC meet in regular meetings known as Conferences of the Parties (COP) to discuss issues related to a global effort to address climate change. The third session of the COP3 in 1997 in Kyoto, Japan adopted the Kyoto Protocol, to which the parties agree to lower their greenhouse gas emissions to 5% below the 1990 level in the period of 2008-2012. However, compared to the emission levels that would be expected by 2010 without the Kyoto Protocol, this limitation represents a 29% cut.

At COP13 in Bali, which adopted the Bali Action Plan, and the COP16 in Cancun, Mexico, the Government of Indonesia has pledged to reduce greenhouse gas emissions by 26% on its own efforts and 41% with international support against the business as usual (BAU) scenario by 2020. The target is included in the Presidential Regulation No. 61 of 2011 (Presidential Regulation 61/2011) on the Action Plan for Greenhouse Gas Emission reduction (*Rencana Aksi Nasional Penurunan Emisi Gas Rumah Kaca*/RAN GRK).

As the Kyoto Protocol soon expires, a new agreement on the target of emission reduction called the Paris Agreement was adopted in the COP21 in Paris, France in 2015. It aims to keep a global average temperature rise well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C above pre-industrial levels.

In contrast to the Kyoto Protocol, which obligates no developing country to lower its greenhouse gas emissions, the Paris Agreement mandates all countries to make Nationally Determined Contributions (NDC). Each reduction target should go beyond previously set target for each period, and developing countries need international support to increase such ambition. Indonesia ratified the Paris Agreement under Law No. 16 of 2016 on the Ratification of the Paris Agreement to the United Nations Framework Convention on Climate Change. With this law, Indonesia is recorded as the 89th country to have ratified the Paris Agreement. In addition, Indonesia is one of the 95 countries that have submitted their NDC to the UNFCCC Secretariat.

The NDC document states that post-2020, Indonesia envisions a progression beyond its existing commitment (26% on its own efforts and 41% with international support). In the first period (first NDC), Indonesia's NDC target is to reduce emissions by 29% on its own efforts (unconditional) and 41% with international support (conditional) against the business as usual (BAU) scenario by 2030. The BAU scenario is projected to be 2,869 $GtCO_2e$ in 2030. Indonesia's NDC commitment for subsequent periods will be determined based on performance assessment and should reflect improvement over the next periods.

Regulation of the Minister of Environment and Forestry No. P.33/2016 on the Guidelines for the Development of National Action Plan for Climate Change Adaptation (*Rencana Aksi Nasional Adaptasi Perubahan Iklim*/RAN- API), which allows local governments to formulate their own sub-national adaptation action plan. While related to environment and Socio-economic area: (1) Law No. 37/2014 on Soil and Water Conservation, which leads to sustainable agriculture and land use. The law guides stakeholders in conserving lands and increasing productivity towards conservation agricultural approach. (2) Governmental Regulation No. 37/2012 on Watershed Management, which leads to enhanced watershed carrying capacity. The regulation provides guideline to identify watersheds that need to be protected, restored, and rehabilitated.

6. **Mangrove Ecosystem Management in Indonesia.**

There are two legal bases for mangrove management, i.e. Law No. 41 of 1999 (Law 41/1999) on Forestry and Law No. 27 of 2007 in conjunction with Law No. 1 of 2014 (Law 27/2007 jo. Law 1/2014) on the Management of Coastal Areas and Small Islands. In law 41/1999 states that forest is an integral unit of ecosystem in the form of lands containing biological resources, dominated by trees in their natural environment (Article 1 paragraph 2). By this definition, a mangrove ecosystem is classified as a forest. Meanwhile, Law 27/2007 jo. Law 1/2014 state that coastal area is the transitional area between land and sea ecosystem influenced by a change in the land and sea. By this definition, a mangrove ecosystem is also classified as a coastal area. Therefore, mangrove ecosystems are natural resources subjected to two Laws, i.e. Law 41/1999 and Law 27/2007 jo. Law 1/2014.

For implementation, two ministries are responsible for mangrove management based on both laws, i.e. Ministry of Environment and Forestry (MoEF), under Law 41/1999 and Ministry of Marine Affairs and Fisheries (MMAF), under Law 27/2007 jo. Law 1/2014. This overlapping authority is the source of a potential management problem. Both can deny responsibility or fight over responsibility. Some argue that management by more than one entity equals to no management, which is similar to the 'common property' concept that often interprets as 'nobody's property'.

Finally, MoEF and the MMAF's agreeing to divide authority according to the status of forest area. The MoEF now is responsible for managing any mangrove ecosystems which are part of a forest area, while the MMAF manages any mangroves ecosystems outside a forest area. Law 41/1999 defines forest area as a government designated area that is to be preserved as permanent forest. Currently, both ministries are waiting for the government's decision on which mangroves are classified as forest areas and which ones are not.

To avoid the negative impact of double authority, the government has also issued Presidential Regulation No. 73 of 2012 (Presidential Regulation 73/2012) on the National Strategy for Mangrove Ecosystem Management with two mandates (1.) To formulate policies, strategies, programs, and performance indicators for mangrove management. And (2.) To establish a National Mangrove Working Group. Also there are two major considerations base the issuance of this Presidential Regulation:

1. Mangrove ecosystems are invaluable coastal wetland natural resources and life support system as well as natural wealth. For this reason, they need to be protected, conserved, and used sustainably for promoting public welfare;

2. Coordination, integration, synchronization, and synergy across sectors, agencies, and institutions are necessary to sustainably manage mangrove ecosystems as an integral part of integrated coastal and watershed management.

The first task was accomplished in 2017 through Regulation of the Coordinating Minister for Economic Affairs No. 4 of 2017 (Coordinating Minister for Economic Affairs Regulation 2/2017) on Policies, Strategies, Programs, and Performance Indicators for Mangrove Management. As stated in Presidential Regulation 73/2012 and Regulation of the Coordinating Minister for Economic Affairs 4/2017, the National Strategy for Mangrove Ecosystem Management (*Strategi Nasional Pengelolaan Ekosistem Mangrove*/ SNPEM) aims to synergize policies and programs for mangrove ecosystem management that deal with ecology, social and economy, institutional capacity, and laws and regulations to ensure functions and benefits of sustainable mangrove ecosystems for public welfare.

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