Climate Change Vulnerability Profile of Indonesian Coral Triangle Region

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ABBREVIATIONS

ADB	:	Asia Development Bank
APBD	:	Regional Revenue and Expenditure Budget
APBN	:	State Revenue and Expenditure Budget
BAZNAS	:	Amil Zakat National Agency
BLU	:	Public Service Agency
BMKG	:	Meteorology Climatology and Geophysics Agency
BPDLH	:	Environmental Fund Management Agency
BPPT	:	Agency for the Assessment and Application of Technology
BSME	:	Bismarck Solomon Marine Ecoregion
COREMAP	:	Coral Reef Management and Rehabilitation Program
CI	:	Conservation International
CT	:	Coral Triangle
CTC	:	Coral Triangle Centre
CTI-CFF	:	Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF)
CTMPAS	:	Coral Triangle Marine Protected Area System
DAK	:	Special Allocation Fund
DAU	:	General Allocation Fund
DBH	:	Profit-Sharing Fund
DD	:	Deconcentration Fund
DTP	:	Co-administered Tasks Fund
EAFM	:	Ecosystem Approach to Fisheries Management
EEZ/ZEE	:	Exclusive Economic Zone
ENSO	:	El-Nino Southern Oscillation
FCPF	:	Forest Carbon Partnership Facility
FMA/WPP	:	Fisheries Management Areas
FRWG	:	Financial Regional Working Group
GCF	:	Green Climate Fund
GEF	:	Global Environment Facility
GHGs	:	Greenhouse Gasses
GIS	:	Geographic Information System
GIZ	:	Gesellschaft für Internationale Zusammenarbeit
HD	:	Regional Grants
HR/SDM	:	Human Resources
ICCSR	:	Indonesia Climate Change Sectoral Roadmap
ICCTF	:	Indonesian Climate Change Trust Fund
IPCC	:	Intergovernmental Panel Climate Change
IUU	:	Illegal, Unreported, and Unregulated
KEHATI	:	Indonesian Biodiversity Foundation
KKPD	:	Regional Marine Protected Area
KKPN	:	National Marine Protected Area

LAPAN	:	National Institute of Aeronautics and Space
LGN	:	Local Government Network
LIPI	:	Indonesian Institute of Sciences
LRFFT	:	Live Reef Fish Food Trade Inter-Governmental Forum
MFZ	:	Marine Functional Zoning
MMAF/KKP	:	Ministry of Marine Affairs and Fisheries
MoEF/KLHK	:	Ministry of Environmental and Forestry
MPA/KKL	:	Marine Protected Area
MAPI	:	Indonesian Fisheries and Society
MSP	:	Marine Spatial Planning
NCC	:	National Coordinating Committee
NGO/LSM	:	Non-Governmental Organization
NPOA	:	National Plan of Action
NRS	:	National Registry System
pH	:	Power of Hydrogen
PKPT	:	Toughness Coastal Zone Program
Pokja	:	Working Group
PRL	:	Seascape Management
ProKlim	:	Climate Villages Program
PSU	:	Practical Salinity Units
PWP3K	:	Provincial Coastal and Small Islands Management
RCP	:	Representative Concentration Pathway
RPJMN	:	Medium-Term National Development Plan
RPOA	:	Regional Plan of Action
RPP	:	Fishery Management Plan
RZWP3K	:	Provincial Coastal and Small Islands Zoning Plans
SC	:	Steering Committee
SDGs	:	Sustainable Development Goals
SEAFDEC	:	Southeast Asian Fisheries Development Centre
SIDIK	:	Vulnerability Index Data Information System
SLH	:	Sea Level Height
SOM	:	Senior Official Meeting
SPREP	:	Secretariat of the Pacific Regional Environment Programme
SSME	:	Sulu Sulawesi Marine Ecoregion
SST	:	Sea Surface Temperature
TERANGI	:	Indonesian Coral Reef Foundation
TNC/YKAN	:	The Nature Conservancy
TST	:	Thermal Stress Threshold
UNEP	:	United Nations Environment Programme
WCS	:	Wildlife Conservation Society
WWF	:	World Wide Fund for Nature
ZIS	:	Zakat, Infaq, dan Sedekah

GLOSSARY

Adaptation	:	The physical or behavioural characteristic that helps an organism to survive better in the surrounding environment
Anthropogenic	:	Of, relating to, or resulting from the influence of human beings
Biocarbon Fund	:	Funding to support efforts to reduce greenhouse gas emissions from deforestation and forest degradation in developing countries
Biota	:	The animal and plant life of a particular region, habitat, or geological period
Center of Excellence	:	Referring to libraries that apply high-performance standards in the implementation of library services and information to fulfil the needs of visitors for details about the culture of the people in the Republic of Indonesia
Center of Industry Science	:	Centre for industrial and natural research activities
Climate change	:	The phenomenon of changes in climate patterns that affect changes in weather patterns of an area to the world in the long term
Climate change adaptation	:	The process of adjusting to current or expected climate change and its effects, including climate variability and extreme climate events, so that the potential damage caused by climate change is reduced, opportunities posed by climate change can be exploited, and the consequences arising from climate change can be mitigated
Coastal	:	The transitional area between land and sea (beach area)
Conservation	:	Preservation, protection, or restoration of the natural environment and wildlife
Coral bleaching	:	The phenomenon of loss of coral colour
Coral reefs	:	An underwater ecosystem consisting of a group of coral animals that form the structure of calcium carbonate, a kind of limestone
Couple-effect	:	Impact arising from the combination of two or more events simultaneously
CT6 *Country*	:	The six countries that are members of the CTI-CFF
Degradation	:	Setbacks, slumps, decreases, and so on
Destructive	:	Causing tremendous and irreparable harm or damage
Diversity	:	Variation of shapes and/or forms of species that living in the same habitat
Ecology	:	The branch of biology that deals with the relations of organisms to one another and their physical surroundings
Ecoregion	:	Geographical areas that have the same characteristics of climate, soil, water, native flora, and fauna, as well as patterns of human interaction with nature that illustrate the integrity of natural systems and the environment
Ecosystem	:	An ecological system formed by an inseparable reciprocal relationship between living things and their environment

Erosion	:	The process of eroding or being eroded by wind, water, or other natural agents
Eutrophication	:	The excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen
Food security	:	Regarding the guarantee of availability, accessibility (affordability), and stability of food procurement for each individual
Forecast	:	Prediction of future events based on certain data
Global warming	:	Conditions of increasing the average temperature of the earth's surface due to excessive concentrations of GHGs
Incentive	:	An Efforts to motivate by materials, giving money, goods, etc.
Intervention	:	An orchestrated attempt by one or many people
Intrusion	:	Leakage of seawater into the soil layer, so seawater and groundwater mixed
Joint Project	:	Cooperation or collaboration project
Katalysator	:	A substance which increases the rate of the event
Mean sink strength	:	The average ability of an object to adapt to its surrounding environment
Mega biodiversity	:	Huge level or measure of biodiversity
Mindset	:	Set of assumptions, methods, or notions held by one or more people or groups of people
Mitigation	:	Active actions to prevent or slow down a catastrophic event
Mortality	:	Number or rate of population death
Multilateral	:	Involving or including more than two nations
No return point	:	A condition when an object is already stressed which makes it impossible to recover
Ocean acidification	:	The ongoing decrease in the pH of the Earth's oceans, caused by the uptake of CO_2 from the atmosphere
Overexploitation	:	Excessive exploitation
Overfishing	:	The removal of a species of fish from a body of water at a rate that the species cannot replenish, resulting in those species becoming underpopulated in that area
Overlay	:	An information system in graphical form formed from merging (overlapping) various individual maps that have specific information / databases
Pelagic	:	Species that live and feed away from the bottom of the sea or lakes (surfaces species)
pH of seawater	:	The degree of acidity used to express the level of acidity or alkalinity of seawater
Philanthropy	:	Giving large donations/funds by individuals or organizations to those in need
Platform	:	Program
Priority	:	Something that more important

Promotion	:	Efforts to inform and offer something with the aim of attracting customers so that sales increase
Resilience	:	The ability to cope with, go through, and recover until it returns to its original state after experiencing stress
Resistance	:	The ability not to be affected by something, especially adversely.
Restoration	:	The action of returning something to a former owner, place, or condition
Run-off	:	Part of the rainwater that flows above the ground because the soil is no longer able to infiltrate the surface water
Salinity	:	The level of salinity or salt dissolved in water
Sasi	:	The local wisdom of indigenous peoples to manage and utilize the potential of natural resources properly from generation to generation
Seascape	:	Areas where the use of natural resources and conservation can be carried out simultaneously as a means of realizing sustainable economic development
Cyclone	:	A large scale air mass that rotates around a strong center of low atmospheric pressure
Stakeholder	:	Groups of people who have an interest in an activity that can influence or be influenced by the actions of the activity
Steering Committee	:	An event committee whose job is more inclined as an advisor, supervisor, and also director at an event
Stress	:	The pressure that can reduce the function of an object
Thermal Stress Threshold	:	The limit of an object can survive from heating / increasing temperature
Tolerance	:	Measure limit or threshold
Transplantation	:	Transfer of body tissue from one place to another
Trustee	:	A person or firm that holds and administers property or assets for the benefit of a third party
Turbidity	:	The cloudiness or haziness of a fluid caused by large numbers of particles that are generally invisible to the naked eye

1

INTRODUCTION

1.1 Background

Marine and coastal resources have a significant contribution to the global economy. One of the potential marine and coastal resources with high economic and ecological value is the coral reefs. Coral reef ecosystems have higher biodiversity than tropical rainforests and other coastal marine ecosystems. Coral reef ecosystems are home of thousands of aquatic species. There are millions of Indonesian depending their livelihoods entirely on the coral reef ecosystem. In a sustainable way, the total production of fish, shellfish and crabs from coral reef ecosystems around the world reach 9 million tons or about 12% of the global production (Coremap-LIPI, 2020). The activities related to coastal and marine resources increases because they are classified as common property with an open access. As the impact, the resources have been overexploited in a destructive way. The utilization rate of several types of fish has exceeded 100% in each WPPNRI area based on data of the estimated potential, JTB, and the level of fish resource utilization in the WPPNRI by the Director-General of Capture Fisheries, MMAF in 2020. This condition is exacerbated by the existence of environmental degradation and climate change.

Climate change significantly affects the coastal and marine resources because they are prone to stress by environmental changes. Rapid changes can increase the disruption to the species that are unable to adapt or even to migrate. By 2030, marine areas are estimated to face various driving factors such as the raising of sea surface temperature and the decreasing of seawater pH, that will affect the ecosystem, (Henson et al., 2017). Approximately 75% of coral reefs worldwide are threatened by a combination factor of human activities and climate change impacts. This number will increase to 90% in 2030, and reach 100% in 2050 when there is no countermeasure (Burke, Reytar, Spalding, & Perry, 2012). Increasing sea water temperature can also cause coral bleaching and the sinking of coral reefs Consequently, the coral reefs may not able to maintain their function as a wave and storm protector of the coastline (Ampou et al., 2017; Mcfield, 2017).

The IPCC Fifth Assessment Report (AR5) (2014) reports that climate change during the 21st century in developing countries and small-islands is expected to have a significant high impact which could bring damages and affect the percentage of GDP. Climate change will directly threaten the coast with extreme waves, tidal flooding, coastal erosion, widespread inundation in lowlands and swamps, intrusion of seawater into groundwater, and drowning of small-islands. This condition will be further exacerbated by patterns and trends of human activities in coastal areas (BPS, 2020). Various studies compiled in the IPCC report that the redistribution of global marine species and the reduction of marine biodiversity in climate-sensitive areas will be a threat to the availability of fisheries productivity and other ecosystem services. Climate change escalates the threat of overfishing and other non-climatic stressors, becoming the challenges for coastal and marine management.

Based on these conditions, coastal and marine management under mitigation and adaptation practices is essential to be carried out, therefore the negative impacts of climate change to the coastal and marine resources can be prevented. Currently, Indonesia already has at least two legal protection related to mitigation or disaster risk reduction including climate change (Diposaptono, Budiman, & Agung, 2013). They are The Law No. 24/2007 about Disaster Management (planned to be revised), and The Law No. 27/2007 in conjunction with the Law No. 1/2014 about Management of Coastal Areas and Small

Islands. After this, further regulation regarding disaster risk reduction activities is needed in order to protect the ecosystem in coastal areas and small islands based on the type, level of risk, typical disaster areas, and the responsibilities of the central government, local government, and communities as stated in Government Regulation No. 64/2010.

Climate change have effects on various regions indeed. However, there are variations in the impact level correlated with the adaptive capacity and the vulnerability of the region. This encourages the formation of specific agenda for determining the targeted area for intervention in adaptation actions. The intervention targeted areas are indicated with a higher vulnerability compared to the low priority areas (BNPB, 2014). Identification of targeted areas is essential. Once the area is identified, the regulation and intervention plans will be carried out, a more effective and directed action, for the coral triangle region in particular.

1.2 The Development of CTI-CFF in Indonesia

The Nature Conservancy in 2003 has conducted a workshop involving 20 researchers and Geographical Information System experts to map coral triangle region. This includes areas in several countries, Indonesia, Papua New Guinea, Solomon, Malaysia, Philippines, and Timor Leste (Mous & Green, 2004). This delineation then was followed up in a meeting of Asia Pacific Economic Cooperation (APEC) leaders by Indonesian governance, President Susilo Bambang Yudhoyono, in which it proposed Coral Triangle Initiative (CTI) as the primary component mechanism for maintaining the sustainability of the centre of global biodiversity (Veron et al., 2009). The coral triangle region has the highest coral reef diversity with 76% of global coral reef species. Areas within the ecological boundary of the CTI are approximately 73,000 km^2 or equal to 29% of the total coral reef ecosystem globally (Burke et al., 2012). According to World Resources Institute (2002), 51% of Southeast Asian coral reefs and around 18% of global coral reefs are located in Indonesian territorial marine.

The resources in marine and coastal ecosystem are sensitively vulnerable, projecting getting worsen without a proper management (Abram et al., 2019; Oppenheimer et al., 2019), and it have been a significant concern worldwide. In August 2007, Indonesia responded to this concern, President Susilo Bambang Yudhoyono proposed to establish a multilateral partnership. This partnership aimed to address the threats faced by marine, coastal, and island ecosystems within the coral triangle region under the Coral Triangle Initiative for coral reefs, fisheries, and food security (CTI-CFF). In the CTI-CFF, six countries (Indonesia, Malaysia, Papua Neogene, Filipina, Solomon Islands, and Timor Leste) have committed to jointly manage the resources in the coral triangle region of 2.3 million square miles including the Exclusive Economic Zone (EEZ) of each country. The main objective of the CTI-CFF is to overcome the threats to marine, coastal and small-island ecosystems in the Coral Triangle Region (CTI Leaders' Declaration, 2009), with the scope of cooperation

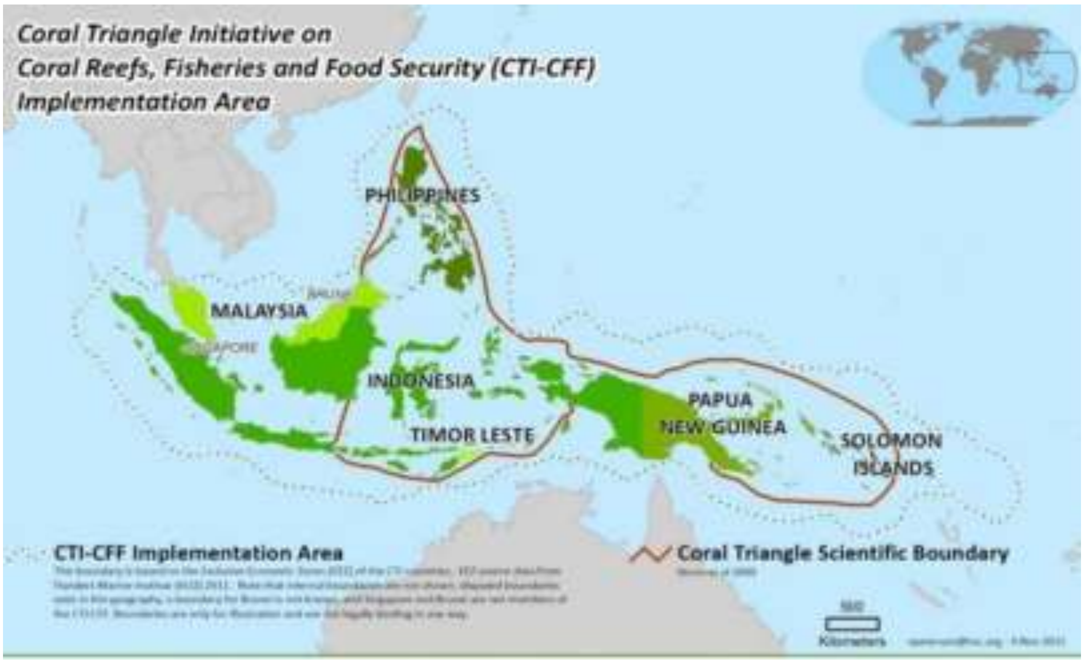


Figure 1.1 Indonesian Coral Triangle Map

including Management of Seascape, Fisheries Management, Marine Protected Area, Climate Changed, and Threatened Species.

The CTI-CFF initiation was formed in a long process, starting with the recognition of CTI-CFF in an official declaration by 21 heads of state in Asia Pacific. Then, annual Senior Officials Meeting (SOM) was held to discuss plans, progress, challenges, obstacles, and opportunities related to CTI-CFF implementation in each country. Indonesia has been actively contributing since the SOM-1 held in 2007 in Bali until the SOM-15 in 2019 held in Solomon Islands. In 2015, the CTI-CFF Regional Secretariat was inaugurated in Manado, Indonesia, and in 2017, the CTI-CFF was recognized as an international organization. Indonesia actively involves in various CTI-CFF working groups and since 2018, Indonesian delegation was elected as the Chair of the Financial Regional Working Group (FRWG).

Indonesia has a legal basis that underlies the CTI-CFF implementation, the Presidential Regulation No. 19/2014 about Ratification of the Agreement on the Establishment of the Regional Secretariat of the Coral Triangle Initiative for Coral Reefs, Fisheries and Food Security; and a regulation regarding the National Committee in Presidential Regulation No. 85/2015 about the National Committee for the Coral Triangle Initiative, Fisheries and Food Security. For more than 7 years of the CTI-CFF membership, Indonesia has realised that the CTI-CFF is a pioneer of multi partnerships in the coral triangle region to expand regional diplomacy. The collaboration of six countries is a must to cope the challenges, ensure the protection of marine resources at the regional level, improve and coordinate management actions and investments, and promote best practices in the Coral Triangle region according to the Regional Plan of Action (RPOA) goals which must be renewed every ten-year. In addition, each country must also complete a National Plan of Action (NPOA) for every five-year, and report their achievements in the annual Senior Official Meeting consistently. The NPOA of Indonesia is stated in the Regulation of the Coordinating Minister for Maritime Affairs, as the in charge institute of the Indonesian CTI-CFF National Committee, No. 2/2018 about the Indonesia National Action Plan for the

Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF) 2018-2020. The forms of the action plan varies according to the level. For examples, at the regional level, the CT government requires a multilateral action and coordination with partnership working on a regional scale; meanwhile at the national level, all stakeholder alliances in every country need to collaborate on a national agenda; and at the sub-national level, the collaboration between local stakeholders is needed to bring an influence of field necessity (CTI 2009).

1.2.1 Indonesian Role in the CTI-CFF

Indonesia is an archipelago country, which is also known as a maritime country because of its extensive marine area of about 6.4 million km^2, with around 1.9 million km^2 of mainland. Indonesia has approximately 16,056 islands with coastline about 108,000 km^2 (Kemenkomarvest, 2018). According to the Indonesia CTI-CFF National Committee report (2017), Indonesia has a total area of coral reefs 50,875 km^2 . Indonesia also has mangrove ecosystems about 34,900 km^2 (KKP Pers Conference, 2020; PDASHL, 2020), and seaweed or seagrass cultivation area on 25% of the total potential area of 11,000 km^2 (KKP, 2019) or about 2.934 km^2 according to LIPI in 2018. Looking at the condition, Indonesia is known as the mega biodiversity country. The coral triangle of Indonesia is the largest one among other CT6 countries. There are about 2,200 species of reef fish found in Indonesia which are widely scattered around the coral triangle region (Burke et al., 2012). The Coral Triangle Region located in Indonesia is covering Palawan/North Borneo, Sulawesi/Makassar Sea, North-eastern Sulawesi, Halmahera, Papua, and Banda Sea.

Table 1.1 The total area of Indonesia territory

Attribute	Indonesia	Source
Total of marine areas (km^2)	6,400,000	Kemenkomarvest 2018
Total coastline (km)	108,000	
Total of coral reef areas (km^2)	50,875	Komnas CTI-CFF 2017
Total of mangrove areas (km^2)	34,900	KKP 2020 and KLHK 2020
Total of seagrass areas (km^2)	2,934	LIPI 2018

Based on the location and the function, the roles of Indonesia in CTI-CFF are categorized into a geopolitical role, Promoting Ecological Point of View, Food Sustainability, and Ecological Balancing. In the international context, Indonesian geopolitical role is seen from the activeness in initiating cooperation, encouraging the institutionalization process to become a permanent institution, and hosting the CTI-CFF Permanent Secretariat. The ambition to keep pursuing sustainable efforts in the CTI-CFF including for completing 30 out of 40 of targeted actions at NPOAs, boosts the position of Indonesia as a conservation country at international level. The role in promoting an ecological perspective is related to the geographical location, in which making this country as a central area for studies related to protection, adaptation risk, and environmental policies about coral reefs. As a country with the largest habitat for various types of fish in the world, Indonesia has a role in food sustainability, becoming one of the highest suppliers of fish-based food in the world. Good coral reef management in Indonesia will encourage the balance of marine ecosystems and the growth of fish population on coral reefs. These roles support Indonesian commitment in a coastal and marine development adaptation plan against climate change impacts. It has five main targets, including seascape management; ecosystem-based fisheries management; resilience principle in the development of 56 marine conservation area network; disaster mitigation; and coastal rehabilitation as well as protection and recovery of endangered species.

1.3 The Potential and Important Value of the CTI

Indonesian coral triangle has diverse marine and coastal resources. Protection of ecosystem areas needs to be reviewed from various aspects for a more effective management. The Indonesian Marine Protected Areas can be considered to be the protection of the Indo-Pacific Ocean area. Furthermore, the protection can be assessed in the form of an ecoregion-based analysis.

1.3.1 The Wealth of Marine and Coastal Resources in Indonesian Coral Triangle Region

Indonesia has 54 registered national parks up to 2020 with a letter of appointment by the Directorate of Nature Conservation and Information Management (PIKA), Ministry of Environment and Forestry. About 14 national parks have marine area, which are Bunaken, Togean Islands, Taka Bone Rate, Wakatobi, Cenderawasih Bay, Karimun Jawa, Kepulauan Seribu, Komodo, Ujung Kulon, West Bali, Baluran, Meru Betiri, Lorentz, and Sembilang National Parks. The total area of marine protected areas (MPA) in 2020 is approximately 23.7 million hectares, or about 7.12% of Indonesian oceans based on KKP/MMAF data. Moreover, Indonesia also has the largest mangrove area in the world (21%), which are grouped into mangrove forest (managed by KLHK/MoEF) and non-forest (managed by KKP/MMAF). Around 81% or 2 million hectares of mangrove forest and 79% or 616,287 hectares of mangrove non-forest were categorised *good* in 2019. Unfortunately, overfishing was detected in each WPPNRI based on the Director-General of Capture Fisheries submission in 2020. As an effort to protect, preserve, and utilize the resources, Indonesia has a list of 20 priority species of fish for 2020-2024

Located in the tropics allows the ecosystems in shallow seas like coral reefs to grow and thrive. The Indo-Pacific region is one of the centres of coral diversity in the world, labelled as an underwater tropical forest which is rich of species of coral from the Philippines and Australia (Stehli & Wells, 1971). The coral triangle region has at least 605 species or about 83% of all species in The Indo-Pacific (Veron et al., 2011), while Kepala Burung Peninsula of Papua, Indonesia, has the wealthiest coral species in the coral triangle region (Veron et al., 2009). Coral reefs provide various functions which make them as the basis of life for coastal communities. Some of the main functions of coral reefs are giving protection for the coastal area, as the habitat for marine organisms, providing materials for cosmetics and medicines, tourism, and most importantly, taking part of life cycle of marine biota larvae. Healthy coral reefs have a high economic value, where each 1 km^2 of healthy reefs are equivalent to 20,000 kg of fish/year, hence, 42.000 km^2 of healthy reefs are equivalent to 840 million tons of fish/year (LIPI, 2017). The potential income of sustainable fish production is about \$15-45,000/km^2 from local consumption and about \$5-10,000/km^2 from exporting live fish (Barbier et al., 2011). Even tough coral reef ecosystems have a high level of resilience naturally, these ecosystems still have an inability to face the excessive pressures from various human activities (Burhanuddin 2013). Therefore, the ecosystems of coral reef need to be taken into account by involving the community in conservation, and increasing the awareness and knowledge about the importance of coral reefs (Tancung 2009).

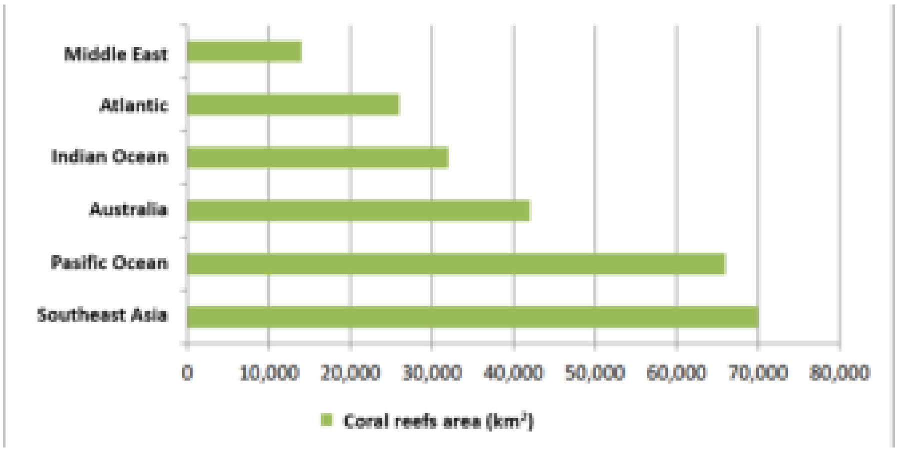


Figure 1.2 Coral reefs distribution by region (Source: Burke et al. 2012)

It is a fact that the Coral Triangle region is the centre of abundant marine biodiversity (Veron et al., 2011). Although the area is only 1.6% of the oceans on Earth, the coral triangle region has very significant roles in influencing the global environmental conditions. Some of them are its contribution to the global warming, climate change, and to address the challenges of food security for the surrounding community and the world. There are over 114 million of people spread across the six CT countries having dependency on the coral triangle region financially (Burke et al., 2012). Indonesia is one of the CT countries which is known as the centre of coral reef diversity in the world. Indonesia has at least 569 types of coral included in 83 coral genera, representing about 69% species and 76% of coral genus globally (Hadi et al., 2020). Indonesia is also home to 76% of the mangrove ecosystems in Southeast Asia, 2,057 species of reef fish and 36 marine mammals species (USAID, 2018). Indonesia has about 16% of the coral reefs of the world, scattered in the entire Indonesian territory (Table 1.2).

Table 1.2 Coral reefs area in different island of Indonesia

No.	Regional	Area (Ha)
1	Bali	8,837
2	Java	67,869
3	Kalimantan	119,304
4	Maluku	439,110
5	Nusa Tenggara	272,123
6	Papua	269,402
7	Sulawesi	862,627
8	Sumatera*	478,587
Total		2,517,858

Source : (Giyanto et al., 2017)
*excluding coral triangle region

Indonesia is an ideal place for growth and development of coral, however, there are several limiting factors causing uneven distribution. Naturally, the highest coral distribution is found in the central and the eastern part of Indonesia such as in the area around Sulawesi, Maluku, Western Papua, and Nusa Tenggara. Java marine, the southern part in particular, and the eastern part of Sumatra, are less diver. The low distribution of coral reefs in Java and Sumatra is led by the high turbidity and the low salinity due to a high number of rivers streaming down to the East Coast of Sumatra and the strong waves from the Indian Ocean which always occur in the area of Southern Java (Hadi *et al.* 2020). Coral growth is almost non-existent in Kalimantan waters, especially in the area with great rivers like in the western and the southern Kalimantan. However, coral is found on islands relatively close to Kalimantan like in Sangalaki Island and Derawan Island (Giyanto 2017).

1.3.2 CTI Protection Concept in Indonesia

1.3.2.1 CTI as Protection for the Indo Pacific Ocean Area

Indonesian position, geographically located between Asia and Australia continents, also between Pacific Ocean and Indian Ocean, creates a high-productivity waters with a strong natural carrying capacity. Known as mega biodiversity because located in a tropical region with a relatively low level of environmental temperature change, allows the development of various marine biodiversity in Indonesia. The management of Indonesian spatial planning related to the CTI-CFF is essential because the largest CTI-CFF area is in Indonesia. The success of the CTI-CFF regional cooperation program is supported by the direction of spatial planning policies in the member countries.

Based on the philosophy and the basic principles of the CTI-CFF which prioritizes comprehensive of management area, the first step of action to be taken is area identification following the legal and spatial regulations in each member country. Therefore, the success of the CTI-CFF regional cooperation program strongly depends on the direction of spatial planning policies in the member countries. The Coral Triangle Centre (CTC) is in close collaboration with the Ministry of Marine Affairs and Fisheries (KKP) of the Republic of Indonesia in encouraging sustainable management of marine resources in Indonesian coral triangle region by the implementation of NPOA and RPOA CTI activities, as well as security cooperation in the Indo-Pacific region (Rani, 2015). The management and the supervision of marine conservation areas in Indo-Pacific are carried out by strengthening and developing the capacity of human resources; the development of Marine Protected Areas as a pilot; the development of learning networks; the development of the partnership with related stakeholders; and lastly the increasing of supervision and monitoring.

1.3.2.2 Ecoregion-based Protection Concept

Ecoregion is an area of land and water including species, natural communities, and environmental conditions that are genuinely united in a geographic environment, and effectively, served as a conservation unit (Omernik, 2004). The physical boundaries of an ecoregion cannot be determined permanently, but an ecoregion includes the area where essential ecological and evolutionary processes is closely interacting. The Ministry of Environment and Geospatial Information Agency inaugurated a map and description book for Indonesian ecoregions in 2013. Specifically for the maritime, the Research and Development Agency of KKP has released a map and a description book of Indonesian Marine Ecoregion based on various data and information related to oceanography, WPP, and articles related marine and coastal resources. Marine ecoregion map is an integration result of sequential marine geospatial data from bathymetry, geomorphology, tides, ocean currents, and biodiversity like coral reefs and reefs fish.

There are eight ecoregions within the Coral Triangle, located in Papua, Banda Sea, Sulawesi Sea / Makassar Strait, Lesser Sunda (NT & Timor Sea), Halmahera, parts of eastern Palawan/North Borneo (contiguous Sulu Sea), Northeast Sulawesi/Tomini Bay, and Arafura Sea. The remaining ecoregions are located outside the coral triangle, in the western region (West Sumatra, Malacca Strait, and Sunda Shelf/South Java). The detailed Information about the condition of mangroves, coral reefs, and seagrass meadows for each ecoregion can be seen in Table 1.3.

In the CTI-CFF framework, ecoregion planning focuses more on identifying the optimal efforts for biodiversity conservation and ecosystem function. Ecoregion planning does not include the zonal controlling like marine spatial planning (MSP) and Marine Functional Zoning (MFZ), but focuses on identifying the most important area for conservation based on several criteria such as biodiversity, important taxonomic groups, primary habitat, ecosystem functions, scarce or unique biological phenomena, and biota migration pathways. An optimization tool like MARXAN being used to support the ecoregion planning process. The result of ecoregion planning can be overlaid with data of activities such as fisheries, coastal development, mining, oil and gas, tourism, etc., in identifying the possible protection measures.

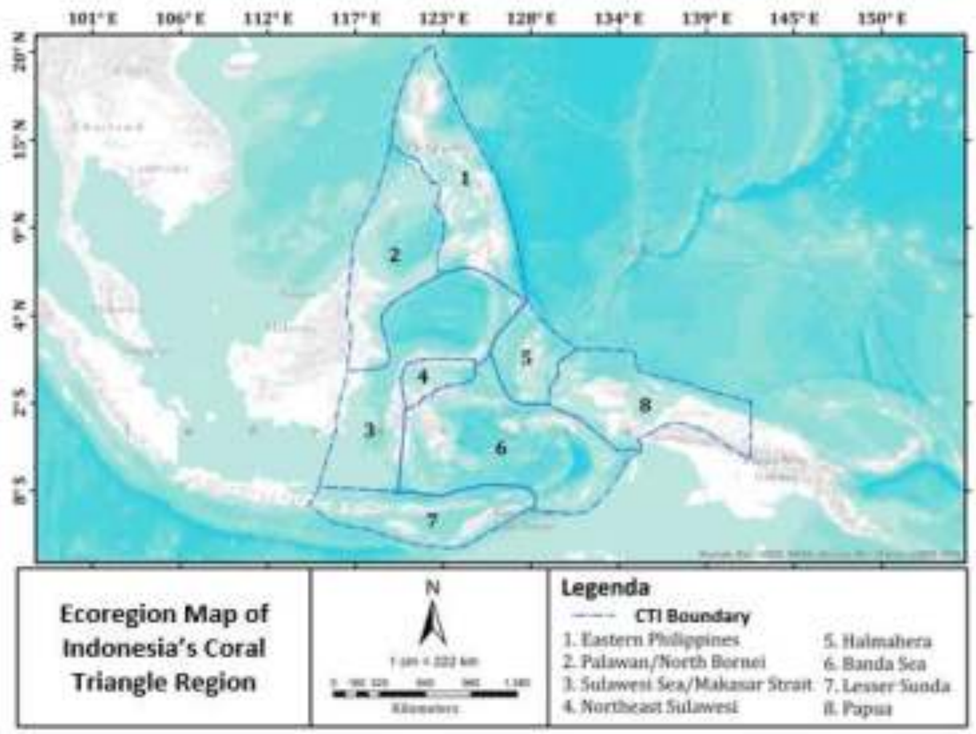


Figure 1.3 Ecoregion map of Indonesian coral triangle region

Table 1.3 The percentage of mangrove, coral reef, and seagrass meadow in the ecoregion of Indonesia

Ecoregion	Mangrove	Coral Reef	Seagrass Bed
Papua	16.9	43.2	52.9
Banda Sea	6.0	17.3	0.6
Lesser Sunda (Nusa Tenggara)	30.7	37.5	22.8
Sulawesi Sea / Makassar Strait	31.4	5.3	23.8
Halmahera	-	-	-
Palawan / North Borneo	5.2	79.1	0
West of Sumatera	11.0	18.2	89.0
Northeast Sulawesi / Tomini Bay	31.4	16.0	0
Java Sea	5.7	19.5	0.2
Arafura Sea	44.2	5.3	0.1
South of Java	17.8	7.1	2.6
Malaka Strait	6.4	17.1	22.2

Source: Yunia (2010)

1.4 Goal and Objective

The development of this document aims to examine data, information, and studies about Indonesian Coral Triangle region. The objective of this study is to identify and to map Indonesian Coral Triangle that is vulnerable to climate change. The vulnerable area is depicted with a map of coastal area intervention targets based on climate change information using coastal and marine parameters in Indonesian Coral Triangle region.

1.5 Scope of Study and Methods

The data and information analysis in this report is focused on Indonesian Coral Triangle region. The study was conducted to determine the current condition of Indonesian Coral Triangle region and the potential for management practices. The available data on coastal and marine parameters are the basis for specifying the targeted area for coastal intervention. The risk analysis approach based on the IPCC (2014) is applied. In this study, the hazards as the climate change impacts are represented by the climate change hotspot data. The vulnerability factor is described according to socio-economic vulnerability index from the Ministry of Environment and Forestry, accessed on SIDIK, and the coastal vulnerability index (CVI) developed by the KKP. Meanwhile, the exposure are the existence of mangrove and coral reef ecosystems in the study area.

Analysis of coastal intervention targeted area is a fundamental to design the appropriate recommendations for the management of Coral Triangle region. The main reference of the development of this report is the document from CTI-CFF website (http://coraltriangleinitiative.org/), data and research reports of the Indonesian CTI-CFF Working Group, LIPI, BIG, NGOs, other stakeholders, and regulations related to the Coral Triangle region. Other references are used from related data, information, and scientific publications. The study also collected information from focus group discussions with several stakeholders and non-governmental organizations related to the management of Indonesian Coral Triangle region. Peer reviews were also undertaken to improve the development of this document. Limitations in this report are the information of the current state of coral reefs, mangroves, and seagrass that was not able to be processed; and data and information management related to the coral triangle region in Indonesia which is not centralized. Table 1.4 shows the type of data used for this study.

Table 1.4 The type of data used to specify the intervention targeted areas

Risk Component	Data	Source	Data Format	Period
Hazard	Climate Hotspot	KLHK	Raster	2020
Vulnerability	Coastal Vulnerability Index (CVI)	Bappenas	Vector	2018 (modified)
	SIDIK	DJPPI (KLHK)	Vector	2019
Exposure	Coral reefs status	LIPI (Coremap)	Report	Annually, tentative
	Coral reefs area	LIPI (Coremap)	Vector	2007
	Location of coral reef habitat distribution	LIPI (Coremap)	Vector	2015-2019
	Marine and Coastal ecosystems habitat distribution	KKP	Vector	2015-2019
	Seagrass distribution		Vector	2018
	Coral reefs distribution	LIPI	Vector	2007
	Coral reefs distribution	BIG	Vector	2009
	Mangrove density map	Dit. KTA (KLHK)	Grid	2009-2013
	Areas and distribution of National Parks	Dit. PIKA (KLHK)	Vector	2020
	ProKlim distribution	DJPPI (KLHK)	Point	2012-2020
	Marine Protected Areas	DJPRL (KKP)	Vector	2009-2019
	Marine ecoregion boundary	CT Atlas	Vector	2019
	Coral reefs boundary	CT Atlas	Vector	2019
	Priority fish	KKP	Tabular	2020-2024
	National Parks with waters area	DJKSDAE (KLHK)	Tabular	2017

Risk Component	Data	Source	Data Format	Period
	National Parks without waters area	DJKSDAE (KLHK)	Tabular	2017
	Marine Tourism Park areas	KKP	Tabular	2020
	Strategic plans and realization of BTN and BKSDA development	KLHK	Tabular	2015-2019
	Fisheries resources status	Dit. PSDI (KKP)	Tabular	2020
	PDPT and PKPT location	DJPRL (KKP)	Tabular	2012-2016
	Mangrove rehabilitation activities	Dit. P4K (KKP)	Tabular	2000-2016
	Mangrove rehabilitation source APBN	Dit. P4K (KKP)	Tabular	2015-2020
	National mangrove distribution	KLHK	Tabular	2013-2019
	Mangrove ecosystem management policies and programs	Dit. P4K (KKP)	Report	2020
	Mangrove degradation	KKP and KLHK	Tabular, map, and graph	2018
	Ecosystem recovery	DJKSDAE (KLHK)	Report	2017
	RZWP3K in 27 Province	Regional	Regulation	2007-2020

Keterangan:

➔ Data used

➔ Unprocessable data

2

PRESSURE ON INDONESIAN CORAL TRIANGLE REGION

2.1 Climate Change Impacts on Coastal and Marine Physics

The impacts of climate change in coastal and marine ecosystems are including the direction changes of waves and ocean currents, the increasing of seawater CO_2 concentration (ocean acidification), Sea Surface Temperature (SST) and Sea Level Rise (SLR), UV concentrations, and a more frequent hurricanes and cyclones (Bappenas, 2018a). Without any countermeasure, these impacts are predicted to become more extreme in the future. Disasters on the coast area such as high waves, tidal flooding, coastal erosion, widespread inundation in lowlands and swamps, seawater intrusion into groundwater, and submergence of small-island, will be more frequent due to climate change impacts. This kind of disasters affect the life of coastal and marine ecosystems, as well as coastal communities. Therefore, knowledge of historical conditions and projected impacts of climate change on the coast and the sea is very crucial. The following sections describe the climate change impacts on coastal and marine ecosystems.

2.1.1 Sea Surface Temperature

The sea surface temperature (SST) along Indonesian coastline is relatively higher than the SST on the further ocean. The median Indonesian SST ranges from 24-30°C, with an average at 28.7°C. In general, Indonesian SST is above 28°C in January and below 27°C in August (Bappenas, 2018b). Model analyses for 1961-2015 shows that SST of Indonesia gradually increased with an average rate 0.15°C/decade. The increasing of SST has also changed from the beginning of the 20th century by 0.075°C/decade to 0.22°C/decade in the last few decades. The average trend of the increasing of SST in Indonesia currently ranges from 0.2°C/decade to 0.23°C/decade (Bappenas 2018b), even reaching 0.5°C in several areas referring to the Bappenas or ICCSR, (2010). The highest increasing rate of SST has detected in South China Sea and Karimata Strait by 0.5°C/decade; SST increasing rate in Java Sea, Banda Sea, Sulawesi Sea, and surrounding seas range from 0.2 to 0.3°C/decade; and the lowest in the Pacific, northern Papua (Bappenas 2018b).

The SST increasing rate will likely raise by 0.6°C-0.7°C in 2030 and by 1°C-1.2°C in 2050 without countermeasure taken. Comparing the condition in 2000, the number will increase by 1.6°C-1.8°C in 2080, and 2°C-2.3°C in 2100 (Bappenas 2018b). This projection is similar to the ICCSR document (2010), where the average SST in Indonesian waters will increase by 0.65°C in 2030; 1.10°C by 2050; 1.70°C by 2080; and 2.15°C in 2100 compared to the SST in 2000 (KLHK, 2020a). The increase or decrease in SST affects the sea level and surface salinity. The decreasing of SST lead to the reduction of the total annual rainfall and the sea level while it increases the salinity at the surface (Bappenas 2018a).

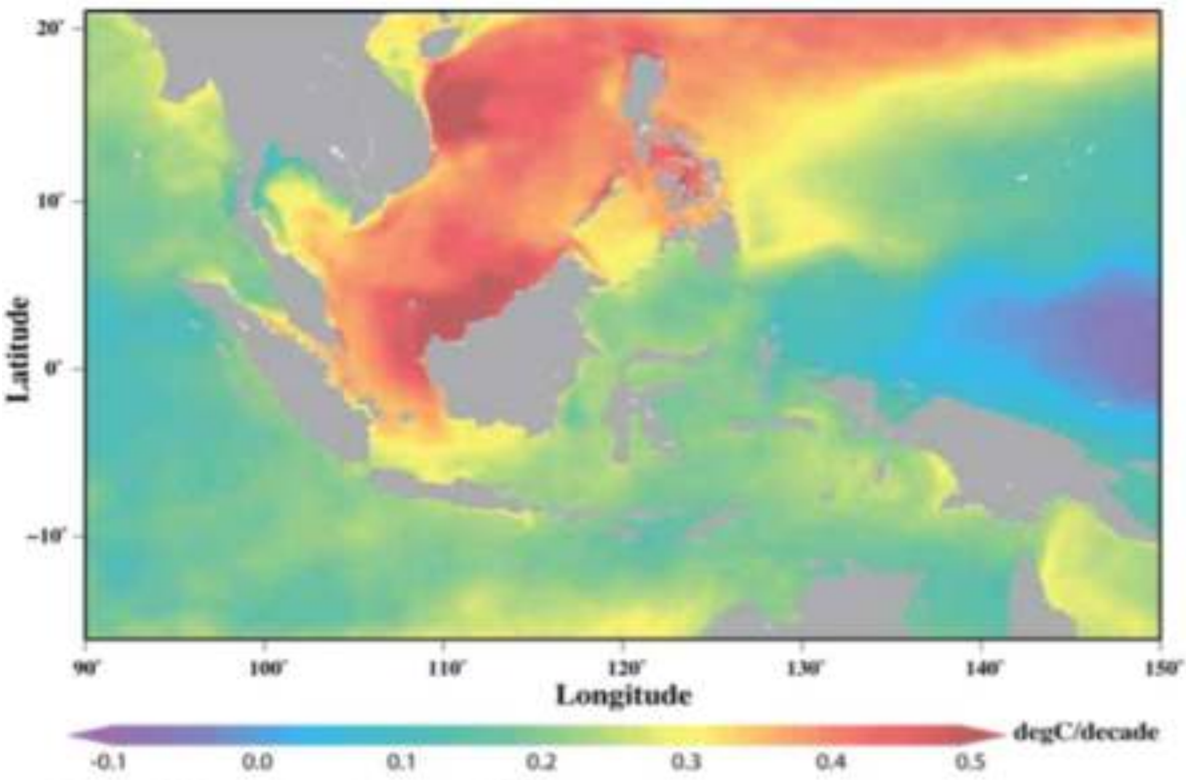


Figure 2.1 SST increasing rate in 2006 – 2040 (Sources: KLHK, 2017a; Boer et al., 2017)

2.1.2 Sea Level Height

The Sea Level Height (SLH) in Indonesian oceans fluctuates daily due to sea tides and seasonally due to monsoon circulation. SLH in Indonesia generally higher in January and lower in August. Referring to the 2010 Bappenas report, the SLH in Indonesian territory decreased about 20 cm below normal during El Niño and rise by 10-20 cm during La Niña (Bappenas 2018a). The SLH in Java Sea is 30-50 cm lower than the SLH in Karimata Strait, which ranges from 0.55 m to 0.65 m. Since 1993, the SLH has increased by more than 12 cm in Indonesian waters. Based on a very optimistic scenario, when SST has increased by 2°C in 2100, sea level will go up by 50 ± 5 cm (Bappenas 2018b). This could cause an economic losses of around 0.1% of GDP (KLHK, 2020a).

Based on HYCOM assimilation and altimetry by Bappenas (2018b), the average sea-level rise (SLR) of Indonesian waters is 7.2 cm. The number has escalated from 0.7 cm/year in the 1993-2003 to 1.1 cm/year in the 2003-2013 continued to the last decade. This increasing rate is might be caused by the changes in the thermal expansion which can be seen from the changing in SST. The highest rate of change in SLR has been found in Pacific Ocean, north of Papua, which is about 1.7 cm/year, while the lowest change is in the Southern part of Java and West Sumatra, ranged from 0.4 to 1.2 cm/year. The consistency of this trend lead to the increasing of SLR from 12 cm to 48 cm by 2030, with average SLR ranging from 21 cm to 33 cm. By 2050, sea level rise could reach 20 cm to 85 cm, with an average 35-55 cm. Next, sea level is estimated to rise by 40 cm to 170 cm, with an average of 70 cm to 110 cm by 2100, relatively to the sea level in 2000 (Bappenas 2018b).

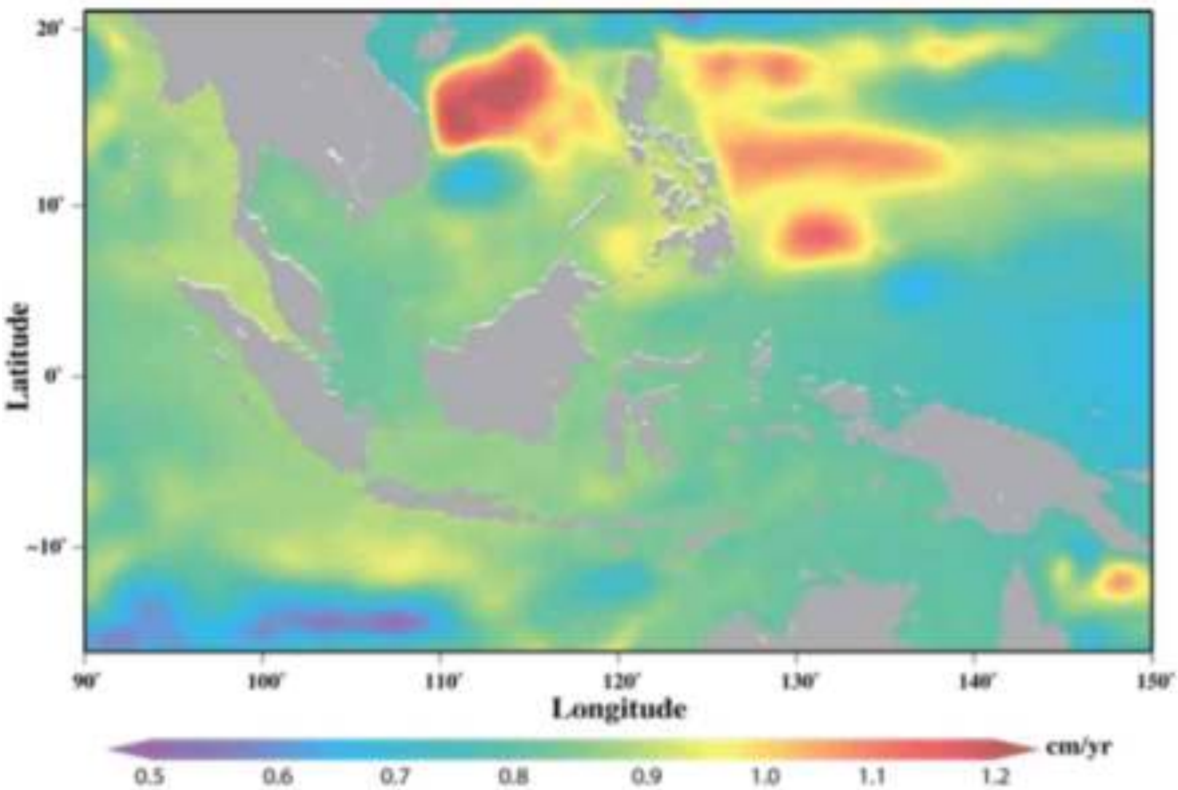


Figure 2.2 SLR rate in 2006 – 2040 period (Sources: KLHK, 2017a; Boer et al., 2017)

2.1.3 Sea Surface Salinity

Surface salinity generally follows the SST conditions, and is also affected by the global ice melting, freshwater flux, and precipitation. Based on the spatial distribution model for 1991-2015 period, Sea Surface Salinity (SSS) tends to decrease by the rate of -0.35 ± 0.2 psu/decade. The greatest changes in surface salinity has occurred on the northern coast of Australia, the southern part of Java Sea, western and eastern part of Sumatra, Tomini Bay, Straits of Malacca, and the Gulf of Thailand. These changes could be caused by the increasing supply from freshwater and precipitation. Changes in surface salinity parameters and sea surface temperature are the main variables to estimate the acidification process because a decrease in salinity goes along with the increasing of sea surface temperature associated with the lowering in seawater pH. Based on climate projections under RCP4.5 scenarios, surface salinity is projected to decline from 33.2 psu in 2000 to 32.1 psu in 2040, hence it is estimated that the acidification process or ocean acidification would continue (Bappenas 2018b). The pH of the low latitude oceans continues to decrease significantly to 7.7 under the RCP8.5 scenario; to 7.8 with the RCP6.0 scenario; to 7.9 with RCP4.5 scenario; and to 8.07 under the RCP2.0 scenario in 2100 (Hartin, Bond-Lamberty, Patel, & Mundra, 2016).

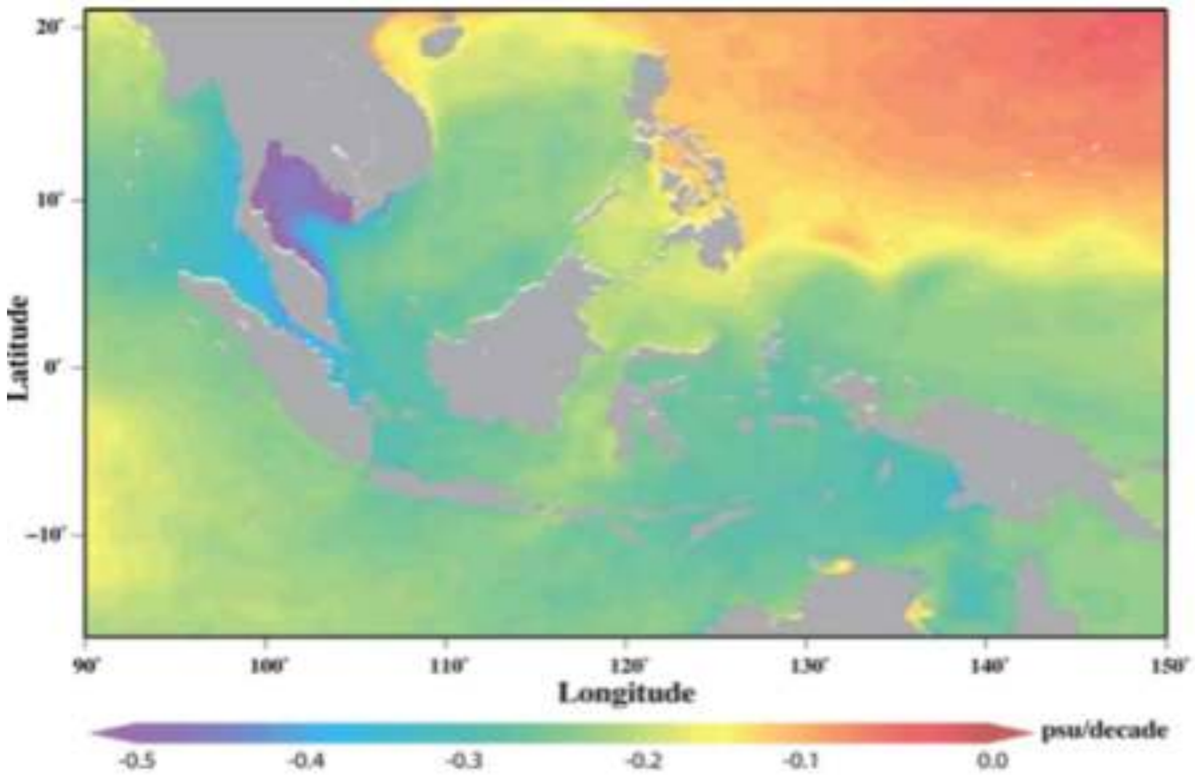


Figure 2.3 SSS decreasing rate in 2006 – 2040 period (Sources: KLHK, 2017a; Boer et al., 2017)

2.1.4 Sea Wave

Global warming or the increasing of air temperature will generally increases the intensity and the frequency of extreme weather. Extreme weather is an important aspect in climate assessment because it is correlated to the climate-related disasters such as floods, landslides, drought, and cyclones. Climate change leads to a more frequent of La Nina than El Nino in recent decades, implicated to a more storm surges in Indonesian Oceans. La Nina contributes to the rise of the sea level as well as to the frequent and the height of the waves in Indonesian archipelago. Based on an analysis of significant wave height (SWH) for 1990-2015, the median of the 6-hour SWH data ranges from 0.2 m to 3 m, with the median SWH 0.6 - 1 m in Java Sea (Figure 2.4a). However, the height of Indonesian Sea wave is higher than 2 m in the ≥ 90 percentile, except near the coast or narrow straits. The wave height in the southern part of Java, the western part of Sumatra, the northern part of Karimata Strait, and South China Sea, exceeds 4 m (Figure 2.4e).

Based on the projected wave height from 2006 to 2040, there is a change at the 50 to 99 percentile (Figure 2.5). The wave height also goes up in Indian Ocean, the western part of Sumatra, and the southern part of Java. It shows that the Indian Ocean Dipole (IOD) might has a more significant contribution than the historical data. The shallow North Karimata Strait and the Riau Islands reduce the spread of Rossby waves from South China Sea, so the wave height on the east coast of Sumatra and Java Sea gets lower. On the other hand, the height of waves in Banda Sea, Sulawesi Sea, South Java, West Sumatra, and the southern part of South China Sea is getting higher. Stronger wind speeds in Banda Sea, north coast of Java Island, Sulawesi, and Flores Sea, causes higher wave heights compared to the historical data. Although 1% of projected extreme waves shows an increase of less than 1 m, the increasing of height waves is still possible up to 1.5 m in real terms because of changes in local and regional wind speed affected by the more frequent climate variability than projected and the effect of sea-level rise (Boer et al., 2017).

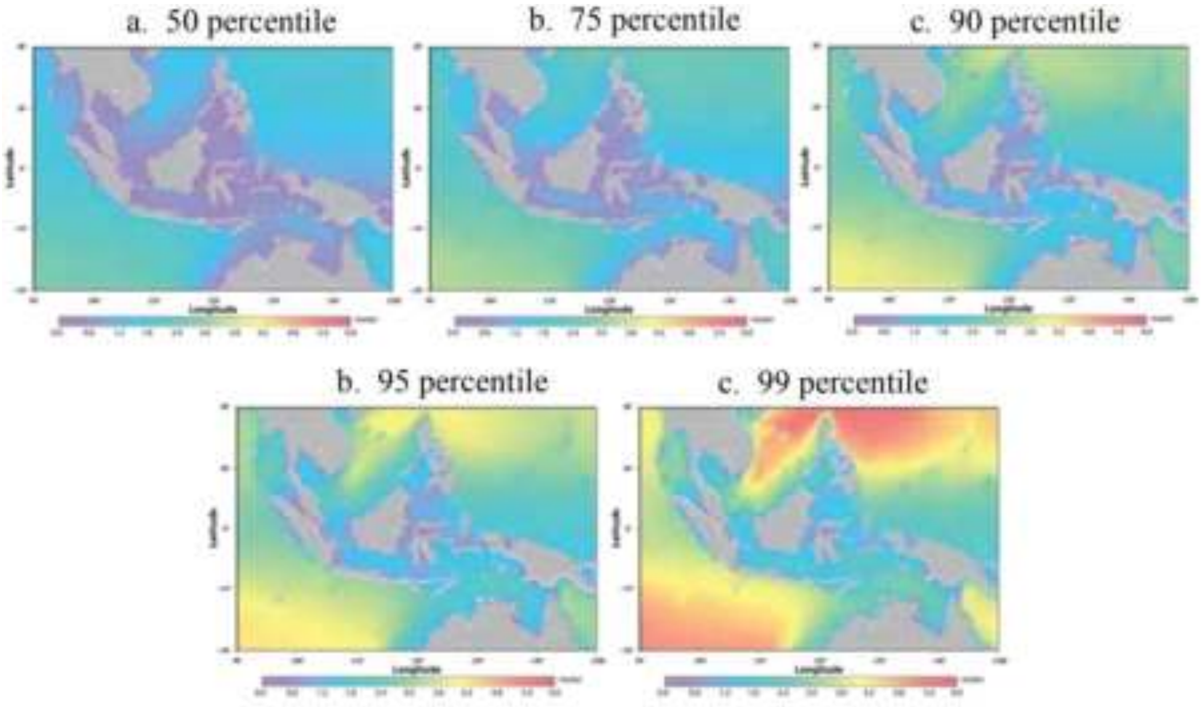


Figure 2.4 SWH percentile rate in 1991 to 2015 period (Source: Boer et al., 2017)

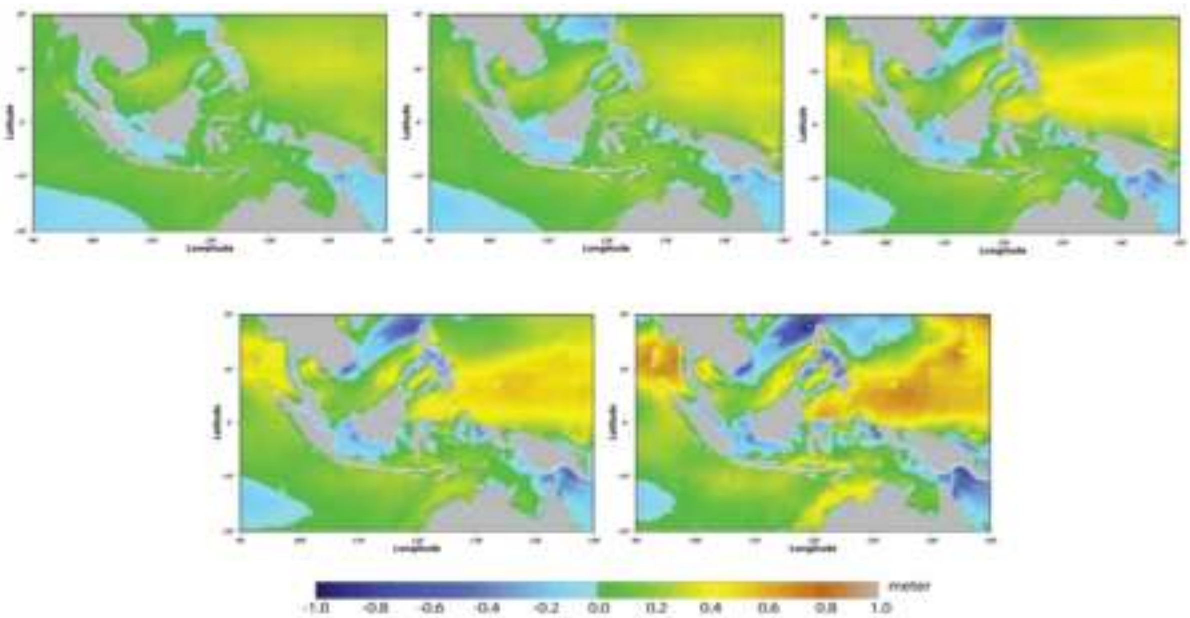


Figure 2.5 Percentile rate of change in wave height from the SWH projection (Source: Boer et al., 2017)

2.2 Pressures on Indonesian Coral Triangle Region

The aquatic resources, including habitats and biota, are faced various threats. Many factors suppressed the life in marine ecosystem, arise naturally or from human (anthropogenic) activities. Apart from climate change, the pressure on marine and coastal ecosystems could intend to be greater along with the accretion of human activities like the extension of development on the coastal area and mainland. These pressures affects the ecosystem in the coral triangle region either directly or indirectly. The following section explains some of the pressures from human activities to the coral triangle region .

2.2.1 Pollution

Marine and coastal pollution is sourced from the wastes of human activities on land, which flow and invade the coastal and marine ecosystems. Most of the wastes contains various kinds of toxic and harmful substances and nutrients to marine ecosystems. Poisonous or toxic chemical wastes are harmful to the aquatic ecosystems. Simultaneously, the more nutrients entering the water column will fertile the waters and encourage the growth of phytoplankton and algae on the sea surface. Once the phytoplankton and the algae grow continuously, there will be a eutrophication causing the disasters in the shallow marine ecosystems because of higher surface cover by the phytoplankton and algae that prevent the sunlight. The growth of coral reefs and seagrass is also hampered due to sediment accumulation and unclean environment (Rahmawati, 2011). Pollution in the oceans is also detected in other form like plastic. Bunch of harmful plastic wastes are entering the marine ecosystem threaten the health of marine life (USAID, 2018).

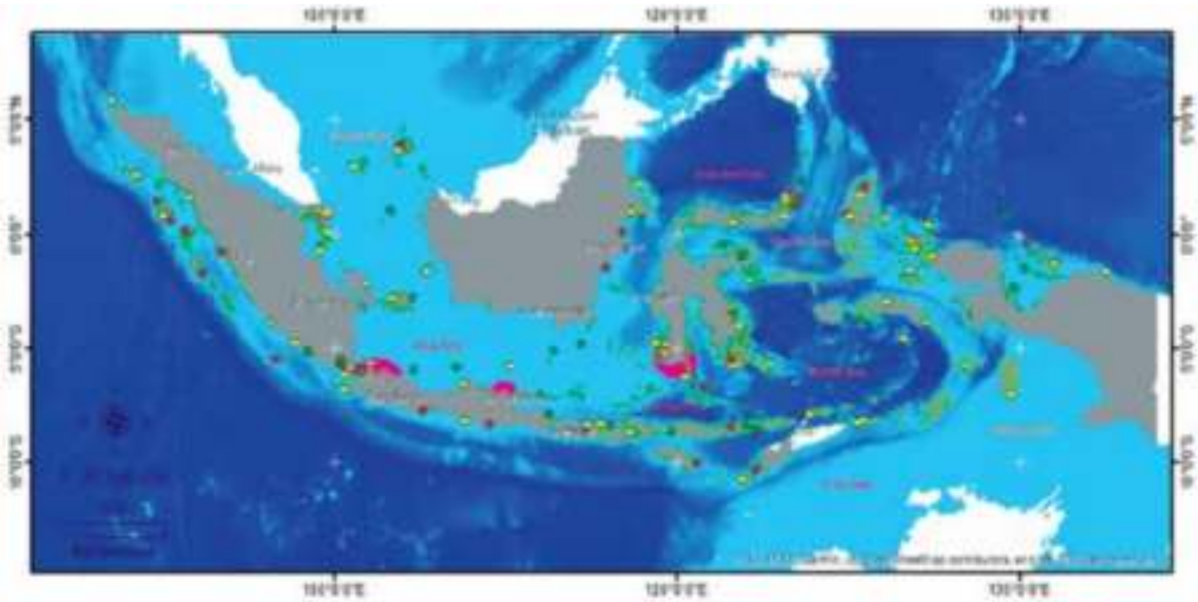


Figure 2.6 Marine coastal pollution areas (Source: Hadi et al., 2020)

2.2.2 Destructive Fishing

Humans have carried out various kinds of fishing practices of marine resources, both using safe and dangerous methods. Explosive fishing, trawl, and poisons bring damages to the coral reef habitats and the associated biota. Large-scale fishing like using purse seines, trawl, gill nets, and ghost nets also poses a significant threat to marine habitats and biota. As many as 7,700 turtles/year are estimated to be accidentally killed by trapping in the shrimp trawls and tuna longlines. Other species such as dolphins, whales, and dugongs are also at risk of being injured by fishing gear and boat propellers. Not only the dangerous fishing tools, fishing activity itself also threaten the aquatic ecosystem by the overfishing, affecting the food chain (the explosion of certain species due to the disappearance of predators). Types of fish in each FMA overexploited during 2015 is available in the Figure 3.7, when fishing was no longer sustainable and other species were already at the level of full exploitation. The decline in fish stocks also occurs due to unfaltering catchment which includes fry and fertile females (USAID, 2018).

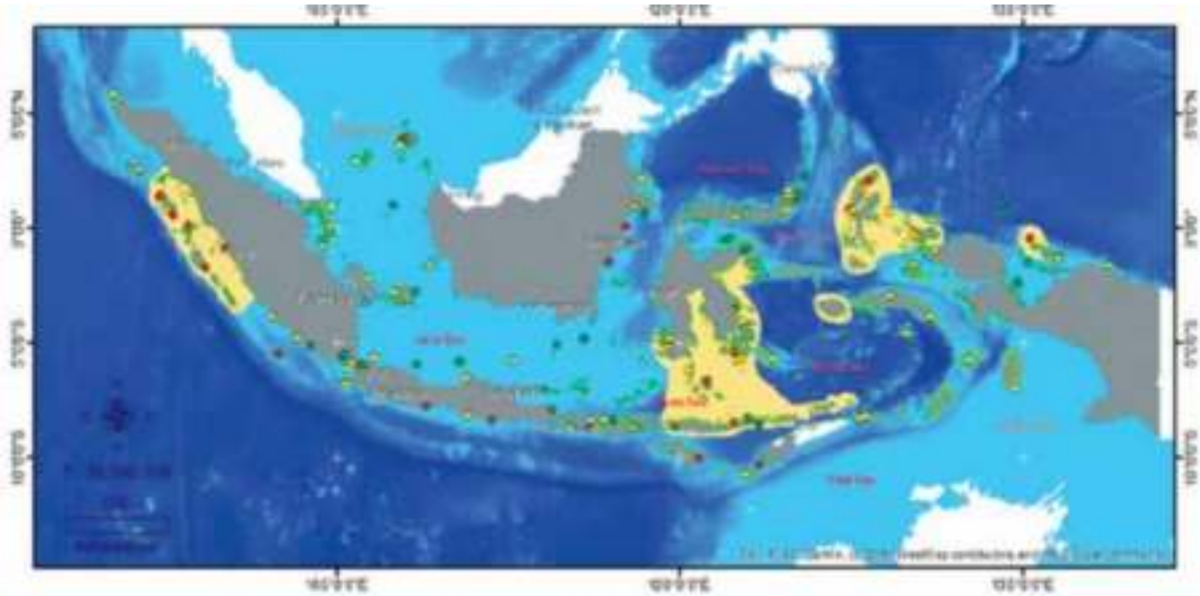


Figure 2.7 Explosive fishing area based on observations and interviews with local people (Source: Hadi et al., 2020)

2.2.3 Illegal Fishing

Illegal, unreported, and unregulated fishing (IUU fishing) has been rife in Indonesia. It is estimated that 25% of Indonesian fish have been stolen under these practices. Typically, this activity involves foreign vessels from neighbouring countries and from Indonesian itself using destructive fishing methods. Supervision of the Indonesian ocean territory from IUU fishing practice is quite a challenge because of the broad Indonesian oceans. Based on Indonesian DFW research in the USAID report (2018), the IUU practise has estimated to cause losses of at least USD 25 million/year. This loss has encouraged Indonesia to prioritize the efforts to handle IUU fishing.

Figure 2.8 Map of the vulnerable zone of violation of marine and fishery resources (Source: MMAF in Muhamad, 2012). The size of the green circle shows the number of violation cases

2.2.4 Mining

The Law No.1 of 2014 regulates the use of small-islands and the surrounding marines prioritized for nine types of concerns including conservation, education, development, and marine cultivation. However, there are small-islands still being used for different purposes like for mining, indicating that this regulation is not implemented optimally in Indonesia. The Mining Advocacy Network (Jatam) notes that there are 55 small-islands with 164 mineral and coal mining concessions. The existence of mines, for example, in Bunyu Island (North Kalimantan) and Gebe Island (North Maluku), has polluted and harmed aquatic resources. At the same time, food sources were destroyed due to the land conversion to mining area. According to the Director of the Marine Spatial Planning Directorate of the MMAF, Suharyanto, mining are carried out in the small-island because it is not regulated in the RZWP3K. Meanwhile, still mining permits can be approved as long as the Regional Spatial Planning Regulation (RTRW), which governs the allotment of area including mining, gives their consent. The impact of mining activities on Indonesian coral triangle region is sourced from the pollution and the waste.

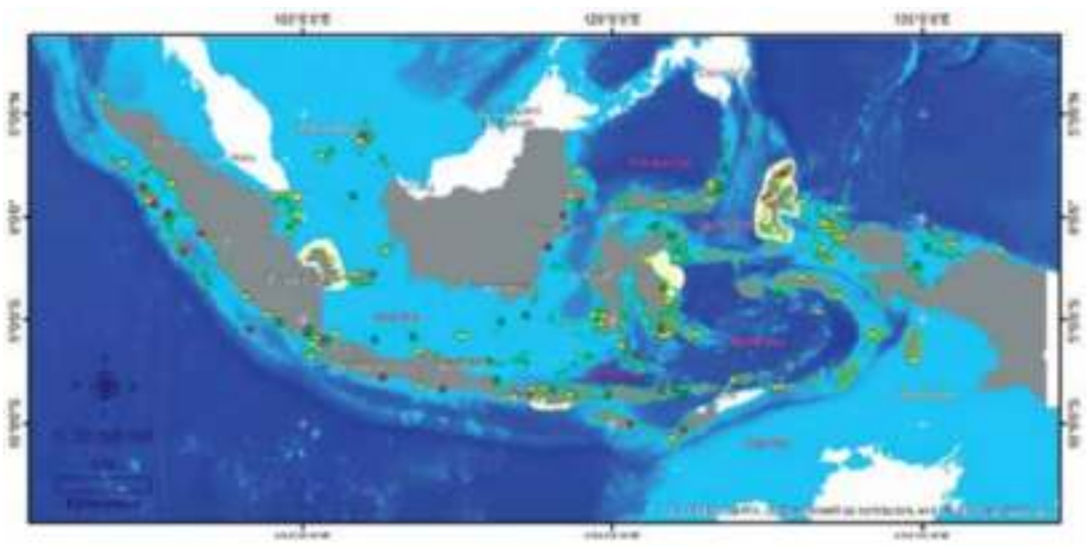


Figure 2.9 Mining areas with impacts on the coast (Source: Hadi et al., 2020)

2.3 Pressures on Preservation of Marine Resources in Indonesian Coral Triangle Region

The marine resource in the Coral Triangle area has different pressure in each location. The pressures are arised from the environment, climate change, and human activities as described in section 2.2. The pressures on marine resources could impact the productivity which is later turns over afecting human life. Moreover, the pressures also ifluence the balance of the ecosystem. Therefore, it is important to know the potential factors that can obstruct the marine resources in the Coral Triangle region. Take an example, the increasing of air temperature by at least 0.5°C would be a pressure which leads to the occupation of mangrove areas, brings damage to mangrove forests by 27%, and harms the coastal ecosystems. A further increase in air temperature by up to 1.5°C could lead to sea-level rise (Figure 2.10) (KLHK, 2017a).

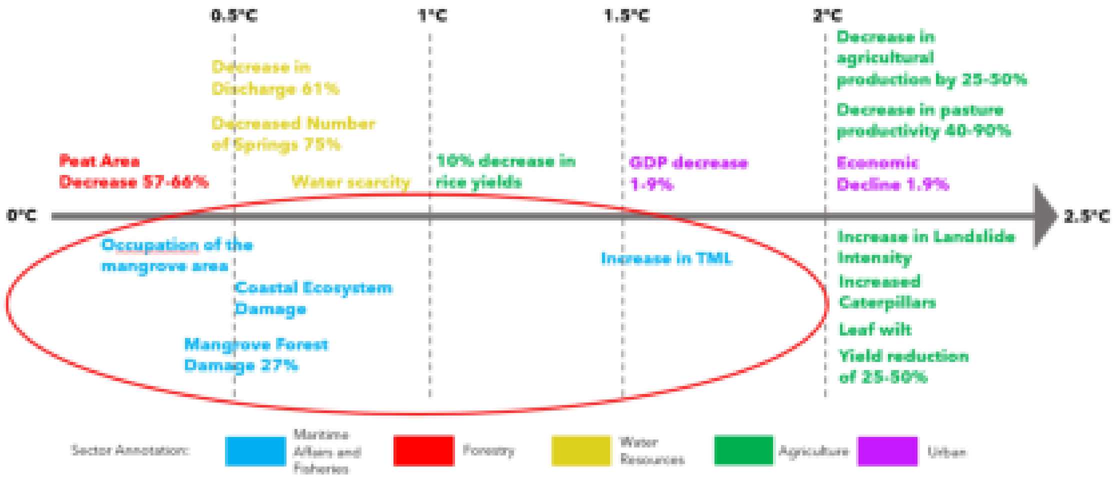


Figure 2.10 Identification of rising temperature impacts based on a literature review on the vulnerability, impact, and adaptation of climate change in Indonesia (Source: KLHK, 2017a)

2.3.1 Coral Reefs

The coral reef is a complex ecosystem consisting of lime-producing biota (especially coral) and other biotas living at the bottom and in the water column. As a stable habitat, coral reefs are inhabited by many associated biotas forming a complex network where there is a relationship between one biota and another biota as well as the environmental factors. The condition of coral reef ecosystems are correlated to the marine environmental factors such as water purity, currents, salinity, and temperature. Corals in the coral triangle region grows well because of the ocean flow across Indonesian where clean water from the Pacific is flowing continuously. This secures the food availability for the corals. Furthermore, the clean water allow corals to grow vertically into more than 30 meters. Limited number of rivers streaming down to this area indicates the stability of salinity and less sedimentation. This area has many hard-base substrates, allowing many coral larvae to stick and grow (Hadi et al., 2018). However, over time, the condition of the coral reef ecosystem has got changes due to environmental changes.

There are at least four main factors dominate local threats found in the ecosystem of the coral triangle region, overfishing, destructive fishing practices, land-based pollution, and the expanding of coastal development. Serious threats in this region continue to increase, exacerbated by the climate change and the acidification of seawater which would multiply the current threats. Increasing of SST by at least 0.2°C/decade worsen the risk of coral bleaching at all existing sites. The increasing of SST by 2°C by 2100 would prevent the recovery process. With an assumption that the coral reefs are adaptable but vulnerable to sudden SST changes (La-Nina) for more than 1.5°C, in that case, it is estimated that all coral reef ecosystems will experience bleaching (Bappenas, 2018b). The variations on increasing or decreasing of sea level could be a driving factor for coral bleaching (Ampou et al., 2017). According to Coremap, LIPI, the deterioration of coral reefs condition lead to smaller fish sizes, fish catch reduction, and longer time for fishing due to the loss on resources.

2.3.2 Seagrass

Seagrass is a type of plant (Anthophyta) living and growing in the marine environment, has vascular, rhizome, root, and reproduction in generative (seeds) and vegetative. There are about 15 types of seagrass found in Indonesian waters (Sjafrie et al., 2018). Wide expanse of seagrass with one or more types are referred to seagrass meadows. The seagrass meadows provide significant benefits both for the surrounding ecosystem and human. This type of ecosystem supports the sustainability of fishery resources in Indonesia. Seagrass habitats also has a role in capturing runoff sediment, stabilizing shorelines, and preventing the widespread of sedimentation further into the marine environment (USAID, 2018). The functions and the benefits of seagrass in shallow water ecosystems are as primary producers, biota habitats, stabilizers, sediment catchers, and nutrient recyclers. Research from the Research Centre for Oceanography of LIPI shows that the seagrass meadows can absorb an average of 6.59 tons C/ha/year or equivalent to 24.13 tons CO_2/ha/year. There are 360 types of fish, 117 types of macro algae, 24 types of molluscs, 70 types of crustaceans, and 45 types of echinoderms that live in Indonesian seagrass meadows according to Kiswara (2009) in Sjafrie et al., (2018). It shows that seagrass needs to be preserved due to its significant role for the life of fishery biota.

The main factor endanger the seagrass the tropics is the increment of sedimentation as the impact of logging and mangrove forest conversion related to aquaculture activities (Sjafrie et al., 2018). Coastal development such as reclamation, logging, mining, and agriculture, produces wastes generating more pollutants and sedimentation into the sea, threatening the life of seagrass and the organisms living in seagrass ecosystem (Sjafrie et al., 2018). The increasing of sea surface temperature lead to the extinction of seagrasses, especially in estuaries and shallow water (KLHK, 2017a).

2.3.3 Mangrove

The mangrove ecosystem is one of the typical tropical marine ecosystems growing on alluvial muds in coastal areas and estuaries influenced by tides. Mangrove ecosystems provide environmental services, including keeping the coastline stable, preventing erosion, strong wave breaker, processing waste materials, habitat and breeding grounds for marine biota, fish and shrimp cultivation, recycling nutrient, recreation, and others. (Purnamawati, Dewantoro, Sadri, & Vatria, 2007). Based on its economic value, 1 ha of mangrove forest is equivalent to 680 kg of fish/year, making 3.49 million ha of mangroves in Indonesia are valued at 2,373 million tons of fish/year (LIPI, 2017). Mangrove forests also have a role on carbon sequestration with carbon stock around 1,083 ± 378 tons C/ha, in which 78% stored in the soil (Krisnawati, 2017). On the other hand, mangrove forests contribute to the production of GHGs, CO2 from land conversion. Converting mangrove forests releases large carbon stock from the soil into the atmosphere by oxidation (Krisnawati, 2017).

The condition of mangrove ecosystem correlates to the condition of two other ecosystems in coastal areas, seagrass and coral reefs. Mangroves act as an essential coastal protector by protecting shorelines from storm and other strong wave that can cause erosion and damage to land and livelihoods. Physically, the typical mangrove root system provides protection for seagrass and coral reefs from the dangers of sedimentation. The semi-submerged roots of mangroves are the essential habitat for fish and juvenile breeding. Like seagrass, mangroves capture sedimentation from land and preventing the widespread to the marine environment (Dharmawan & Pramudji., 2014). This prevents the waters from becoming muddy. Ecologically, mangrove forests are the habitat for the growth of coral biota at certain phases of their life.

The mangrove area has declined because of various pressures on the ecosystem. Some of them are the pressure from climate change and human activity. Mangrove ecosystems, including molluscs living in mangrove area, are very vulnerable to climate change, although, some species of fauna are quite tolerant of high temperatures like fish, gastropods, and crustaceans which are adaptable to a rapid change (KLHK, 2017a).

Mangroves are able to survive and thrive at a sea-level of about 8-9 cm/100 years despite experiencing stress, meanwhile opposite case found when the sea-level rise is more than 12 cm/100 years which inundate the mangrove habitat. The increasing of temperature by at least 0.5°C brings damage to coastal ecosystems and mangrove forests by 27%, temperatures higher than 35°C will adversely affect root structure, seeding formation, and photosynthesis processes (KLHK, 2017a). The increasing of air temperature affect the distribution of mangrove and increase its diversity at higher latitudes (sub-tropical) in particular. The escalation of salinity and sulphate on seawater inhibit the growth and development of mangrove plants. The increasing of extent area of tides spread the mangroves habitat to inland, resulting a zoning shifting and composition changes in mangrove species. Major tropical storms also put pressure on mangrove ecosystems even though the purpose of mangroves to prevent the destructive from tropical storms. The climate change projections show a reduction of mangroves on the coastal area or on small-islands due to sea level rise (KLHK, 2017a).

2.3.4 Fish Resources

Indonesia has a high level of fish consumption, as twice as the global average at 16 kg/year. It is crystal clear that fisheries resources hold an important role in food security in Indonesia (USAID, 2018). One of the factors that put pressure on fish resources is the overfishing. Along with the effect of increasing SST on the movement of fish catchment areas, overfishing also affects the balance of the marine ecosystem due to the disturbances in the food chain.

One of measures to describe the abundance level of reef fish is CPUE (Catch per Unit Effort), representing the size of yield per catchment. Based on CPUE calculation during 1996-2011, the fluctuation tended to increase in reef fish. A significant increase has detected during 2006-2008, then has decreased significantly until 2010 and back on rise until 2011 (Figure 2.11). The highest CPUE has occurred in 2011 at 88.93 kg/trip, when the condition of oceans was relatively warmer. The CPUE during La-Nina was relatively higher than during El-Nino. The increasing of sea temperature during La-Nina is associated with the life-history-character of reef fish because several types of tropical reef fish grow to the smallest maximum size which is faster in a warming sea surface (Puspasari et al., 2015).

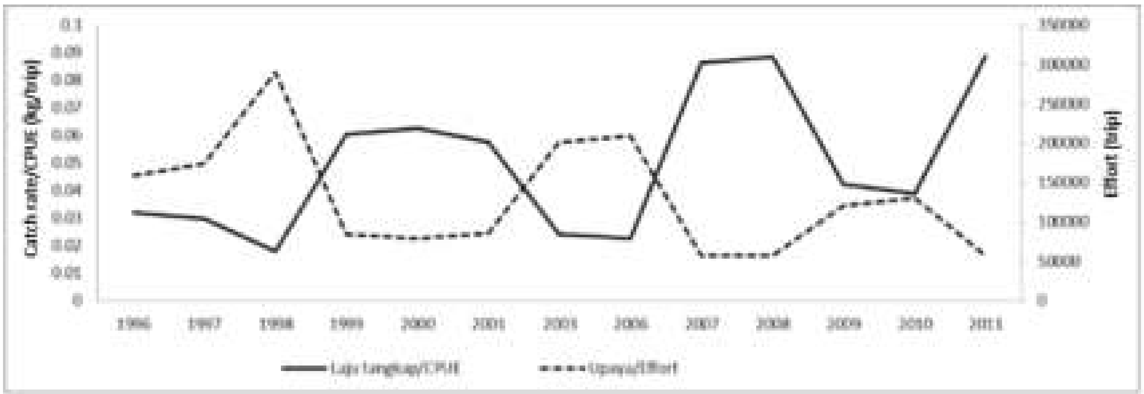


Figure 2.11 CPUE distribution and reef fishing catchment (Source: Puspasari et al., 2015)

On the other hand, pelagic fish shows the opposite condition, where its CPUE is higher during El-Nino (Puspasari et al., 2015). Pelagic fish tend to be more susceptible to the rising sea surface temperatures. However, there are several types of pelagic fish having high tolerance to the water temperatures, such as flying fish, mackerel, *lemuru*, and tuna. These four types of fish have higher level of resilience, faster reproductive period, and faster growth period (except for tuna with a longer reproductive period and slower growth) comparing to other species. Overfishing lead to the decreasing of small fish resources, hence looking at the type of food, tuna, which is a carnivore, is more vulnerable than the other types. The analysis by Puspasari *et al.* (2016) shows that these four fish species have a higher vulnerability in Bali Strait than in Makassar Strait. Although the annual average of SST in Bali Strait is lower than in Makassar Strait, the fluctuation of SST in Bali Strait is significantly higher than in Makassar Strait, causing the oceanographic conditions of Bali Strait is more dynamic and more vulnerable for pelagic fish (Puspasari et al., 2016).

2.4 Initiatives for Community Empowerment

Climate change increases the vulnerability of community in coastal areas. The sea-level rise due to climate change brings impact on coastal erosion, shoreline changes, loss of coastal wetlands, inundation/rob, loss of small-islands due to erosion, seawater intrusion, and the disruption of tourism and transportation sectors. The climate change impacts, which are starting to develop risks in various aspects of human life, has encouraged the form of Climate Village Program initiative (ProKlim) by the MoEF. ProKlim was formed in order to increase the community involvement in actions of adaptation and mitigation of climate change. ProKlim is an evident of government recognition for initiative, dedication, and commitment of the community in supporting and strengthening capacity for sustainable adaptation and mitigation of climate change .

Up to 2020, the number of ProKlim registered in the National Registry System (NRS) for Climate Change Control has reached 2,775 locations of Climate Villages at the small-region level, spread across 33 provinces in Indonesia. This number is expected to keep growing and reaching the target of 20,000 Climate Villages by 2024. ProKlim Villages in the Coral Triangle area are widely available in South Sulawesi, Bali, and Lombok. However, this number is still far less comparing to the number in Java and Sumatra. ProKlim villages are measly in Papua and West Papua, and even a rare in small-island region, for example there is no Proklim village among small-islands located surrounding Banda Sea (Figure 2.12).

The MMAF has established another initiative in community-based interventions through the Toughness Coastal Zone Program (PKPT). The PKPT initiative has begun in 2011 with the Toughness Coastal Village Development Program (PDPT). PKPT is an intervention carried out by the MMAF with an emphasis on community empowerment to develop the capacity of human resources in coastal and small-island communities, hence the community is able to manage various challenges and dangers they are facing including the climate change impacts. Up to 2017, PKPT has been implemented in 113 villages spread over 49 cities/districts. looking at the distribution, PKPT is mostly focused on Java Island, while in the Coral Triangle area, the existence of PKPT needs to be improved (Figure 2.13).

ProKlim Village and PKPT provide benefits for the area in dealing with the negative impacts of climate change. The community is encouraged and trained to be able to encounter risky conditions. Moreover, this initiative is expected to improve the welfare of the community. The effective involvement of the stakeholder and knowledge management on climate change adaptation and mitigation at the community level are the important aspects to achieve the target of climate change control at national and global level.

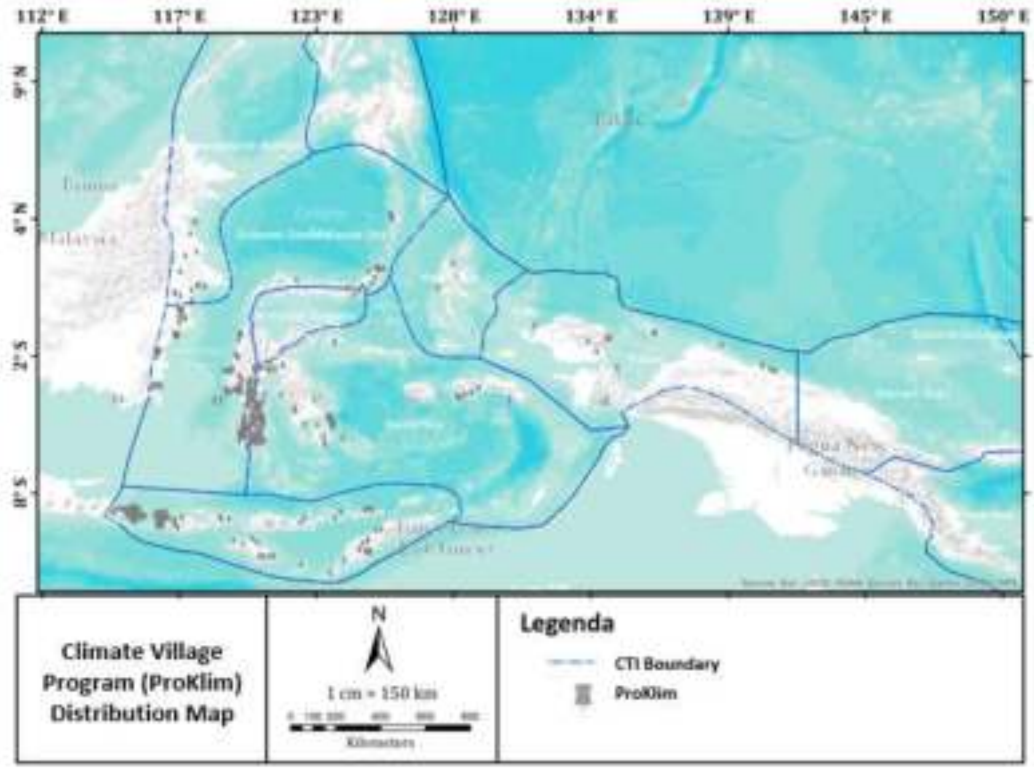


Figure 2.12 ProKlim Distribution in Indonesian Coral Triangle region

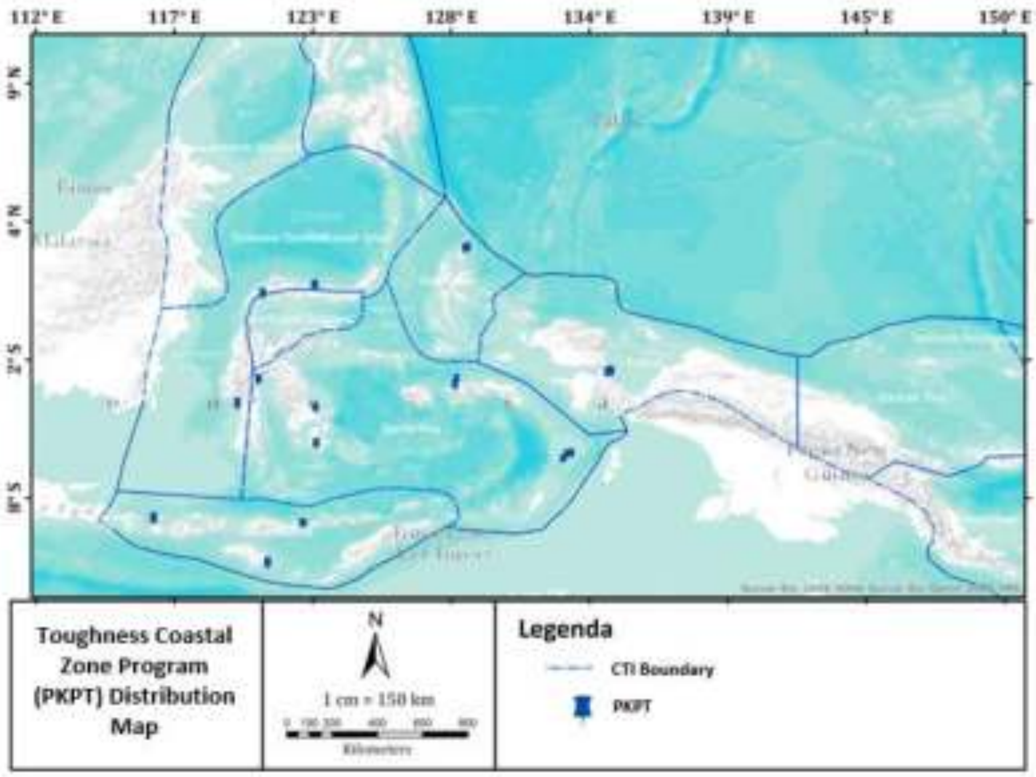


Figure 2.13 PKPT Distribution in Indonesian Coral Triangle region

2.5 Availability and Access of Information Related to Indonesian Coral Triangle Region

Information related to marine and coastal resources, especially in the coral triangle area, is an essential basic in a policymaking. Information availability is important because the various climate change-related hazards (coral bleaching, ocean acidification, sea-level rise, and flooding) increase the threat to marine and coastal resources in the coming decades. Losses to the agricultural and coastal sectors due to climate change in 2100 are estimated to reach 2.2% of total GDP (ADB, 2009). One of the units used to determine the characteristics of marines and to estimate the potential, conservation, control, and supervision of fisheries management, is the State Fisheries Management Area of the Republic of Indonesia (WPPNRI). Some important information to be known along with examples are to:

1. Identify and map the vulnerability of climate change impacts in Indonesian Coral Triangle region, and link it to the biodiversity and the socio-economic values (2020).
    - Southeast Maluku (WPP 714): map of potential resources of small-islands.
    - Bali Strait, Banda Sea (WPP 713,714): research on ocean dynamics and fisheries-related primary production.
    - Bali (WPP713): Trainings about the marine environmental condition-related to fishery resources and climate change.
2. Formulate early warning systems, response to weather and temperature variability, storm, and phenomena changes including coral bleaching, and formulate direct strategies or rapid responses to climate change impacts on fishermen like the changes in weather patterns and seasons, sea temperatures, and storms impact (2020).
    - Makassar Strait, Lombok Strait, Karimata Strait, the southern part of Java (WPP 713, 711, 573): Calculation on seasonal shifts using time series data.
    - Bali, Raja Ampat (WPP713, 715): measurements on marine health indicators.
3. Conduct capacity building for education, research, and information systems on climate change issues related to the consequences and the adaptation measures (2020).
    - Sondaken, Raprap, South Minahasa (WPP 716): training for climate change vulnerability assessment
    - North Sulawesi (WPP 716): knowledge and communication management about climate change.
    - North Sulawesi (WPP 716): capacity building for disaster preparedness
    - Lampung (WPP 712): the seaweed seeds capacity increment.
    - Sondaken and Raprap (WPP 716): a qualitative assessment of vulnerability to climate change.
    - Sondaken, Raprap (WPP 716): capacity building for disaster preparedness and improvement of health and sanitation systems.
    - North Sulawesi and Maluku (WPP 716, 714): APIK system (Adaptation and Resilience to Climate Change).
    - Manado, Yogyakarta, West Kalimantan, Riau (WPP 716, 712, 713, 571): technical guidance for climate change adaptation.
    - Saburai Jua, East Sumba (WPP 713): increasing the institutional capacity to integrate climate resilience into sustainable development at provincial level.

- Sabu Raijua, East Sumba (WPP 714, 713): Provincial and District/City Government policies regarding programs and budget allocations related to priority actions of climate change adaptation.
- Sabu Raijua (WPP 714): strengthening rural communities on climate change

4. Develop policies and conduct various studies about climate change impacts on biodiversity, socio-economy, direct and indirect costs and benefits (2020).
   - Karimun Jawa Island, north coast of Java, North Sulawesi, Bali, Derawan (WPP 712, 716, 713): mapping and measuring carbon stocks in mangrove forests and seagrass meadows in Indonesia.
   - Karimun Jawa Island, north coast of Java, North Sulawesi, Bali, Derawan (WPP 712, 716): analysis of ecosystem services from coastal area and coastal community aspects to local climate change.
   - North Sulawesi (WPP 716): strengthening the waste management system in three villages.
   - Bali (WPP 713): provide information (databases) to understand fishery and marine resources and of coastal ecosystem adaptation.

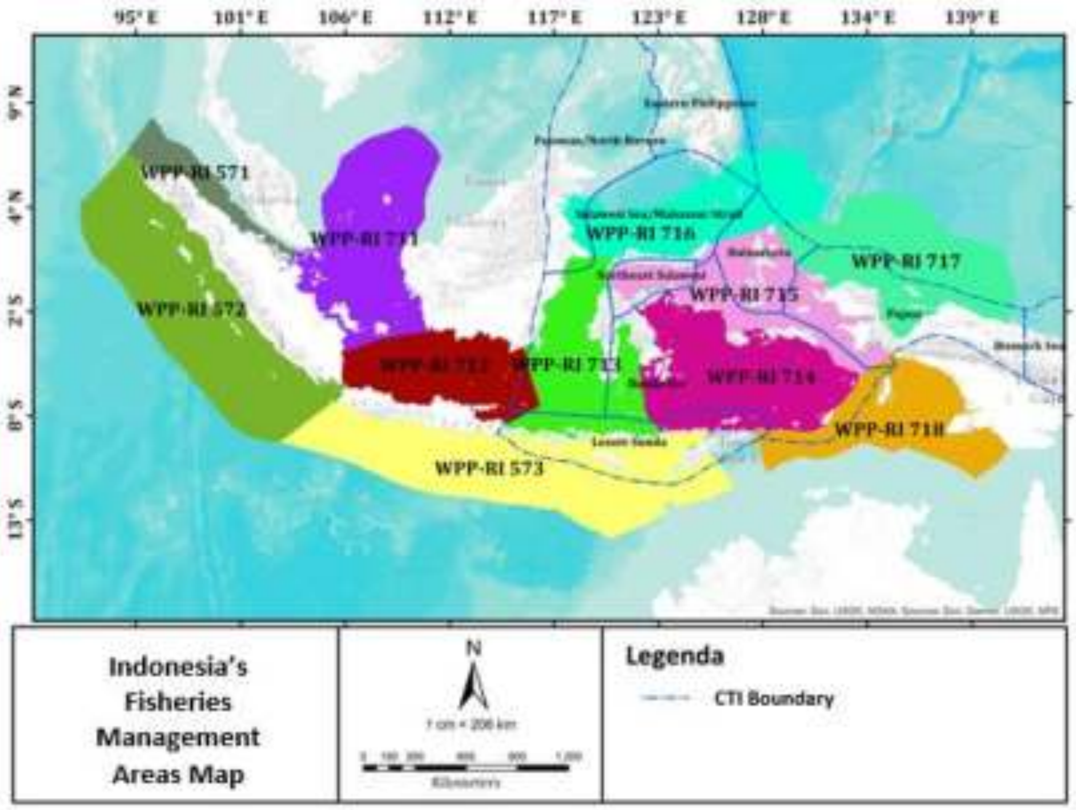


Figure 2.14 Indonesian Fisheries Area Management map (MMAF Regulation 18/2014)

Information related to the coral triangle region is needed for area management. This information is applied to formulate the possible strategies to achieved the goals of the Coral Triangle Initiative (CTI) Regional Plan of Action (RPOA). Indonesia already has a prominent role and responsibility for sustainability of coral reefs. This is related to fact that the largest coral triangle area is located in Indonesia (Burke et al., 2012). Therefore, the availability of data and information regarding the condition of coral reefs in Indonesia are essential as the evident of Indonesian commitment to the CTI-CFF.

Data and information related to Indonesian coral triangle are presented in different forms. Data and information related to coral reefs, available in raw data to reports, can be used for coral reef management. In Indonesia, the agency that provides monitoring data and information related to coral reefs is LIPI. Research and data regarding maritime and coral reef are under the responsibility of the Oceanographic Research Centre in the COREMAP-CTI project. Added to coral reef monitoring data by LIPI, information related to other variables about coral reefs, especially in Indonesia, are also included in data collections from several international agencies, both with open and limited access. Some data and information related to coral reefs, especially in Indonesia, can be seen in Annex 1.

3

CURRENT VULNERABILITY OF INDONESIAN CORAL TRIANGLE REGION

3.1 Status of Indonesian Coral Triangle Ecosystem

Indonesia has abundant marine resources and becomes the second-highest fish-producing country in the world. Indonesia has a role in providing seafood-based products for domestic and international needs (USAID, 2018). It is estimated that Indonesian fishery products provide 54% of animal protein consumption. This makes Indonesia as one of the countries with the highest dependence on fishery resources (ADB, 2014). Indonesian coastal and marine biodiversity is supported by three important ecosystems, coral reef ecosystem, seagrass ecosystem, and mangrove ecosystem. The three ecosystems have interaction by physical and biological connectivity. Physically, mangrove ecosystem is the barrier to the sedimentation flowing from the land, maintaining the purity of water entering seagrass and coral reef ecosystems. The same role is also provided by seagrass ecosystem. Biologically, the connectivity of the three ecosystems can be seen from the their function as a nursery ground. The observations conducted by Jaxion-Ham et al. (2012) concludes that juvenile fish are the common species found both in seagrass and mangrove ecosystems, while adult fish are found mostly on coral reefs. Information on the current condition of various ecosystems is very important to know as the basis knowledge for designing sustainable ecosystem management.

3.1.1 Status of Coral Reefs Ecosystem

The Coral Triangle region has a vital contribution to the national economic activity. However, this area also has the most threatened coral reef ecosystem in the world because it has been damaged. In general, the anthropogenic factors are the main factor causing damages to coral reefs in central and eastern Indonesia. Meanwhile, the natural factors are the main factor of damages to coral reefs in western and southern Indonesia (Hadi et al., 2020). Based on the indicator of local threats and damages to coral reefs, there are more than 45% of the coral reefs of the world are at a high level of threat. In Indonesia, the area of coral reefs under threats reaches 93% or around 39,538 km^2 (Burke et al., 2012). The estimated losses to coral reefs due to climate change in 2010 was IDR 1.3 trillion or 18% of GDP (KLHK, 2020a).

Meanwhile, based on the results of 2019 COREMAP monitoring on 1,153 coral reefs, the status of coral reef ecosystems in Indonesia were: 33.82% in *bad* category; 37.38% in *moderate* category; 22.38% in *good* category; and 6.42% in *very good* category. There were about 30.85 ± 0.29% of coral reef ecosystem having more than 50% of coral cover with a relatively stable trend in 1993-2019. Meanwhile, 69.15 ± 0.29% of the reef ecosystem having less than 50% coral cover tend to fluctuate (Figure 3.3a). A negative trend is led by the stress condition of coral reefs. The condition at "no return point" lead the ecosystem to collapse and disappear. Pressure from climate change such as rising sea surface temperatures and ocean acidification are some of the factors that could cause bleaching on coral reefs. Coral bleaching does not found in all locations, depending on the hydrodynamic factors in each region. The increasing of sea surface temperature also vary on region because of diverse geomorphological conditions of the Indonesian archipelago (Hadi et al., 2020).

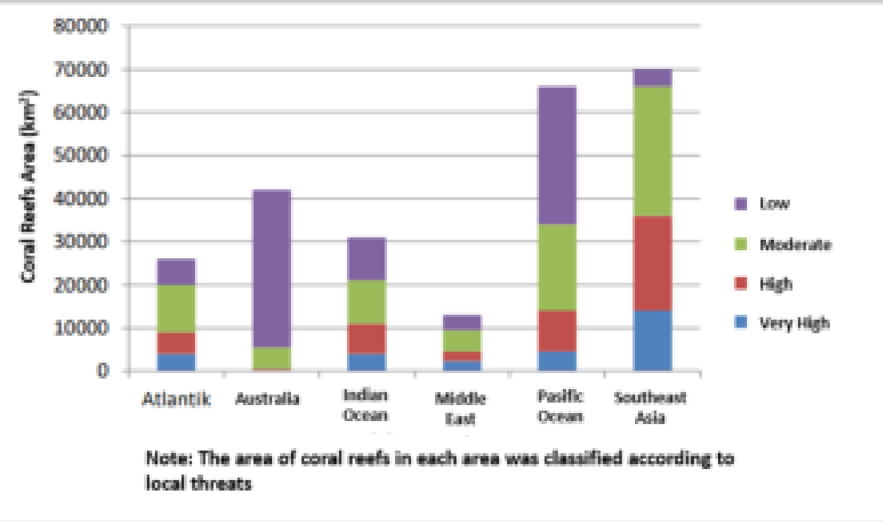


Figure 3.1 The total area of coral reef at risk by region (Source: Burke et al., 2012)

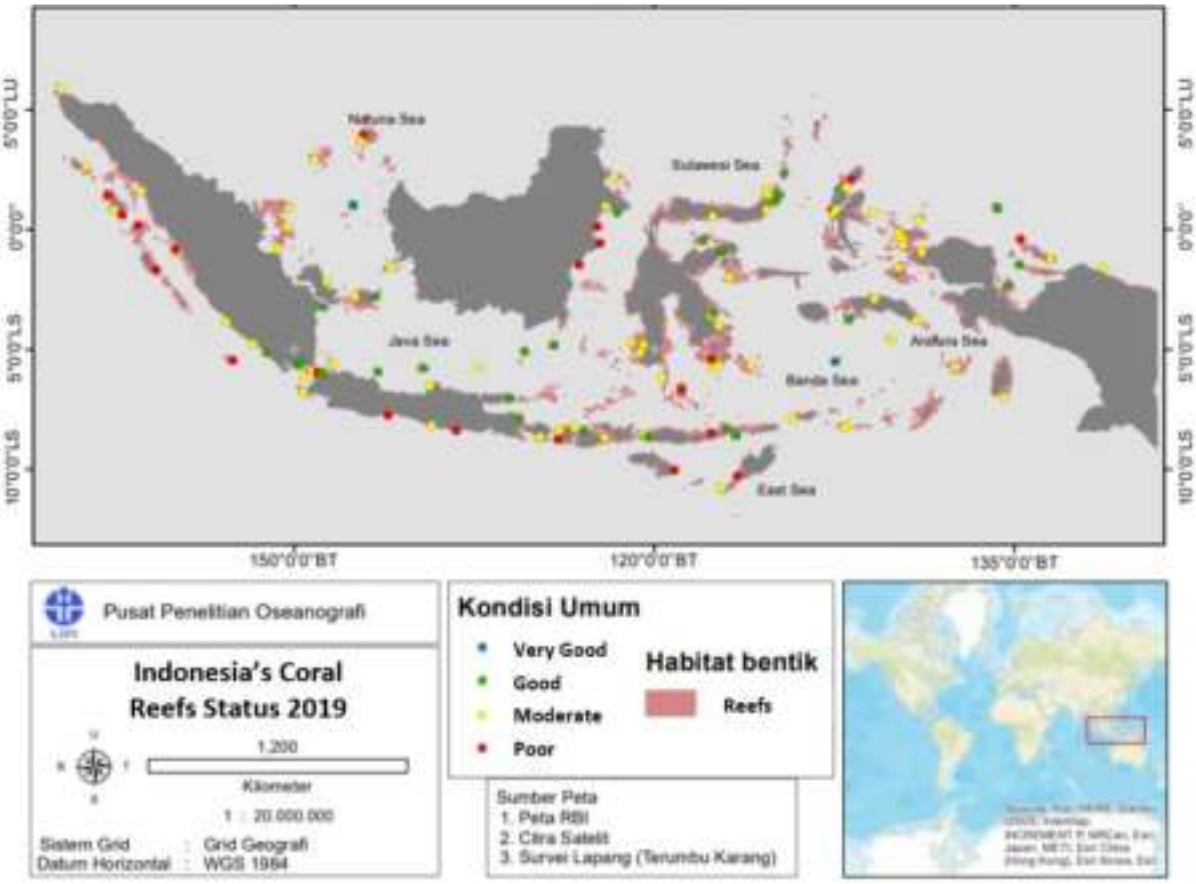
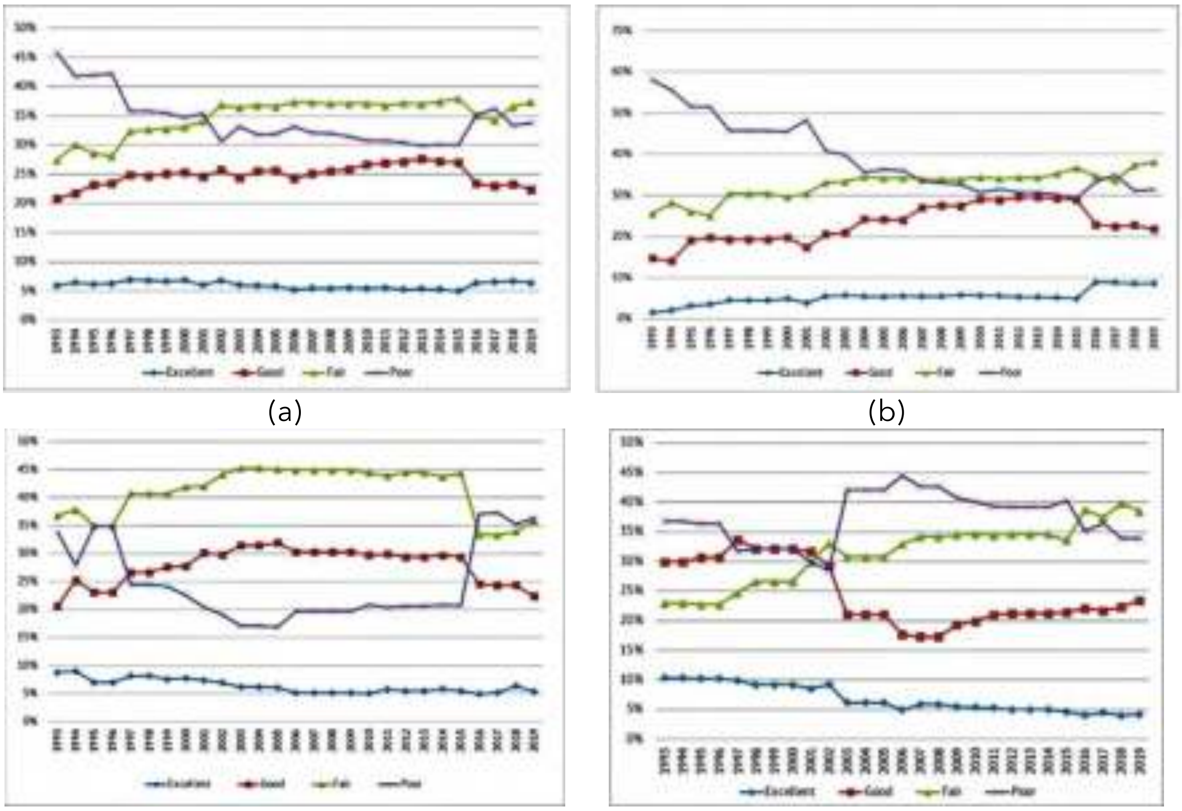


Figure 3.2 Distribution of location and condition of coral reefs in Indonesia (Source: Hadi et al., 2020)



(a) (b) (c) (d)

Figure 3.3 Trends in the general condition of Indonesian coral reefs (a); Western Indonesia (b); Central Indonesia (c); Eastern Indonesia (d) (Source: Hadi *et al.* 2020)

The monitoring in the COREMAP-CTI location showed a significant reduction of coral cover from 2015 to 2016. This is due to a severe global coral bleaching through the year, which then increase gradually until 2019 (Figure 3.4). This shows that the recovery process of damaged coral reefs has been carried out. For an example, the condition of coral reefs in western Indonesia have been improving as seen from the increasing of the coral reef percentage categorised in *very good* and *moderate* classes after the coral bleaching in 2015 (Figure 3.3b). This recovery is expected as the results of the contribution and efforts carried out by Indonesian community, although the exploitation area has been shifted to the potential eastern part. The percentage of *very good* and *moderate* categories of coral reefs in central Indonesia also has increased after the coral bleaching in 2015 (Figure 3.3c). Then, the percentage of *good* and *moderate* categories on eastern coral reefs was continually increased until 2019 (Figure 3.3d) as the results of the heat pressure neutralization of Indian Ocean flow by ocean flow from Pacific Ocean, hence the eastern part had a slightly impact of the coral bleaching in 2015-2016 (Hadi et al., 2020).

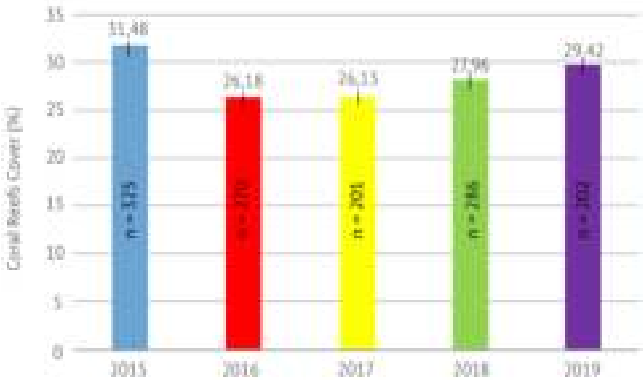


Figure 3.4 Trends in coral cover at monitoring locations (Source: Hadi *et al.* 2020) (n = number of reefs monitored)

3.1.2 Status of Seagrass Ecosystem

Changes in environmental conditions affect the growth of seagrass implicated to the changing of total area of seagrass ecosystem. Information on the extent of seagrass meadows indicates the general condition of seagrass. The analysis from LIPI Oceanographic Research Centre shows that the area of Indonesian seagrass was approximately 293,464 ha in 2018. This number only describes 16% - 35% of the potential area of Indonesian seagrass (Sjafrie et al., 2018). The condition of seagrass meadows in Indonesia has been categorized under the Decree of Minister of Population and Environment No. 200/2004. In the Ministerial Decree, the condition of seagrass are grouped into three categories: *healthy*, *unhealthy*, and *poor*. These categorises picture different percentage of seagrass cover where the *healthy* category with >60%, the *unhealthy* with 30-60%, and the *poor* with <30%. Based on the monitoring of seagrass conditions from P2O LIPI under COREMAP-CTI project, the percentage of seagrass cover in Indonesia of 110 observation stations was 42.23% in 2018 (Figure 3.5). This shows that the condition of seagrass in Indonesia is considered unhealthy in 2018 (Sjafrie et al., 2018).

3.1.3 Status of Mangrove Ecosystem

Around 26.6% (3.31 million ha) of global mangrove ecosystem, or 76% of mangrove ecosystem in Southeast Asia, is located in Indonesia (Bakosurtanal, 2009). This number has increased to 3.49 million ha in 2020 (MMAF Press Release (2020) and MoEF News Archives (2020)). Indonesian mangrove forests store 0.95 tons/ha of carbon which more than three times higher than the carbon storage in lowland tropical forests (Donato et al., 2011), and more than five times higher than tropical forests in highlands (Murdiyarso et al., 2015). There are at least 18 mangrove genera with 101 species identified in Indonesia in various forms including mangrove trees (47 species), shrubs (5), herbs and grasses (9), lianas (9), epiphytes (29), and parasites (2) (ADB, 2014). The mangrove ecosystem is a support system of natural life and a high value natural resource. Unfortunately, various problems have led to the increase in mangrove degradation in Indonesia. Studies compiled by the MMAF until 2018 show that Indonesian mangroves are in a threatening condition and experiencing the fastest rate of destruction in the world. Indonesia had lost at least 40% of mangrove areas in the last three decades (FAO, 2007). Deforestation in mangrove forest is estimated for about six percent of total forest loss in Indonesian (Murdiyarso et al., 2015).

Mangrove forests are scattered mostly in eastern part of Indonesia. More than 50% of Indonesian mangrove forests are found in the coral triangle area, particularly in West Papua. Mangrove distribution density indicates the condition of mangrove forests in Indonesia. The canopy density, which are *rare* and *very rare,* is categorized as a critical condition. Meanwhile, *medium, dense*, and *very dense* of canopy density is categorized as a non-critical condition. Based on this, there are around 637.624 ha or 19.26% of mangrove areas in Indonesia are in critical condition (KLHK., 2020).

Figure 3.5 Seagrass distribution and condition in Indonesia (Source: Sjafrie et al., 2018)

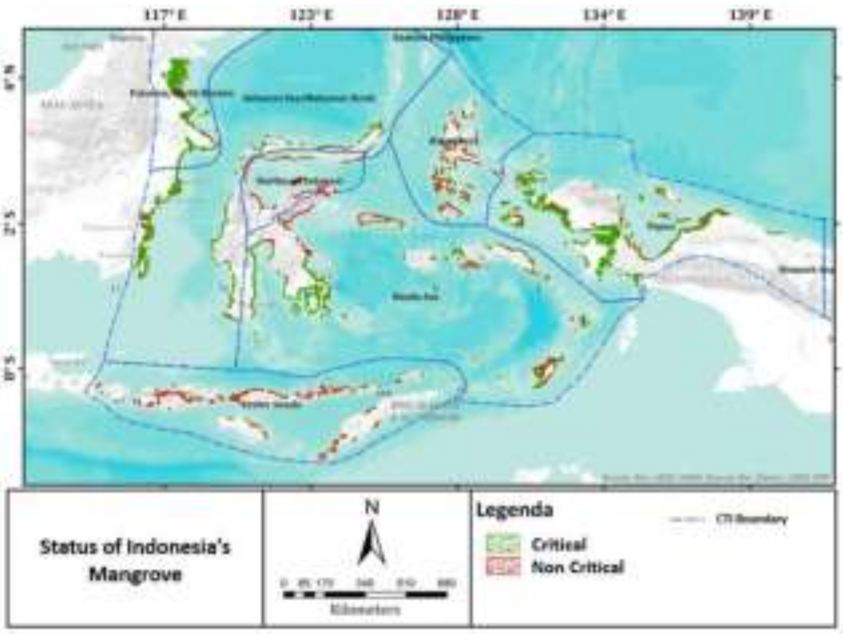


Figure 3.6 Mangrove distribution and condition in Indonesia (Source: Directorate General of Watershed Control and Protected Forest, MoEF, 2020b)

3.1.4 Status of Fisheries Resources

Coral reef, seagrass, and mangrove ecosystems are home to many fish species. The sustainability of these three ecosystems is significantly contributing to the status of fish resources. As the second-highest marine fishery commodity-producing country in the world, Indonesia has produced about 5.4 million tons of fish, with the total from permitted catchment reached 7.95 million tons with production potential at least 9.93 million tons in 2012 (Ministerial Decree of MF 47/2016). The major species is the pelagic species, where the production of small pelagic species is about 34% of national fishery production, while the large pelagic species like tuna have almost doubled in 2000-2016 making Indonesia as the largest supplier of tuna (16% of the global tuna supply). Domestic demand and consumption per capita of fishery products has increased from 10 kg/year in the 1970s to 30 kg/year in the 2000s.

According to the presentation delivered by the Directorate of Fish Resources Management (MMAF) in preparing a climate change adaptation profile in the Coral Triangle region about the utilization level of fish resource in Indonesia FMA, there are several types of resources that have been exploited beyond their capacity in each FMA (Table 3.1). Lobster is the most exploited resource that exceeds the capacity of almost FMA except in the Indian Ocean waters near west of Sumatra to the south of Java Island, and in Karimata Strait, Natuna Sea, and South China Sea. The second exploited species is squid with utilization level reaches 200% in Java Sea; 190% in Tomini Bay waters, Maluku Sea, Halmahera Sea, Seram Sea, and Berau Bay; and 180% in Karimata Strait, Natuna Sea, and South China Sea. Fish resources with a utilization rate that exceeds the minimum capacity are demersal fish in the waters of Aru Sea, Arafuru Sea, and East Timor Sea.

Table 3.1 The utilization rate of fish resources at FMA

FMA	571	572	573	711	712	713	714	715	716	717	718
Small pelagic fish	0,83	0,50	1,50	1,41	0,38	1,23	0,44	0,88	0,48	0,73	0,52
Big pelagic fish	0,52	0,95	1,06	0,93	0,63	1,13	0,78	0,97	0,74	0,95	0,65
Demersal fish	0,33	0,57	0,39	0,61	0,83	0,96	0,58	0,22	0,49	0,45	1,14
Reefs fish	0,34	0,33	1,09	1,53	1,22	1,27	0,76	0,34	1,11	0,81	0,5
Penaeid shrimp	1,59	1,53	1,70	0,53	1,11	0,52	0,39	0,78	0,7	0,2	0,76
Lobster	1,30	0,93	0,61	0,54	1,36	1,40	1,73	1,32	1,02	1,21	1,23
Crab	1,00	0,18	0,28	1,09	0,70	0,83	1,55	1,19	0,9	0,9	0,8
Small crab	0,93	0,49	0,98	1,18	0,65	0,73	0,77	0,98	1,1	1,5	0,77
Squid	0,60	0,40	1,10	1,80	2	1,20	1,00	1,90	1,4	0,7	0,7

Figure 3.7 Status of fish resources exploitation in Indonesia (Red: 'overexploited'; Yellow: 'fully exploited'; and Green: 'partially exploited')

3.2 Coral Reefs Vulnerability

Study of Rizal and Anna (2019) explains that climate change causes the increasing of sea temperature by 0.2°C to 2.5°C, lead to negative impact potential on 50.000 km^2 of coral reefs in Indonesia or around 18% of the total area of coral reefs in the world. Stern (2006) stated that an increase in 1°C temperature would disturb the coral reef ecosystem. Under a 2°C-scenario or more, most of the coral reefs are estimated to disappear from many shallow coastal areas in the world (Eakin et al., 2008). Vulnerability is defined as the tendency of a system to experience negative impacts covering sensitivity to negative impacts and low adaptive capacity in dealing negative impacts.

In 2030, it is estimated that marines will be having various driving factors affecting marine ecosystems, increasing of sea surface temperature and decreasing of pH in particular (Henson et al., 2017). Stress conditions causing by the increase sea surface temperature, reduction in pH, and sea-level variations lead the coral reef ecosystem under vulnerable position, threaten by coral bleaching (Ampou et al., 2017; Henson et al., 2017). The further condition of stress-exposed coral reefs is determined by three main ecological attributes, that is the resistance (the extent to which coral reefs can withstand stress without experiencing bleaching), the tolerance (the ability of coral reefs to withstand bleaching), and the recovery (the ability of coral communities to replenish after destruction). These factors that associates to these ecological attributes are presented in the following table.

Table 3.2 Factors affecting three main ecological attributes

Resistance	Tolerance	Recovery
• SST pattern • Weather differences (regional and local) • Proximity to cold water upwelling • Water currents and flow regimes • Coral genetic identity • Genetic variations of algae (zooxanthellae) • The severity of local stress due to human activities	• The severity of the bleaching • Coral reef immune system response to bleaching • Metabolic adaptation	• Better environmental conditions (water quality, availability of algae, healthy population, etc.) • Availability of larvae • Connectivity with living coral reefs for nurseries • Grazing or food supply for important herbivores • Natural selection • Synergistic effect

Source : Reef Resilience Network (The Nature Concervancy)

In general, the average percentage of coral reef cover across Indonesia shows a faster declining rate than expected with a higher increasing of temperature and additional input of variability in sea surface temperature between years (Figure 3.8). Under a scenario with a slight temperature rise, some of coral reefs would be destroyed within ten years, while others would be sustained until 2057. While in a scenario with a maximum temperature rise (2°C), half of the coral reef ecosystems would be destroyed by 2030. In the last section of temperature rise simulation, a scenario without the influence of sea surface temperature variability (filtered SST) shows 3 to 37 times of the number of coral reefs in the highest cover category than the scenario with influence of sea surface temperature variability (McManus et al., 2020).

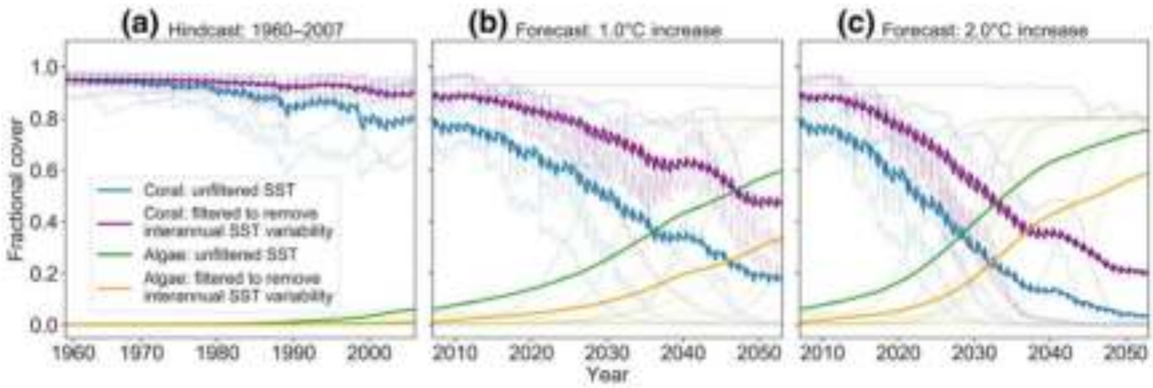


Figure 3.8 Algae and coral reef cover based on *hindcast* (a); forecast with a temperature rise of 1°C (b); and forecast with a temperature rise of 2°C (c) (Source: McManus et al., 2019)

It can be stated that coral reefs would survive with fraction cover at least 0.1 until the end of the forecast period. The higher probability of coral reefs survival at the local scale is associated with the condition of Thermal Stress Threshold (TST) and a high mean sink strength. This effect is strongly detected during the last forecast period (2041-2054) showing an increase of 1 unit TST and scaled mean sink strength reduce the risk to coral reefs by 82% and 89%. Coral reefs under the SST-filtered scenario has a higher probability of resilience than the one with SST-unfiltered scenario. Based on warming scenarios, coral reefs with an SST filtered scenario has a 54% survival chance, while a scenario with an unfiltered SST has a 27% chance. (Gambar 3.9) (McManus et al., 2019).

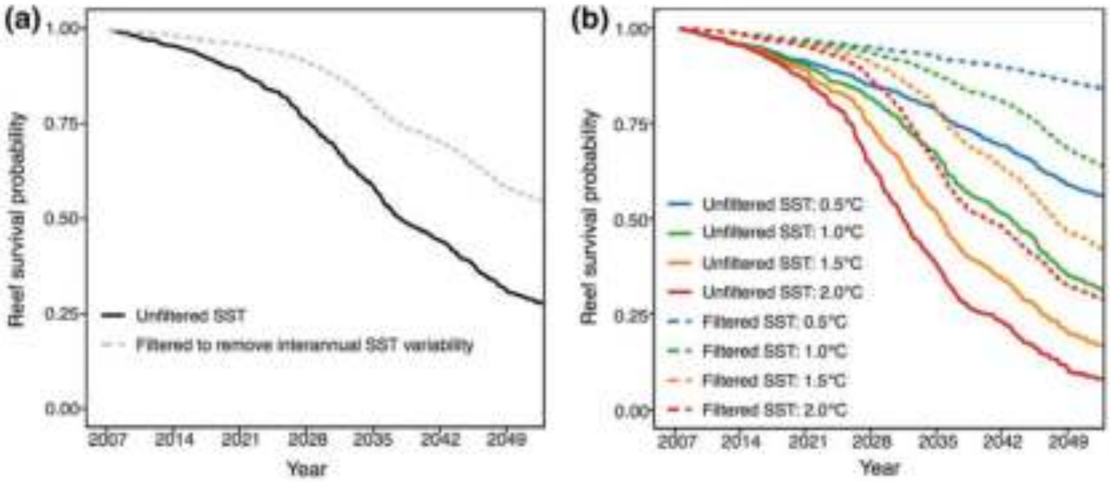


Figure 3.9 Kaplan-Meier resistance curves compared with probabilities for reef resilience under various scenarios (Source: McManus et al., 2019)

3.3 Coastal Areas Vulnerability

The coastal is the area of interaction between land and sea. According to Nicholls et al. (2007) in the IPCC Fourth Assessment Report, coastal areas consist of two systems, natural system and social system. The natural system is the mainland including shores, rocky-shore and cliff, river deltas, estuaries, lagoons, and coastal ecosystems such as mangroves, seagrass, and coral reefs. Meanwhile the social system is the infrastructures, society and their activities. Both systems are highly vulnerable to climate change hazards such as sea level rise, storm surges, rising temperatures, rainfall, and increasing of CO_2 concentrations.

In RAN-API 2018 renewal study, a coastal hazard assessment was carried out using Coastal Vulnerability Index (CVI) approach which is described in a Coastal Vulnerability Index Method (Thieler and Hammar-Klose, 2000). This approach aims to assess the coastal areas for coastal damage anticipation (abrasion and accretion) affected by sea-level rise. This method applies six physical parameters related to the hazards and potential of coastal damage (or the vulnerability of coastal destruction), which are coastal geomorphology, coastal slopes, sea-level rise, level of coastal erosion, sea tides, and waves.

The most dominant factors in determining the coastal vulnerability index are coastal slope and erosion/accretion. A high level of vulnerability is found in an area with a relatively gentle slope and a high erosion/accretion index. The coastal area has a higher vulnerability because it is a multifunctional area, a region where generally the centre of government, settlement, industry, port, aquaculture, agriculture, and tourism sectors are located. This causes a high land demand in coastal areas that commonly lead to a poor management sacrificing the protector function of the coastal ecosystem. The high level of vulnerability in small-island is related to the clean water availability and climate change impacts, the sea-level rise and wave height (Hantoro, 2020).

The distribution of the aggregate CVI value in 2018 as the baseline period along the coastline in the Coral Triangle area can be seen in Figure 3.10. The CVI in Indonesian territory in the projection period 2020-2034 and 2030-2045 shows a slightly change from the baseline condition (Bappenas 2018a). This is affected by several assumptions used due to data unavailability and the limitations of methods on modelling and analysis. The assumptions made because of data unavailability are unchanging of the tidal conditions affected by the astronomical cycles, the geomorphological conditions of the coast, the slope, and the accretion/erosion of the coast.

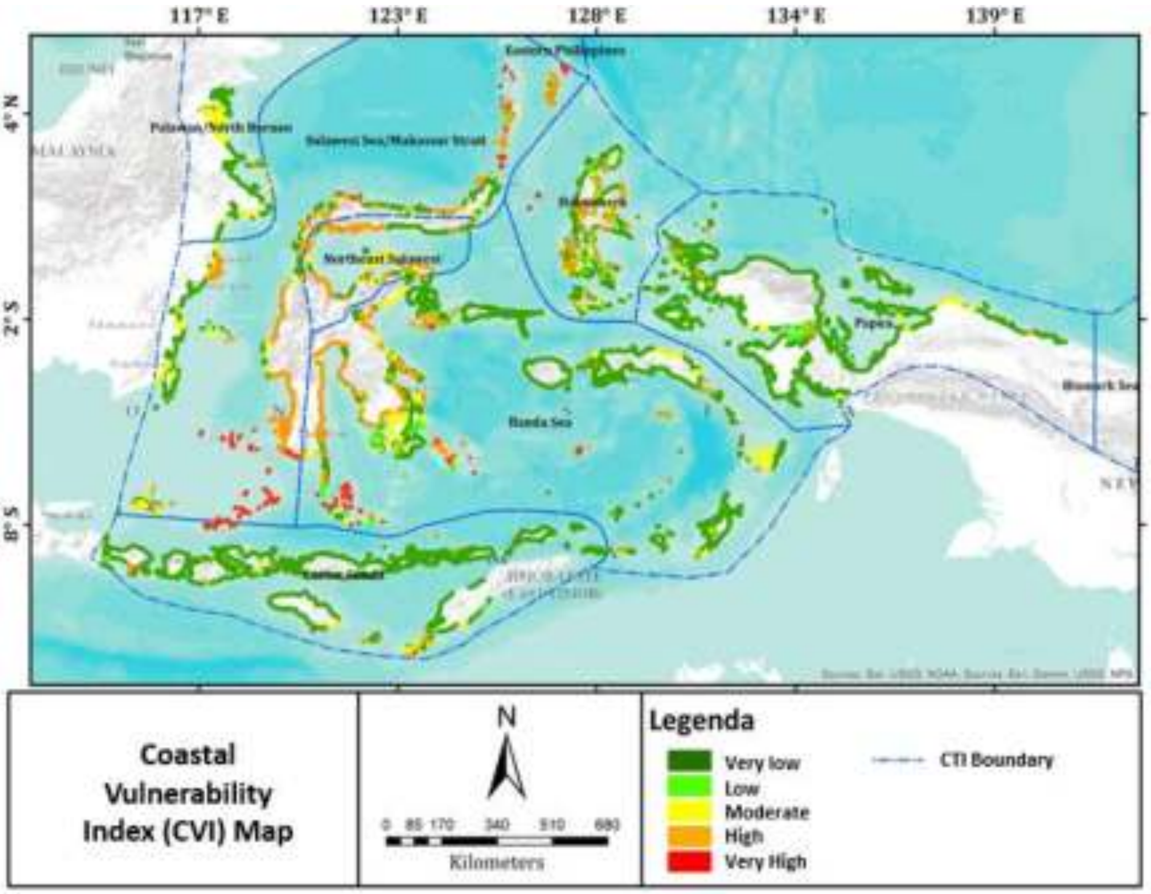


Figure 3.10 CVI index map in Coral Triangle region (Source: Bappenas, 2018a)

There are five clusters ranges from very low to very high of Coastal Vulnerability Index (CVI) . In general, the regions with a high vulnerability index are located in Indonesian western region while the eastern parts of Indonesia tend to have a lower vulnerability index. A high to a very high vulnerability level of coastal areas in the Coral Triangle region located in coasts of South Sulawesi, West Sulawesi, small- islands in Sulawesi Sea, Bali Sea, Flores Sea, striking to Banda Sea. Most of area in Lesser Sunda and Bismarck Solomon is dominated by the area with a very low vulnerability. Meanwhile, Sulu and Sulawesi Seas have a higher vulnerability.

3.4 The Vulnerability of Indonesian Coral Triangle Region to Climate Change

The vulnerability level to climate change is determined by indicators that affect exposure, sensitivity, and adaptive capacity of a region. These three factors change over time in line with the development agenda and adaptation actions. The exposure and sensitivity level are reflected by the biophysical, environmental and the socio-economic conditions. The Directorate General of Climate Change Control represented by the Directorate for Climate Change Adaptation, the MoEF, has developed a Vulnerability Index Data Information System (SIDIK) that provides data and information related to climate change vulnerability at village level. The information can be accessed at http://sidik.menlhk.go.id. SIDIK works on socio-economic, demographic, geographic, and environmental infrastructure data from the Village Potential (Podes) published by the Statistics Indonesia/BPS.

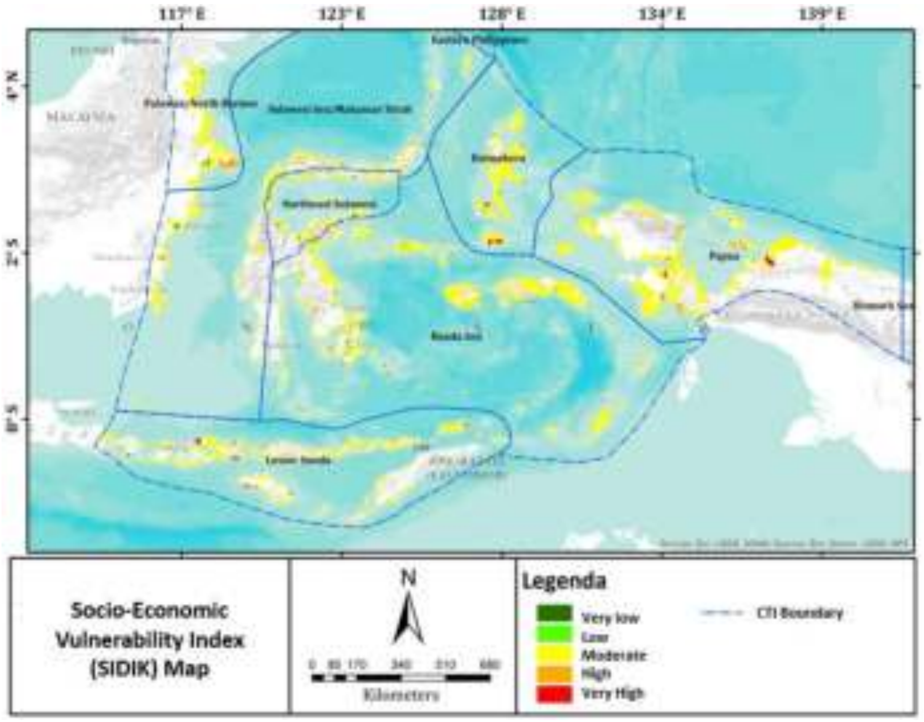


Figure 3.11 Vulnerability Index Map based on socio-economic data according to SIDIK analysis in Indonesian Coral Triangle Region (Source: KLHK, 2017b)

Based on the analysis using Podes data in 2014 on SIDIK, it was found that 2.92% of the total area of villages in Indonesia was categorised in the *very high* vulnerability class. The results shows there were 5.94% area with a *high* vulnerability, 72.34% with *medium* vulnerability, 8.62% with *low* vulnerability, and 10.18% with *very low* vulnerability. The *high* to *very high* vulnerable areas of the Indonesian Coral Triangle are in Papua and West Papua, while most of the areas in the Coral Triangle region of Indonesia are categorised in the *medium* vulnerability class. The *high* vulnerability area, indicated by orange colour, are detected in several villages along the coast of Kalimantan. Meanwhile, insignificant number of the very high vulnerability areas are mostly in Maluku, Papua, and Lesser Sunda region.

3.5 Integration of Vulnerability of the Coral Triangle Region with Climate Change Hotspots based on Coastal and Marine Parameters

IPCC in Fifth Assessment Report – AR5 2014 defines hotspot as an area associated with a high vulnerability and exposure to climate change. Under the Directorate of Climate Change Control in 2020, the MoEF, has developed a climate change hotspots map of Indonesia. Climate change hotspots are developed based on the potential projected air temperature rise in various regions of Indonesia. The climate change hotspot region is a strong basis to determine targeted areas for planning and intervention program. This map contains supporting information along with other data such as vulnerability map and disaster risk map in determining the intervention targeted area for climate change management program including in the coastal and marine sectors.

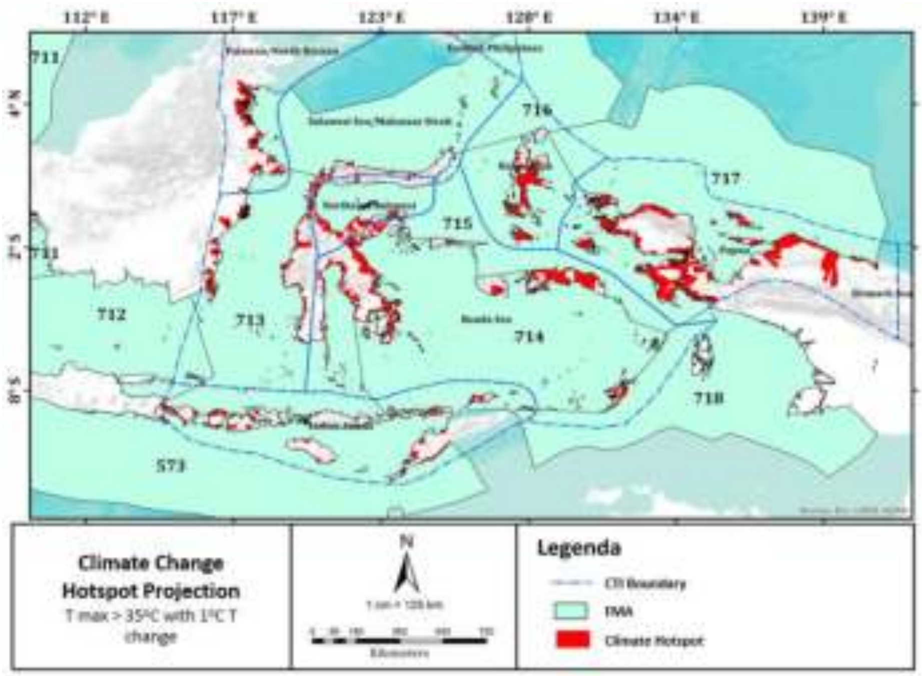


Figure 3.12 Indonesian climate change hotspots map with an temperature rise by 1°C and a future maximum temperature of more than 35°C scenario

Figure 3.12 shows that climate change hotspots with temperature rise projected up to 1°C and maximum temperatures of more than 35°C have appeared around FMA 714, 715, 716, and 718 regions. This is a signal concern regarding the impacts of temperature rise to the coral triangle habitat. An increasing of temperature by 0.5°C to 1°C brings damages to the coastal and marine ecosystems, (KLHK 2017) and to coral reef ecosystems (Stern 2006). Coral reefs prone to experience bleaching at temperatures around 32°C (Dias et al., 2019). Meanwhile, a condition with temperature of more than 35°C disrupts the growth process of mangroves (Kusmana, 2010).

Climate hotspot map has the based-climate change vulnerability information to identify intervention areas in the Coral Triangle region. Identification of targeted areas for intervention in the Coral Triangle region is carried out by analysing several available data and information including projection of climate change hotspot map, SIDIK vulnerability map, CVI map, and habitat presence. The Figure 3.13 illustrates the framework for composing climate change vulnerability in the coral triangle area of Indonesia.

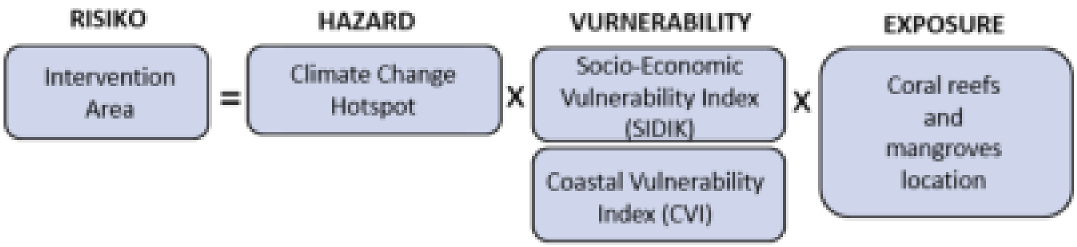


Figure 3.13 Framework for Coastal Climate Change Vulnerability Index method in Indonesian Coral Triangle region

The intervention targeted areas were specified using the risk analysis approach adopted from the IPCC Fifth Assessment Report. The intervention area is considered as a risk analysed by the assessment of hazard, vulnerability, and exposure components. The climate change hotspot represents the climate change hazard component. The vulnerability component consists of a combination of the socio-economic vulnerability index and the coastal vulnerability index, while the exposure component is represented by the existence of habitat in the Coral Triangle area. The habitat considered in this study is limited to mangrove and coral reef habitats. Some assumptions are apply because of unavailability of data and methods. Several assumptions applied are the presence of seagrass and fish resource production from the Coral Triangle region. Thus, the formulations used is showed in Figure 3.14.

$$\boxed{\mathbf{R = (0{,}5\ (H + 0{,}25\ V)) \times E}}$$

Figure 3.14 The formulation for interventions in the coastal areas prone to climate change (R=Risk; H=Hazard; V=Vulnerability; E=Exposure)

The target area for intervention is divided into three classes, *low*, *medium*, and *high*. Based on the identification (Figure 3.15), 9,235 out of 12,015 coastal villages, or around 76.9% of villages, are categorised in the *low*, 2,403 villages (20%) in the *medium* class, and 377 villages (3.1%) in *high* class.

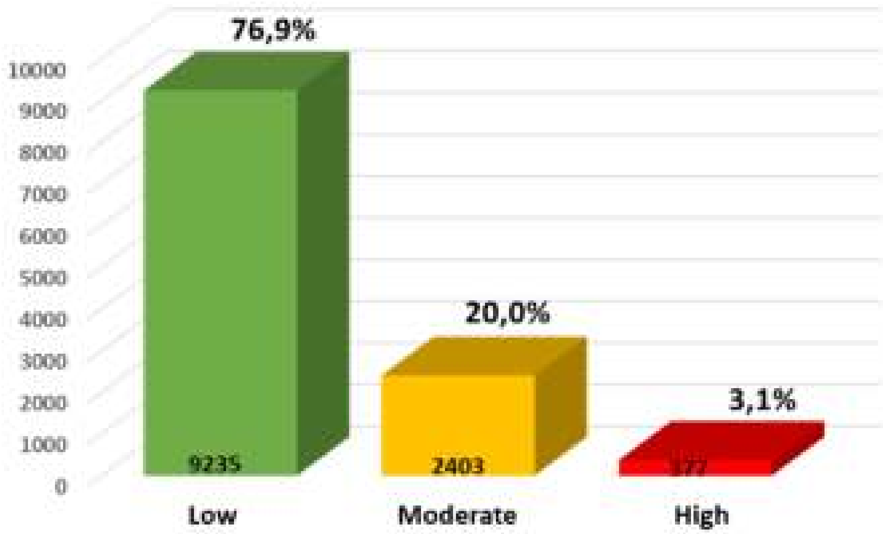


Figure 3.15 The status for coastal intervention areas in Indonesia in percent

The distribution map of intervention target area prone to climate change in coastal areas in the Coral Triangle Region of Indonesia is presented in Figure 3.16. Overall, most of coastal areas in the Coral Triangle region are in the *low* and *medium* classes. Areas with low intervention targets are predominantly located in Maluku Island, around Banda Sea, and in Lesser Sunda region. The *medium* category of intervention target area is found in Sulawesi, Sulawesi Sea, Papua, and Kalimantan. Meanwhile, areas categorised as a high intervention target are in several areas in central and western parts of Sulawesi and in West Papua. Looking at the three priority areas for marine ecoregion-based management, the area around the Sulu Sulawesi ecoregion is classified as *medium* and *low* intervention targets. Low intervention class dominates the Lesser Sunda ecoregion, while the status of area in the Bismarck Solomon ecoregion is more varied, dominated by *moderate* class. A more detailed distribution of the intervention target areas are mapped for each island, Kalimantan (Figure 3.17), Sulawesi (Figure 3.18), Maluku and Papua (Figure 3.19), Bali and Nusa Tenggara (Figure 3.20).

The distribution of intervention data only covers areas in Indonesia. Data in the Philippines border area for the SSME ecoregion and the Solomon Islands border is not available. Therefore, the intervention map for Bismarck Solomon and Sulu Sulawesi ecoregions is only represented by Kalimantan coast in Palawan ecoregion, Sulawesi Sea, and Papua (Box 1).

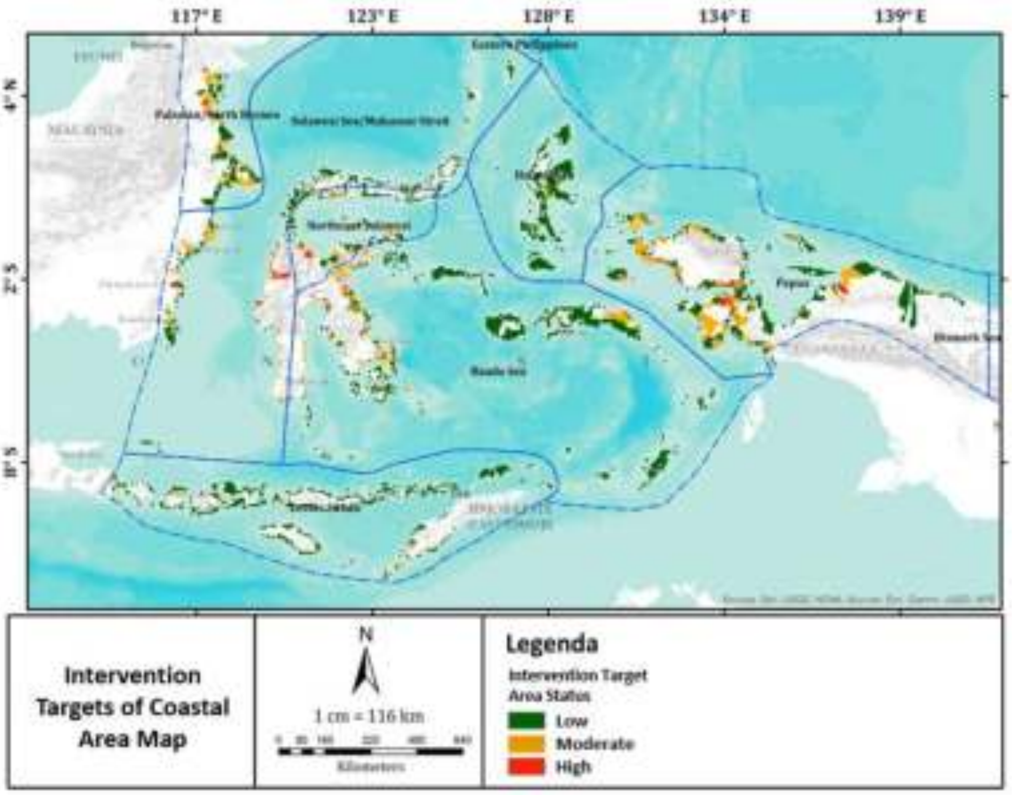


Figure 3.16 The distribution map of target area for interventions in coastal areas prone to climate change based on coastal and marine parameters in the Indonesia Coral Triangle Region

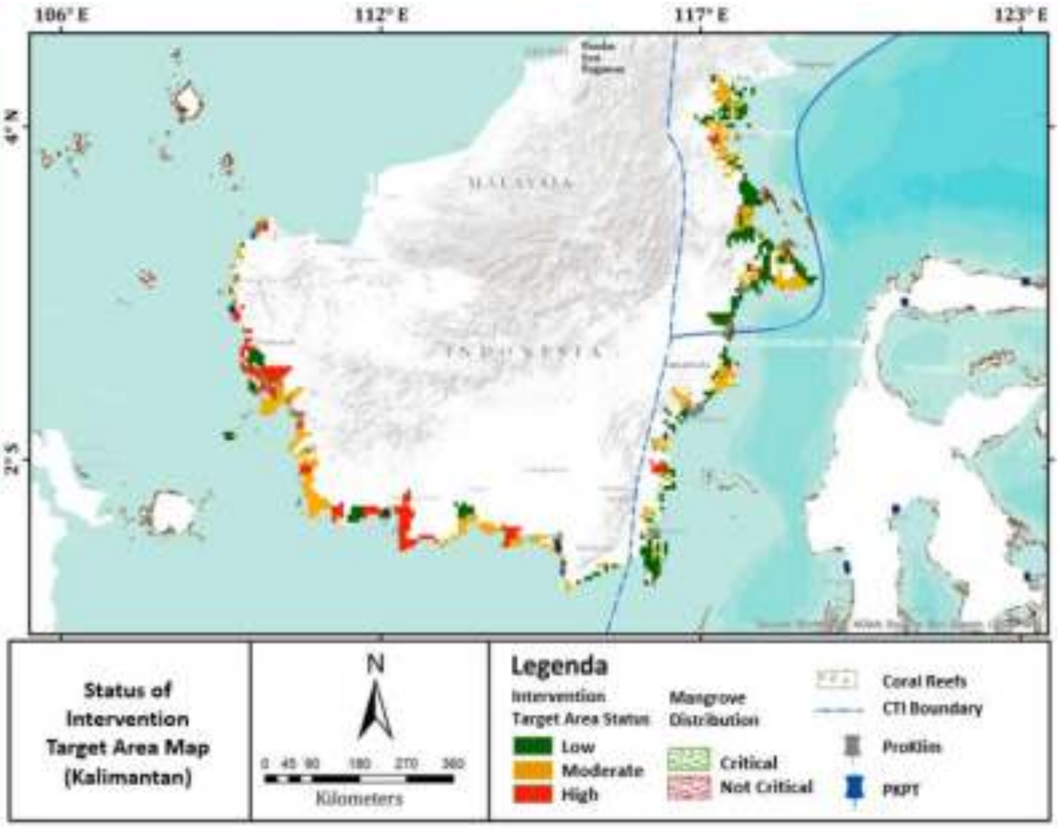


Figure 3.17 The distribution map of target area for interventions in Kalimantan coastal

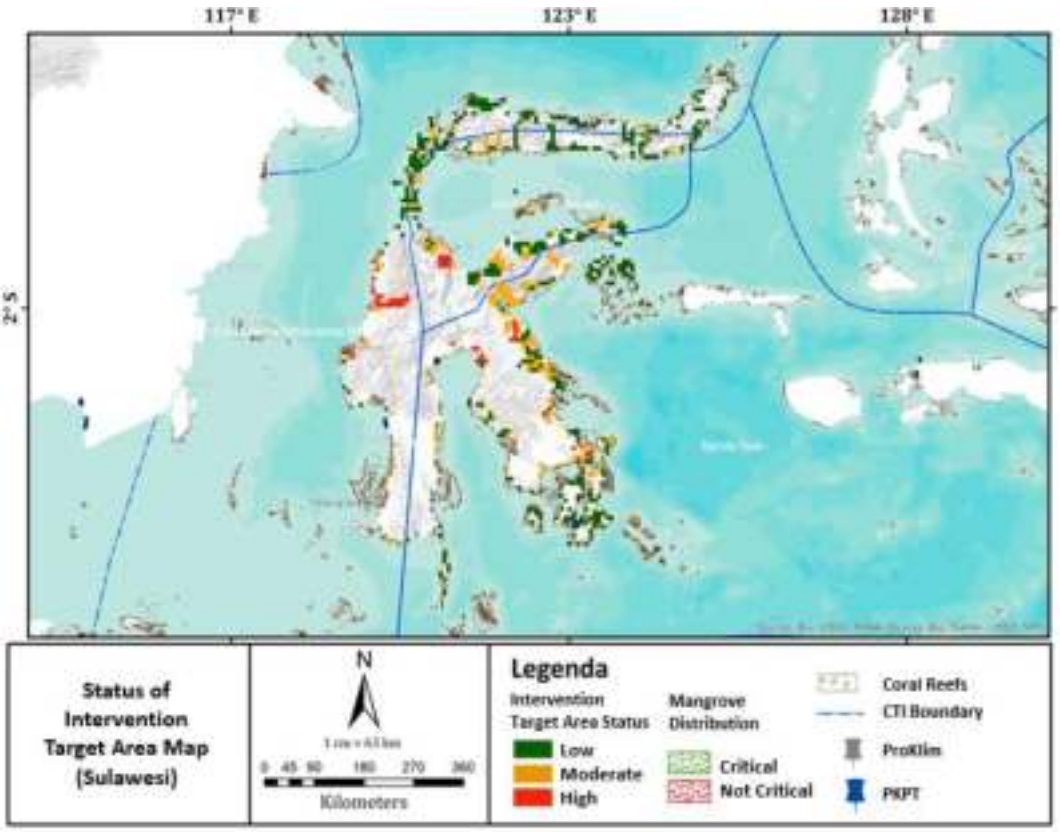


Figure 3.18 The distribution map of target area for interventions in Sulawesi coastal

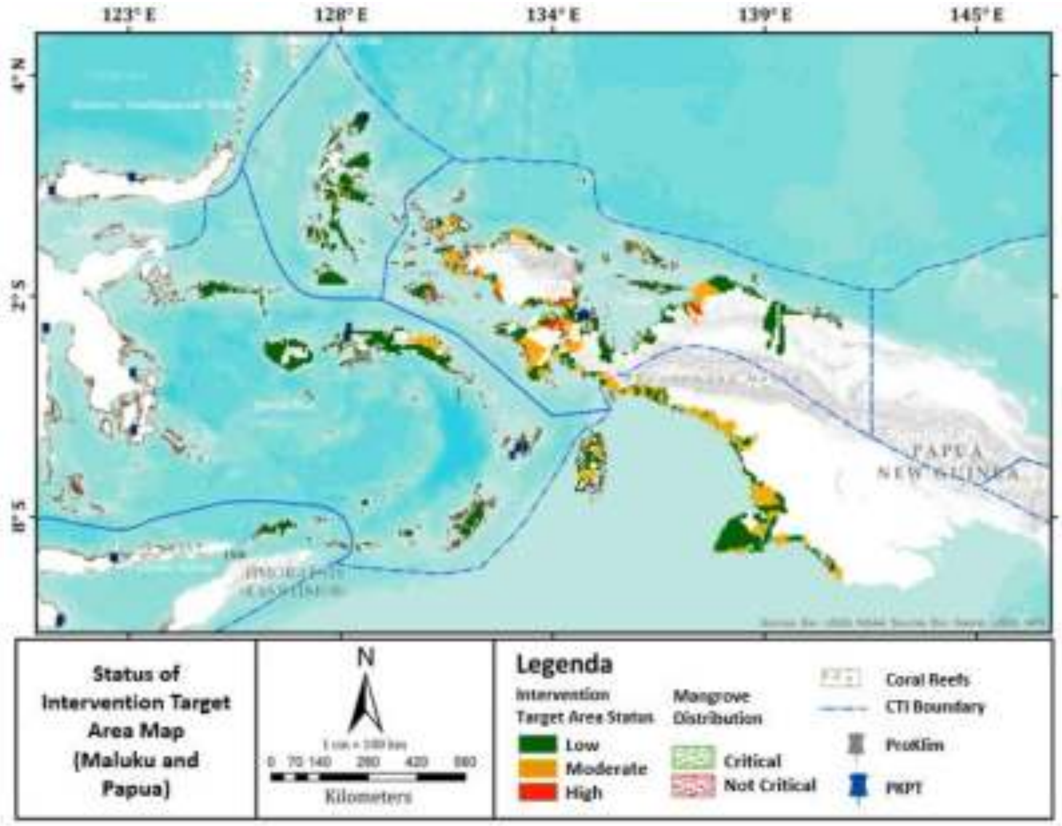


Figure 3.19 The distribution map of target area for interventions in Maluku Island and Papua

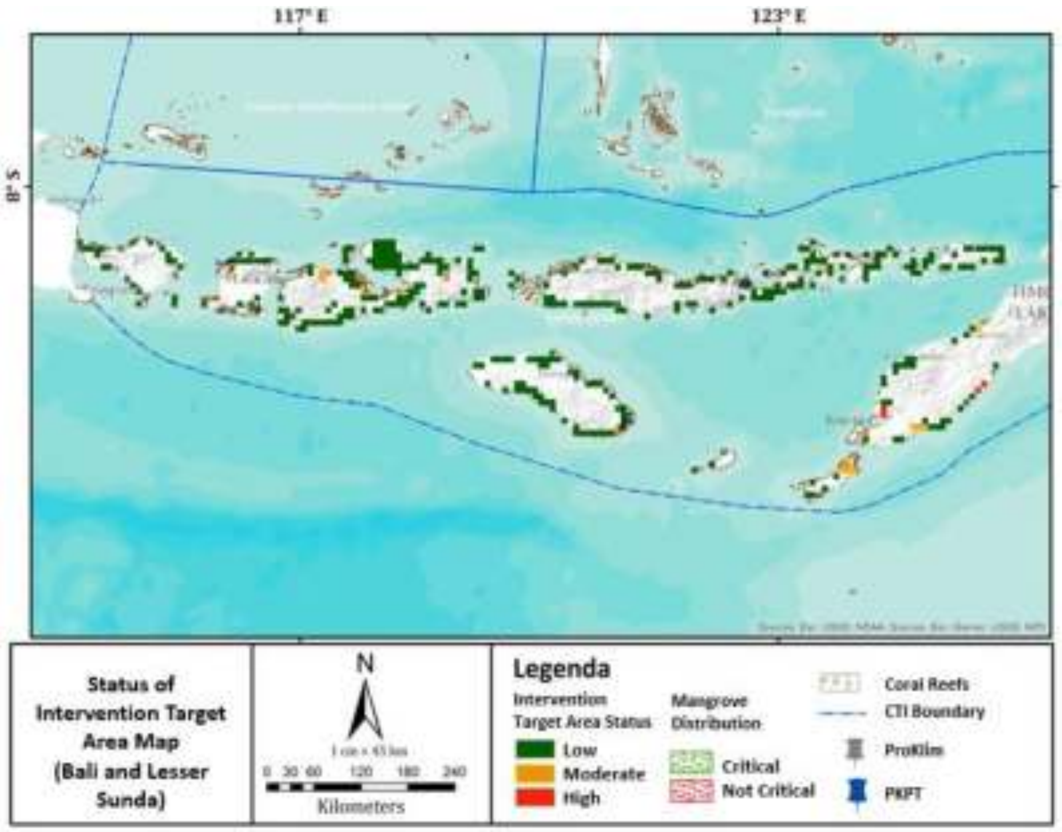
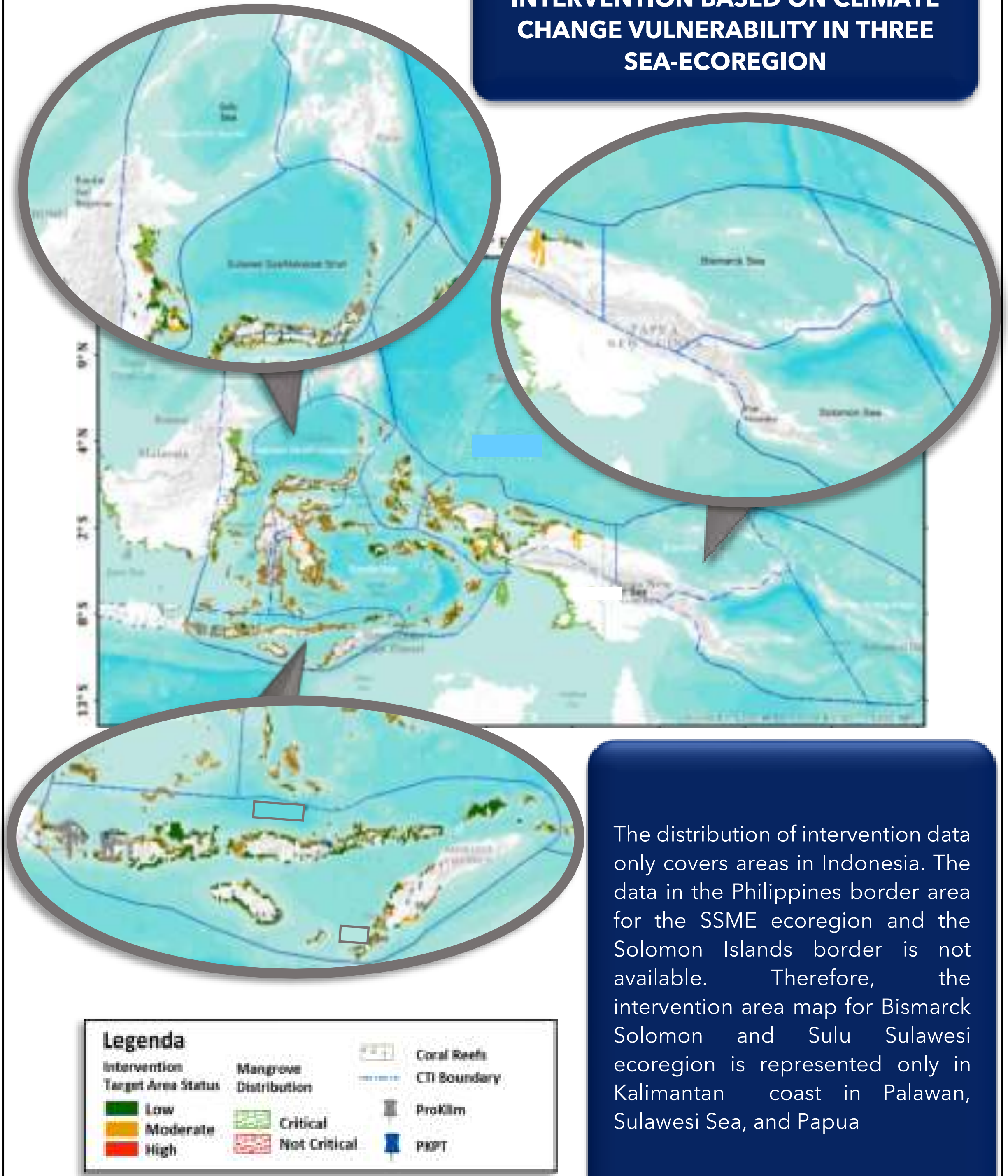


Figure 3.20 The distribution map of target area for interventions in Lesser Sunda

The identification of target areas for intervention is the first step to design a management plan for the Coral Triangle region. The status of area can support the action plan of climate change adaptation in coastal and marine ecosystem. Adaptation action plan in coastal and marine areas must take into account the conditions of climate change vulnerability and the resource availability to prevent the actions as "business as usual". Furthermore, actions on threaten marine species or biota should be prioritizes. The welfare of coastal community is also an important aspect to be noticed, due to the fact that millions of people are depending to marine and coastal resources financially. The community needs to be prepared to deal with any possibility or potential harmful damage that may occur as the negative impact of climate change. Collaboration for area management is important in achieving sustainability of coastal and marine resource in Indonesia.

BOX 1

TARGET AREA FOR COASTAL INTERVENTION BASED ON CLIMATE CHANGE VULNERABILITY IN THREE SEA-ECOREGION



The distribution of intervention data only covers areas in Indonesia. The data in the Philippines border area for the SSME ecoregion and the Solomon Islands border is not available. Therefore, the intervention area map for Bismarck Solomon and Sulu Sulawesi ecoregion is represented only in Kalimantan coast in Palawan, Sulawesi Sea, and Papua

4

MANAGEMENT OF INDONESIAN CORAL TRIANGLE REGION

4.1 Actions to Manage Indonesian Coral Triangle Region

4.1.1 Principles and Policies

The governance actions for Indonesian Coral Triangle Region have to be effective and efficient considering the important role of this region. As an archipelagic country, Indonesia certainly has modalities related to the interests of the islands. The major attention to the sustainability of Indonesian coastal and marine resources is strengthened in the Medium-Term National Development Plan (RPJMN) 2020-2024. Moreover, the basis for the Indonesian Coral Triangle region management is also supported by a number of regulations. In the global level, the area management is an action as part of Indonesian commitment to implementing Sustainable Development Goals (SDGs).

4.1.1.1 RPJMN 2020 - 2024

The Medium-Term National Development Plan 2020-2024 in Presidential Regulation No. 18/2020 is developed as a guideline for Ministries/Institutions in preparing strategic plans, as materials for the Regional RPJMs preparation, governmental guidelines in preparing government work plans, and as a fundamental reference in monitoring and evaluating the implementation of the RPJMN. In the 2020-2024 RPJMN, management related to coastal ecosystem has been included in the national strategic priority project, which are the post-disaster recovery and the coastal protection from disasters. In 2024, the target area for marine/aquatic conservation is 26.9 million ha, 20.4 million tons fish production, 12.3 million tonnes seaweed production, a pilot model for strengthening FMA governance, and a settlement of marine spatial planning and coastal zoning for a total of 102 Zoning Plans. The direction of policy and resource management strategies for 2020-2024 improving maritime, fishery, and marine management are to:

a. Prepare the Fisheries Management Area (FMA) as the spatial basis for sustainable fisheries development, transform FMA institutions and functions, improve the quality of FMA management, and manage marine spatial and coastal zoning plans;
b. Manage marine ecosystems and the provided ecosystem services in sustainability;
c. Upgrade the production, productivity, standardization, quality assurance, and safety of marine and fishery products;
d. Improve business-related facilitation, financial, technology and markets; enhance the welfare and empowerment of integrated fishermen; protection of small-scale marine and fishery businesses; and
e. Improve the quality and competence of human resources, technological innovation, maritime, marine, and fisheries research, and strengthening marine and fisheries databases

4.1.1.2 Regulation

Indonesia, as an archipelagic country, certainly has various kinds of regulations related to maritime affairs. Indonesia has regulations related to maritime affairs and fisheries, leading to all kinds of policies related to maritime affairs in Indonesia (Figure 4.1). Indonesia understands that coastal area and small-island are the vulnerable areas and must be protected, as seen in Indonesian modalities in this regard (Figure 4.2). Specifically regarding the CTI-CFF, Indonesia has shown the seriousness and the commitment in the approval of Regional Secretariat, the National Action Plan as the guideline, the formation of CTI-CFF National Committee, and the determination of the location of the CTI implementation village (Figure 4.3).

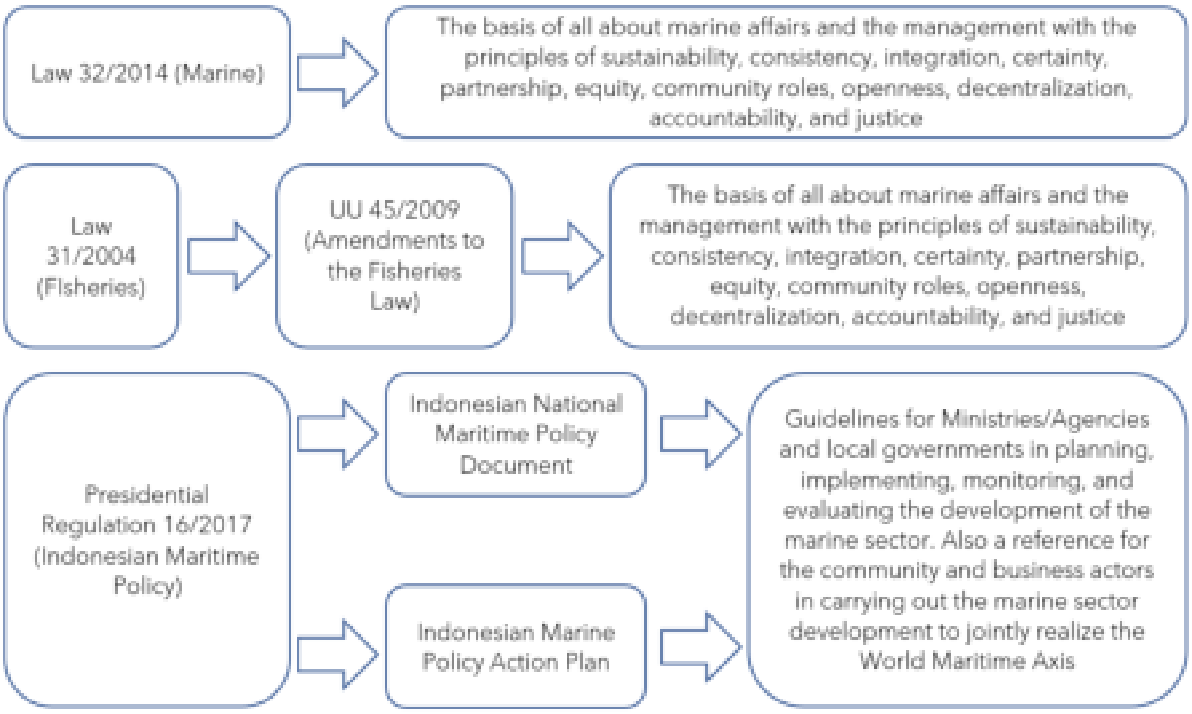


Figure 4.1 Maritime and Fisheries-related Regulations in Indonesia

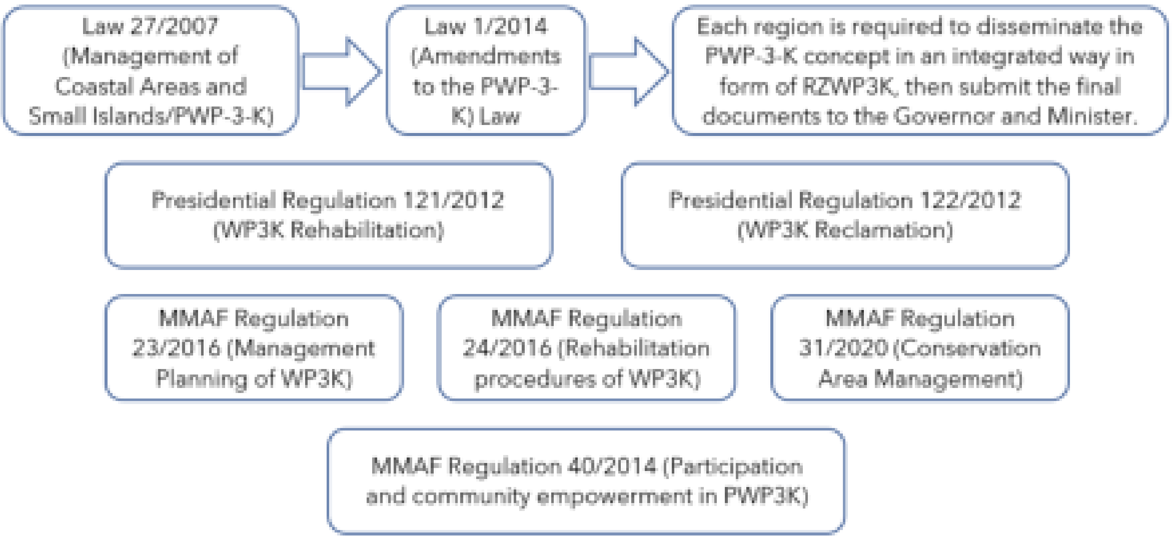


Figure 4.2 Regulations related to WP3K in Indonesia

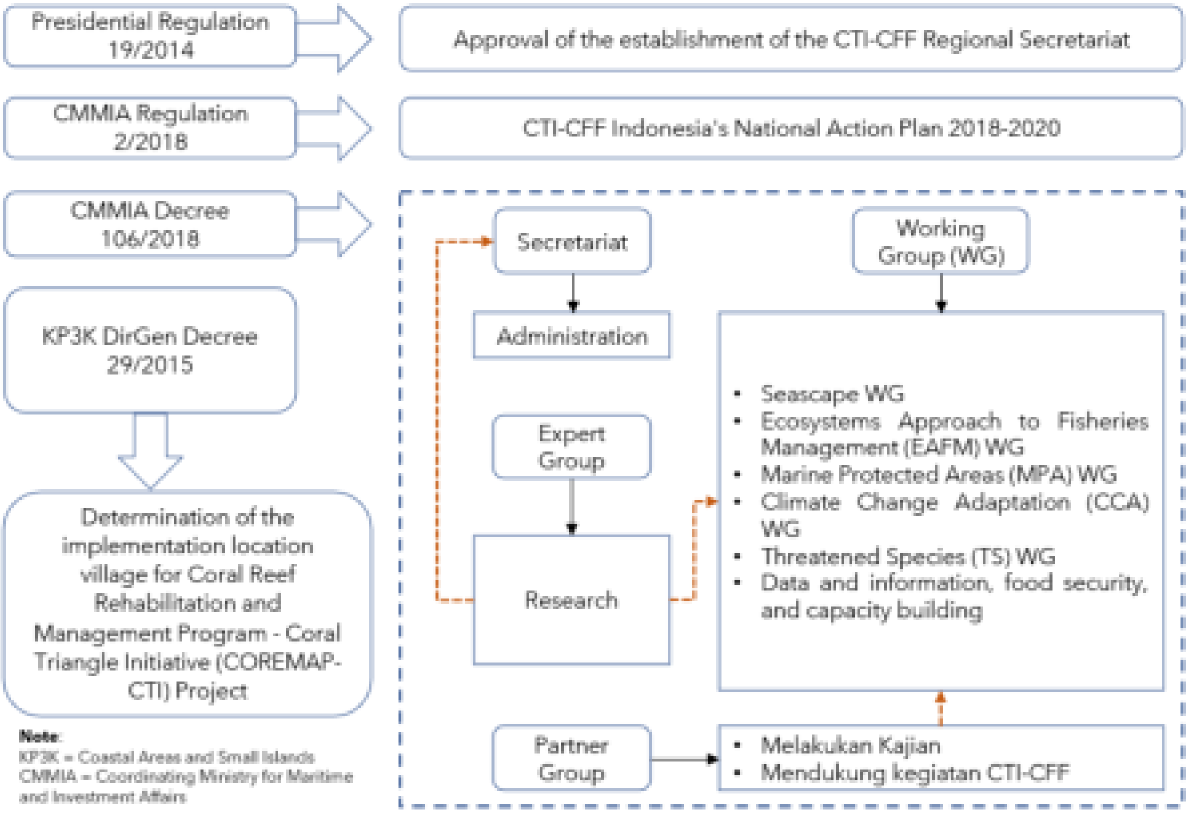


Figure 4.3 Regulations related to the CTI-CFF in Indonesia (---> = provide input)

4.1.1.3 SDGs

Indonesia is one of the countries that is committed to Sustainable Development Goals (SDGs) implementation. Indonesian commitment is not only for the global agreements, but also for Indonesian goals. Global challenges that are included in the SDGs are relevant to Indonesian development issues in achieving Indonesian welfare. SDGs are a common goal and cover various issues including environmental, social, economic, governance, and partnership. Collaboration between stakeholders between government, academia, NGOs, the private sector, and all actors at social levels is needed. Management of the coral triangle area in Indonesia can contribute to achieve the SDGs, as the following information (Table 4.1).

Table 4.1 The potential role of the coral triangle area in achieving the SDGs

SDGs	The Role of the Coral Triangle Area
Goal 1: No Poverty	Eastern Indonesia has a higher poverty rate. The utilization of the abundant resources of coral triangle area in eastern Indonesia will improve the economy of community
Goal 2: Zero Hunger	The coral triangle has abundant fish resources. An appropriate and optimal use supports food security and overcome food-related problems in Indonesia.
Goal 6: Clean Water and Sanitation	Sustainable management of the coral triangle region contributes to the availability of clean water to the community especially in Indonesian coral triangle region because of the proper water

SDGs	The Role of the Coral Triangle Area
	management, a clean environment, and a healthy marine ecosystem in this region.
Goal 8: Decent Work and Economic Growth	Losses from the agricultural and coastal sectors due to climate change by 2100 are estimated to be around 2.2% of total GDP. A healthy and well-managed coral triangle region has the potential for employment opportunities, hence the sustainable management and utilization of resources in the coral triangle region's will be able to support the economy of the surrounding community.
Goal 13: Climate Action	A more coastal ecosystems in the coral triangle area, such as mangroves and seagrass, absorbs CO_2 and reduce GHG emissions. Furthermore, mangroves and seagrass also has a significant role in overcoming the negative impacts of climate change on the oceans.
Goal 14: Life Below Water	The coral triangle is the area with the richest marine ecosystem. Management like strengthening and improving fisheries governance, sustainable fishing principles, ecosystem preservation, and expanding conservation areas help in achieving this goal.
Goal 15: Life on Land	Management of mangrove forests and other coastal ecosystems on a sustainable basis reduce the risk of coastal disasters which are harmful for both land and ocean

Note: The potential role of the coral triangle area derived from this document.

4.1.2 Governance of Indonesian Coral Triangle Region

The governance of the Coral Triangle Region in Indonesia is parallel with the global initiative in the CTI-CFF. The CTI-CFF governance in Indonesia has the National Committee Coordination known as NCC. The NCC is incorporated between multi-sectoral ministries, non-governmental organizations, development partners, and academic experts. The legal basis for the national committee for Indonesian CTI-CFF is regulated in the Decree of the Coordinating Minister for Maritime Affairs No. 106/2018 about the Secretariat, Working Group, and Expert Group of the Indonesia National Committee for the Coral Triangle Initiative for Coral Reefs, Fisheries and Food Security. The formation of NCC aims to lead the implementation of the CTI-CFF Regional Action Plan (RPOA) and the CTI-CFF Indonesian National Action Plan (NPOA). The NCC has six working groups, five of them are covering technical matters such as seascapes, fisheries, marine protected areas, climate change, protection of threatened species, and one cross-cutting theme including data and information, food security, and capacity building. According to the Regulation of the Coordinating Minister for Maritime Affairs No. 2/2018 about Indonesia National Plan of Action for the Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (CTI-CFF) Indonesia 2018-2020, the effective management has taken a part in Indonesian CTI-CFF NPOA. This shows that according to regulations, Indonesia already has the modalities to implement CTI-CFF governance. Out of the regulations, a proper and effective governance should been accompanied with a well-developed plan and strategy to direct the achievement of its objectives.

The CTI-CFF management requires collaboration action between stakeholders. The Ministry of Marine Affairs and Fisheries under the Directorate General of Marine Spatial Management is appointed as the National Coordinating Committee to manage Indonesian

CTI-CFF supported by the Ministry of Foreign Affairs as the manager of relations between CTI-CFF member countries. In general, the coordination direction of the CTI-CFF institutional in Indonesia is pictured in Figure 4.4.

Figure 4.4 The institutional structure in the management of the CTI-CFF at national level (refers to Decree of the Coordinating Minister for Maritime Affairs No. 106/2018 and Regulation of the Coordinating Minister for Maritime Affairs No. 2/2018)

At the regional level, the local Government is the main cast in introducing and implementing programs designed in the RPOA and the NPOA to the community at the site level. Local governments are dealing directly to the conditions at the site level that shape the strategy and contribute to the success of the Coral Triangle management, including poverty, floods, hunger, damage to the ecosystem, illegal fishing, security, and other socio-economic problems. This condition should be controlled to support the management action. In this case, the local government must be able to act as a protector for local communities .

4.1.3 Achievements in the Coral Triangle Region Management by Indonesian Government

CTI-CFF, as an organization engaged in the conservation of marine and coastal biodiversity, has endeavoured to preserve the coral reefs in the world coral triangle region. The actions have to be made because a lot of damages has been found in the Coral Triangle region. Indonesia Government has made various kinds of actions in responding to the damage of coral reefs in the Coral Triangle region. These efforts can be measured based on the NPOA target up to the 2017 period, which is outlined per CTI objective as follows:

- Determination and effective management of priority seascapes of The National Marine Spatial Plan is under the arrangement process at the State Secretariat,
- Five Provincial Coastal and Small Islands Zoning Plans (RZWP3K) have been established (North Sulawesi, West Sulawesi, West Nusa Tenggara, East Nusa Tenggara, Central Sulawesi)
- The Marine Spatial Plan for Lesser Sunda Seascape has been finalized,
- Socialisation the General Seascapes Model and Priority Seascapes Regional Framework document.

1. The application of the Ecosystem Approach to Management of Fisheries (EAFM) and other marine resources
   - Availability of legislation, policies, and a strong regulatory framework to achieve fisheries management with an ecosystem approach (EAFM) by the issuance of a Decree of the Minister of Fisheries and Marine Affairs concerning the FMA-based Fisheries Management Plan (11 FMA) and species (crab, flying fish, lemuru, tuna, and skipjack)
   - The establishment of Learning and Information Centre EAFM: (LC) in 28 universities for each FMA (determined under KEPDIRJEN 49/2017),
   - Reduction of Illegal, Unreported and Unregulated (IUU) Fishing by the development of fishing communities based on the IUU fishing reporting system, and the placement of Observer on Board on 160 vessels in 11 Fishery Management Areas (WPP),
   - The distribution of 1,109,313 fisherman cards (2009-2017) and 500,000 fisherman insurance premiums (2016-2017) in 34 provinces,
2. The formation and effective management of Marine Protected Areas (MPAs)
   - The total area of Marine Protected Areas (MPA) reaches 19.14 million ha with a total of 173 MPAs (95.7% of 20 million ha of total target in 2020),
   - Provision of access and partnerships to local communities
   - Indonesian MPAs covering 940,707 hectares or 37% of the coral reef ecosystem.
   - A rehabilitation project targeting 15,000 ha of mangrove rehabilitation area starting in 2020 supported by approximately 35,000 people
   - Development of protection infrastructure, beach belt, in Brebes (2016), Rembang (2017) and Demak
   - Development of protection infrastructure, hybrid structure, in Demak (620 m) 2013-2014; Cirebon (2,910 m), Brebes (910 m), Semarang (3.145 m), Demak (915 m), Jepara (3,140 m), and Pati (3.140 m) 2015; in Cirebon (1.850 m), Rembang (1.100 m), Demak (3,300 m), and Gresik (1.200 m) 2017; in East Lombok (275 m), Bone (600 m), and Bombana (1,100 m) 2019; and in East Lombok (75 m) 2020.
   - Development of concrete structure in West Aceh (140 m), Padang Pariaman (41 m), Pangandaran (180 m), Pati (110 m), and Mempawah (30 m) 2017.
   - Development of protection infrastructure, elongated geotextile sack, in Karawang (600 m), Subang (600 m), Indramayu (600 m), Tegal (366 m), and Kendal (483 m) 2015; in Brebes (1.700 m), Tegal (700 m), Kendal (1.000 m), Pekalongan (3.300 m), and Tubang (3.300 m) 2016; and in Karawang (3.300 m) and East Kotawaringin (1.260 m) 2017.
   - Development of a Coastal Ecosystem Restoration and Development Centre (PRPEP) by providing assistance for coastal ecotourism facilities and increasing the mangroves area
   - A programs for mangrove nurseries in 12 locations with 500,000 seedlings for each location
   - Training on mangrove processed products in 12 locations in Indonesia
3. The implementation of Climate change adaptation measures
   - Identification and proposal of existing institutions as Centre of Excellence for Climate Change Adaptation

- Identification, mapping, development, and research for vulnerable areas and ecosystem damage by climate change

4. The status improvement of Threatened species
    - The compilation of National Conservation Reports and National Assessment Reports for sharks, mantas, marine mammals, and turtles,
    - Studies of Green turtle genetic (*Chelonia mydas*), olive turtle (*Lepidochelys olivacea*) and leatherback turtles (*Dermochelys coriacea*),
    - Migration studies of whale sharks in West Papua,
    - Development of a network of stranded marine mammals in a specific location,
    - The fishing pilot project using green LEDs to reduce 38% of turtle by-catch

4.1.4 Best Practices of Coral Triangle Region Management

There are considerable actions, activities, lesson learned, rescue actions, and local wisdom have been carried out to protect and preserve coral reef ecosystems in Indonesia. This is implemented by programs designed by community groups, foundations, institutions, and governments. Best practices are expected to restore the damaged coral reefs. Some of the best practices that have been implemented are:.

1. Coral transplantation, the most common coral reef restoration action. This aims to improve the condition of coral cover, diversity, and topographic complexity which is not possible to be recovered naturally, using fast-growing corals. However, it cannot be done in unfavourable conditions (low salinity, high turbidity, high wave energy, rich in nutrients, and algae bloom) (Hadi et al., 2020).
2. Fishery management (fishing gear adjustment); campaign and capacity building; strengthen data monitoring of shark and ray landing; critical habitat protection and migration routes; development of alternative livelihood; priority species protection; and development of conservation plan for endangered species in Indonesian coral triangle region (WCS, 2020)
3. Governmental assistance for a 32.5 million hectare of conservation area by 2030 by developing partnerships in managing conservation area networks and climate change issues, as well as climate change adaptation and mitigation actions (YKAN, 2020)
4. Capacity building for marine resource management by training in the Coral Triangle region for target groups: practitioners, scientists and academics, private sectors, women leaders, community and local government, students, and young people, cross-sectoral initiatives; promoting sustainable tourism (CTC, 2020), :
5. Conservation empowerment, led by coastal community on a large scale; marine ecosystem protection and restoration; a catalyst for raising peace and security that support a sustainable economy; a regional Governance Framework development for nature-based tourism and location selection criteria in the Coral Triangle; demonstration of the coral triangle brand for tourism promotion, establishment of tourism portal and investment page; and plastic free movement (WWF, 2020)
6. Institutional strengthening; increasing capacity of human resource, raising awareness and conservation behaviour; outreach stakeholder participation (CI, 2020)
7. Play a role in harnessing power in laws, norms, structures, commitment authorities and regional networks, national policies and regulations, implementing programs at the grassroots level, grounding RPOA / NPOA CTI-CFF at the grassroots level (LGN, 2020)

8. Cooperation between related parties to support the success and sustainability of the objectives of the program; mapping conditions of social, economic and business network in the community; development of participatory community groups to support the sustainability of the program; incentives for environmentally friendly principles; provide alternative fishing gear (Yusri & Mardesyawati, 2010) / Yayasan Terangi.
9. SASI local wisdom, aims for a wise management of marine resources and agricultural products by the community and appropriate profit sharing to protect the balance between nature, humans, and the spiritual world (Persada et al., 2018).

4.2 Gap Analysis

4.2.1 Challenges in Indonesian Coral Triangle Region Management

All forms of threats and damages to coral reefs generate plentiful challenges. Indonesia, as the country with the largest coral reefs area in the Coral Triangle Region, has a bigger challenge in managing the coral reefs. The threats and challenges have prompted the formation of several institutions, foundations, organizations, and associations specialized on sustainability of Indonesian coral reef. The involvement of these institutions is expected to increase knowledge and contribution among the society to build and manage coral reef resources. The major drivers, identified from the regional workshop attended by the CT6 government, are population growth, cultural differences, education, coastal development, poverty and governance, fish demand, and climate change. The description of some challenges in Indonesia are:

1. Couple-effect between climate change and anthropogenic factors

   Climate change is the biggest challenge in coral reef preservation. Climate change impacts like sea temperature rise and ocean acidification cause coral bleaching and destroy coral reefs (McField., 2017; Hadi et al., 2020). The impact could be worse with the present of pressure from human activities like overexploitation of high-value species, destructive fishing, unfriendly coastal development, and water pollution. The couple-effect of these two factors interfere the sustainability of aquatic resources, reduce community and ecosystem resilience, increase the economic loss of resources and social problems like poverty. The negative impacts of climate change cannot be prevented by direct intervention, the impacts are exacerbated by harmful human activities that further destroy marine resources (Lukman et al., 2017).
2. Public awareness

   Community involvement in coral reef management actions requires a clear vision and goal understanding. Community assistance from the beginning is needed to obtain community contributions in achieving coral reef management goals. Assistance must be carried out continuously and regularly for a long term period to changes in the destructive community behaviour. Assistance in a short term period, unfinished program plan, unclear assistance and funding mechanisms, and no awareness only create money-oriented impression of the community (Yusri & Mardesyawati, 2010). Capacity building of community is unable to complete in a short time (Christie et al., 2016). Support, participation, compliance, co-management, and public awareness of endangered species are still very low in communities, especially in remote areas (CTI-CFF Regional Secretariat, 2019).

3. Water pollution

   Water pollution is a challenge because it involves the sustainability of all aquatic resources. Water pollution is sourced from the waste from land activities streamed down into the sea. Development in coastal area also plays a big role in seawater pollution through construction activities on the coast, runoff from construction, waste disposal, and unsustainable tourism activities (Burke et al., 2012). Runoff from coastal development contaminates the seawater from the sedimentation and affect the growth of coral reefs (Yusri et al., 2017). Moreover, excessive nutrient content in runoff could be poisonous to marine resources (ADB, 2014). The risk of water pollution will increase in line with the accretion of population (Burke et al., 2012)
4. Population growth

   The population growth with limited natural resources and diminishing ecosystem services and functions will create challenges in balance of demand for marine resources (ADB, 2014). This problem is estimated to be more severe because of the very high dependence of the community on coral reefs. Indonesia is one of the top 3 coral fishing countries in the coral triangle area. More than one million fishermen depend their livelihood on coral resources (Burke et al., 2012). The higher demand increase the possibility of overexploitation of fishery resources and the uses of harmful fishing equipment (Yusri & Mardesyawati, 2010; ADB, 2014). Without prompt and appropriate solution, this will generate loss and damage on habitat of marine resources.
5. Cultural and educational differences

   Differences in culture, traditions, community characteristics, and management systems between region and island, especially in Indonesia, is a challenge for the government in making policies. Education level is also an important factor in ensuring sustainable marine resources. The more people are educated, the higher awareness of the importance of coral reefs increases. The integration of traditional ecological knowledge into management can be carried out to increase the restoration actions(ADB, 2014).
6. Marine and coastal disasters

   Climate change increases the hazard intensity. The sea surface temperature rise escalates the potential of cyclone. The rising sea level and land degradation increase the potential of high waves, tidal flooding, coastal erosion, widespread inundation in lowlands and swamps, the intrusion of seawater into groundwater, and the submergence of small islands. Damage and mortality of coral reefs caused by climate change impacts will also reduce their ability to protect coastal areas from these disasters. Furthermore, mangrove forest conversion lead to a higher vulnerability (BPS, 2020).
7. Limited information on population of marine resources makes species conservation plans hardly to be developed.
8. Lack of communication and coordination between stakeholders, the synergy of thematic working group activities, and harmonization of regulations between sectors, becomes obstacles in implementing activities at national level (CTI-CFF Regional Secretariat, 2019).

9. Low research support related to CTI issues. Also, alternative funding to support NPOA implementation is still unclear (CTI 2019).
10. Policy of governance supporting Indonesian coral triangle region and climate-related data are not compiled and centralized.

4.2.2 Opportunities

As the initiator of the CTI-CFF, Indonesia has a huge role in managing the Coral Triangle not only in Indonesia but also at the global level in parallel with other CT6 countries. Indonesian role in this multilateral cooperation can provide opportunities and benefits for Indonesia. Some of Indonesian interests in the CTI-CFF are to:

1. Encourage international recognition as a conservation country for implementing adaptive policies that support the solution for global environmental problems,
2. Elevate Indonesian image as the host of the CTI-CFF multilateral cooperation secretariat,
3. Prevent illegal fishing by conducting collaboration and cooperation with the other 5 CT countries across national borders,
4. Expand export sector, meet domestic needs for fishery products,
5. Boost investment, foreign capital, and aids from other countries by promoting the potential of Indonesian natural resources in the field of marine tourism development, conservation areas, and improving the economy of coastal and small-island communities to achieve the goals of the CTI-CFF which are in line with the governmental objectives,
6. Increase the potential of nature-based and marine-based ecotourism by making the coral triangle area an example of sustainable ecosystem management, which will have an impact on the foreign exchange,
7. Expand joint-project collaboration network with CTI-CFF partners,
8. Be the centre of industrial science related to biodiversity,
9. Be the global focus as the initiator of the CTI-CFF, hosts the CTI-CFF secretariat, and has the most extensive coral triangle region.

4.3 Recommendations

4.3.1 Acceleration of CTI Governance in Indonesia

The concerning condition of Indonesian Coral Triangle region needs rapid and precisely solutions. Without proper management actions, the loss from coral reef ecosystems, especially in Indonesian Coral Triangle, will grow up. An effective area management is supported by an active, participative, and responsible institution. Therefore, strategies are needed to increase the awareness and participation of various groups in the management of the Coral Triangle region. The strategies are including:.

1. Promotion

   Information are available and can be accessed. Nowadays, almost everyone has social media. Through this, promotions related to the beauty and the importance role of coral reefs are easily reach the community. Promotion-related to the economic potential of coral reefs that are in good condition in the future can also be done. With these kind of promotions, every action taken related to coral reef conservation is expected to prolong the existence of coral reefs.

2. Sustainable marine tourism and nature laboratory centre
   As an archipelagic country with the broadest coral triangle region (Burke et al. 2012), Indonesia has enormous potential as a marine tourism centre. Indonesia is known as the global mega biodiversity. A well-maintained and sustainable marine tourism will invites tourists which lead to the development of local economy activities. It is expected that the benefits derived from sustainable marine tourism will promote awareness of the surrounding community to preserve and sustain existing coral reefs. In addition to the potential of marine tourism, high biodiversity with better management in Indonesia is a premise to develop a natural laboratory. This natural laboratory is expected to encourage researchers to study coral reef in Indonesia.
3. The community-based management
   The community should be involved in coral reef management because of their direct interaction to coral reefs. The coral reefs are still a source of livelihood for many coastal communities. Involving coastal communities in planning, implementing, monitoring, and evaluating management actions would improve the sustainable coral reefs.
4. Enhancement of cooperation between the community, government, private sector, NGOs, and academics
   A single contributor on a practical management action would not work properly. Every person and institution should contribute based on their fields. Universities or academics play a role in conducting research related to coastal and marine resources. Moreover, non-profit organizations also carry out various studies through the implemented programs . For an effective strategy of Coral Triangle management, the research results needs to be disseminated to the related government (ministries/agencies). The strategies are designed refer to duties and functions of contributed institutions to avoid overlapping programs.

4.3.2 Sustainable Funding for the Coral Triangle Management

Coral reefs are a concern to international organisations because of their significant economic value. The United Nations Environment Program (UNEP) assesses that the value of properly managed and conserved coral reefs in Indonesia is equivalent to US$ 37 billion by 2030. The annual economic value is approximately US$ 2.6 billion (Hidayat, 2020). Considering this, Indonesian coral triangle area needs a very serious attention. CTI management requires a large number of funds to obtain significant results. Since its establishment in 2009 until 2013, the funds for the Coral Triangle region management have reached US$ 1.4 billion or equivalent to US$ 280 million per year (Lumiu, 2020). Presidential Regulation No. 85/2015 about the National Committee of the Coral Triangle Initiative for Coral Reefs, Fisheries, and Food Security, explains that the funding to carry out the duties of the Indonesian CTI-CFF National Committee is from the State Revenue and Expenditure Budget (APBN) and other legal and non-binding sources according to laws and regulations. According to a study conducted by RARE Indonesia (submitted by (Alimi, 2020), funding from Indonesian Government and philanthropy is only 18.5% of available funds for marine biodiversity needs. Differentiation of funding sources for CTI-CFF under various funding instruments is expected to effectively and efficiently support the Coral Triangle region management.

Financial resources for the Coral Triangle region management are expected to be more optimal by using the funding managed by the Environmental Fund Management

Agency (BPDLH). BPDLH has task with managing and distributing environmental and climate funds to support Indonesian vision of preservation of environmental functions and prevention of pollution and environmental degradation. The BPDLH allows domestic and international, public and private, funding to be distributed by various financial instruments in a variety of sectors (including forestry, energy and mineral resources, carbon trading, environmental services, industry, transportation, agriculture, marine, and fisheries). The total potential funds managed by BPDLH reach IDR 30 trillion (Dhewanthi, 2019). In general, the mechanism for fund management by BPDLH can be seen in the following chart:

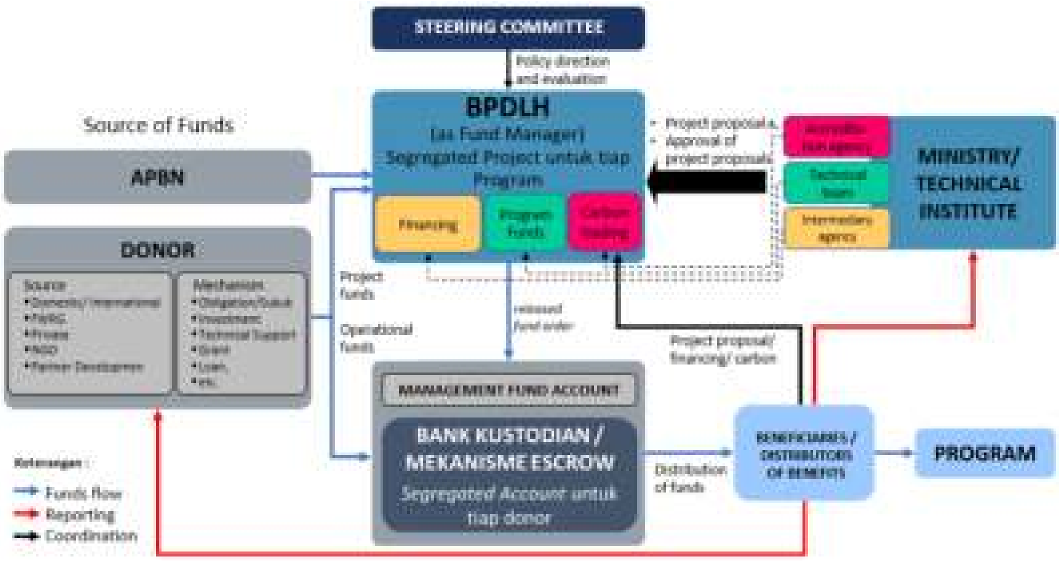


Figure 4.5 Environmental funding mechanism in Indonesia

Contributions of business actors, philanthropists, and civil society are necessary to support the Coral Triangle region management. A philanthropic institution is an organisation that collects charity and generosity funds from a person or organization to be distributed to the beneficiaries. Several philanthropic institutions in Indonesia have particular programs to distribute funds for coastal and marine areas, including the Indonesian Coral Reef Foundation (TERANGI), Indonesian Fisheries and Society (MAPI), and the Indonesian Marine Conservation Foundation. Moreover, there are philanthropic Institutions that do not have programs specifically for coastal and marine areas but focus on environmental conservation in general, such as the KEHATI Foundation, Belantara Foundation, and Greenation.

Sustainable funding for the Coral Triangle region management requires long-term and diverse sources of income. Financial mechanisms also includes tourism-related taxes and fees, compensation of environmental damages, bonds, debt swaps, conservation trust funds, payments for environmental services, and investments. However, it usually takes more than one mechanism to ensure the financial sustainability. The combination of financial mechanisms (blended finance) must be increased to support sustainable financial for coral reef management.

Lumiu (2020) explains that the Trust Fund mechanism (Innovative Trust Fund) is easier to apply for CTI-CFF sustainable funding than the traditional mechanisms. The trust funds are more flexible with low management cost and easily measure impacts. Several institutions have implemented the trust fund mechanism in Indonesia with various schemes, including Belantara Foundation, KEHATI Foundation, and Rare Indonesia. Funds that are managed include endowment funds (endowments), sinking funds (shrinking funds), and revolving funds (revolving funds)

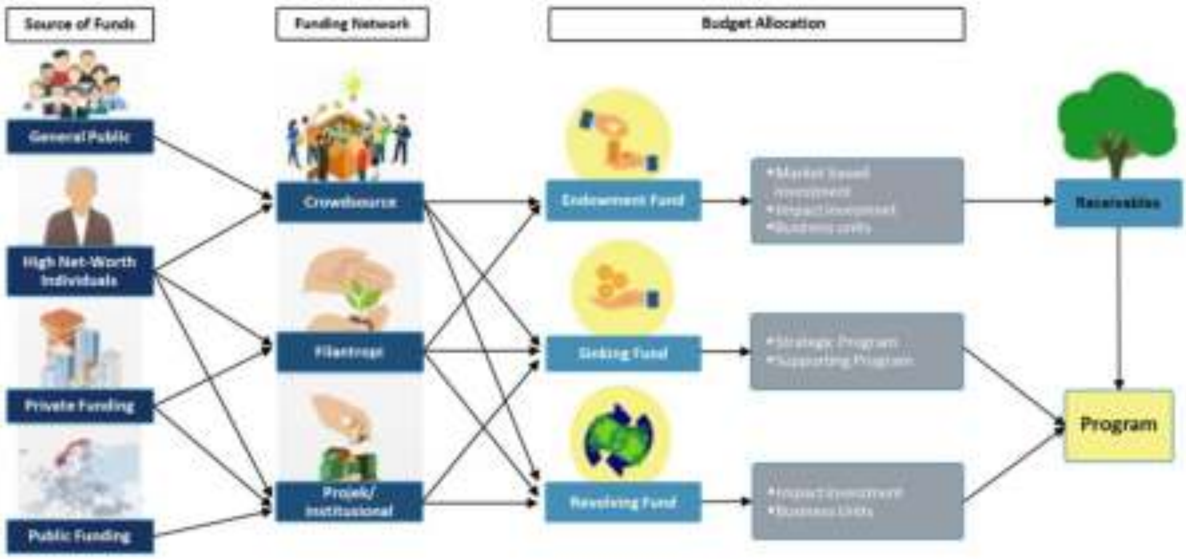
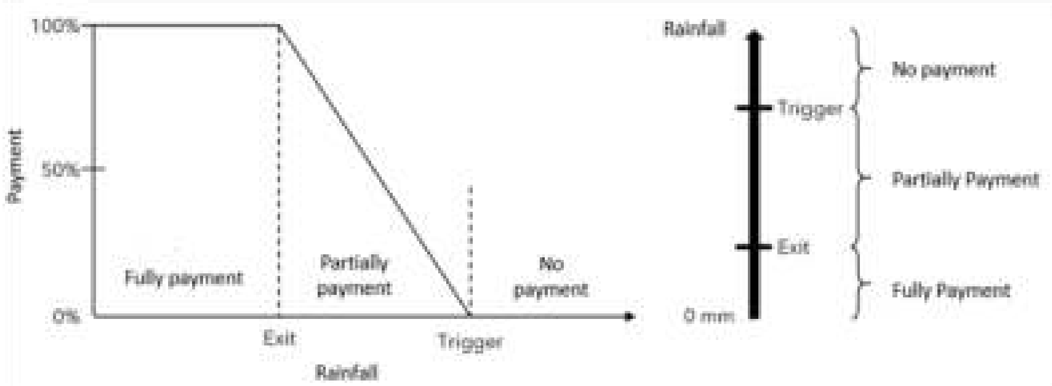


Figure 4.6 The concept of a sustainable funding scheme (Source: Belantara Foundation)

Other than the funding as mentioned above, insurance can also be used as a financial source for Indonesian coral triangle region management. According to Law 40/2014 about Insurance, insurance is basically an agreement between two parties, the insurance company and the policyholder, which forms the basis for receiving premiums by the insurance company in exchange to: a. provide compensation to the insured or policyholder due to loss, damage, costs incurred, loss of profit, or legal liability to a third party that the insured or policyholder may suffer due to an uncertain event; or b. provide payment based on the death of the insured or payment based on the life of the insured with benefits of a predetermined amount and/or based on the results of fund management. In the case of coral reefs, insurance that can be applied is the environmental insurance. Based on Law 32/2009 about Environmental Protection and Management, the description of environmental insurance is the insurance that provides protection from environmental pollution and/or damage. The development of environmental insurance is a form of incentive and/or disincentive, which is one of the three environmental economic instruments. One example of using insurance as funding can be seen in the climate index insurance payment scheme based on the risk of drought in agriculture (Box 2).

BOX 2

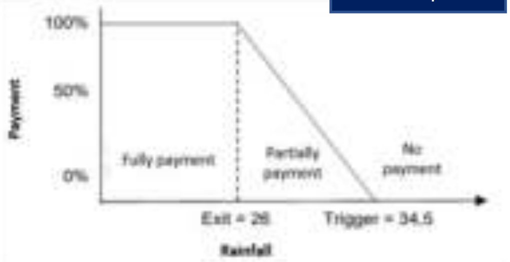
CLIMATE INDEX INSURANCE PAYMENT CONCEPT



Source: IRI (2012)

- The concept of climate index insurance payments is determined by using the Historical Burn Analysis which relies on historical rainfall data (adjusted total rainfall) to provide the key to what may happen in the future.
- This approach assumes that the coming year will similar to one of the years that already happened.
- The exit value or lowest point is set equal to the amount of rainfall in the worst year so that a full payment will be made
- The Trigger value is determined based on the selected return period. For example, the selected period is 4 years, then in 40 years of data period there will be 10 payments. The lowest 10 values of the sorted data are the trigger values.
- The event when the rainfall is between the exit and the trigger will be paid partially.

Example:



Source: Estiningtyas et al (2013)

- Example of climate index analysis for the Sliyeg region, the trigger value is 34.5 mm and the exit value is 26 mm.
- Insurance period → Mei-Agustus (the period insured in this example analysis)
- If CH during the insurance period <26 mm, the farmer is entitled to receive full payment as agreed
- If 26 <CH <34.5, the farmer is entitled to receive partial compensation based on the size of the CH reduction
- If CH> 34.5, there is no compensation

4.3.3 Green Fisheries Endorsement Concept

The climate change effect that mainly affecting the fisheries and marine sectors endanger the ecosystems and resources of fishery. In a sustainable fisheries management context, a crucial strategic is needed to reform the fisheries development plan immediately. The green fishery is a framework for how the concept of fisheries management is developed by taking into account ecosystem health, economic justice, and sustainability of resources. Multi-sector and multidisciplinary approaches need to be applied in the re-design of integrated and sustainable fisheries management approaches in Indonesia. Prof. Rokhim Dahuri has introduced this concept since the early 1990s, but the integration implementation of this form has not been conducted. Various forms of management institutions have not succeeded in compiling the right scenario for implementing the concept of sustainable fisheries. At least three basic reasons why fisheries management reform is needed as follow:

1) Traditional fisheries management is still focused on the fishermen approach without paying attention to the ecosystem and the biological facts of fish resources. Many ecosystems of fish habitats are threatened (as described in Chapters 2 and 3). In the ecological structure, the impacts of this habitat destruction have implications for changes in tropical chains like the biological cycle, "life cycle", of fish resources. The breaking of the biological chain and tropical levels can cause a large scale reduction on fish stocks
2) Failure to collect accurate fisheries data. The gap in fish population data becomes the cause of the high estimation of overfishing or under fishing. The use of statistics in stock estimation with various assumptions in the use of statistics is indispensable.
3) Differences in models used and the define of efficient response. This lead to failure to the transition of an institutional from an industrial demand model to a biological model. Most recently developed models can show fish stocks but have not further interpreted how long it takes for these fish to grow.

Fishery management needs to be encouraged to return the investment from the fishing business. Fishing activities are constantly faced with the idea that fishing does not exceed the level of sustainable use. In this, the sea is seen as a high valuable source for unlimited exploitation. Whereas maximizing the benefits of a public property resource (common property) ultimately becomes a burden on the biological costs of the resource itself. Efficiency in the market concept so far does not integrate biological considerations. So that the rate of return on investment is only calculated from the level of prevalence known as management by feeling.

Combining the concepts of commercial fisheries, ecosystems, equity, and wellbeing with biological models will be very complex. However, it will provide a clear limit to the permitted catchment size, which then adjusts the size of gear mesh . This concept also needs to consider the carrying capacity aspect in the form of the biomass recovery rate (turnover rate) to be captured. If these concepts can be integrated, illegal fishing will become another item from a legal point of view. In this case, the fish resources management from the biological models perspective becomes the initial biological conservation concept supported by economic theory. Based on a multi-species ecosystem approach, of course, the initial limitation that needs to be known is the limitation of the carrying capacity of the use of fish resources to protect the ecosystem, including protection of genetic and multi-species diversity.

Sustainable fisheries management must also differentiate various considerations for policymaking. This condition has not integrated the anthropogenic factors such as CO_2, rising sea levels, pollution, and other global climate change effects. The perspective of fisheries, coastal, marine, and small-island development must be carried out in an integrated manner. As a multi-use space, the Coral Triangle region can be developed to implement green fisheries management practices that unite the strength of the ecosystems and the resources in supporting the economy and sustainability of community fairly.

4.3.4 Momentum for Regional Strengthening

The CTI countries are mostly small size countries with difficulties to find their position as developed countries in technology. The countries have no capable industries and reliable technology. The growth of the maritime sector in the Coral Triangle region is less than than 5.06 percent annually. This is a motivation and encouragement for CTI member countries to prepare fisheries and marine governance in their countries to be more structured. With a good governance, the coral triangle region can become a maritime centre and supplier of marine-protein food to the world. This potential can also be a message in various big world agendas such as in the G20. In addition to the potential for food resources, Indonesia and other CTI countries also supply corn and wheat, including world vegetable oil.

Seizing Momentum.

The momentum of the global maritime countries should also remain in the 2020-2024 RPJMN to compete at global level. Without this, Indonesia will always be a trend follower country and the global currents. For this reason, the CTI government should be able to take the momentum of world diplomacy as an initiative room to take a role with the biodiversity and marine biological resources. For that, the thing that needs to be done is:

a. Reorienting the long-term goals of CTI as a common platform for the economy through biodiversity
b. strengthening the CTI institution to fully understand the problems of the biodiversity-based economic sector
c. Designing industries based on natural resources, including fisheries and marine

4.3.5 Intervention Options

In planning an action program to manage the Coral Triangle region, the recommendations are divided into soft intervention and hard intervention. The soft intervention aims to improve institutional governance and community capacity, while the hard intervention is to maintain the physical resilience of infrastructure. This intervention recommendation is proposed based on the study of various sources related to the condition of the Coral Triangle region and the identification of intervention target areas in the Indonesian Coral Triangle Region.

Table 4.2 Recommended action intervention options for the Coral Triangle region management

No.	Recommendations	Actions
1.	*Soft Intervention*	a. Strengthen policy support for both central and local governments for the management of climate change impacts in coastal areas b. Improve the management of financial resources with a sustainable funding mechanism c. Increase the availability and the access to weather and climate information d. Collaborative and participatory management of the area involving NGOs, philanthropic foundations, business actors, and private agencies. e. Adaptation integration system for coastal and marine conservation f. Evaluate and increase the supervision of the utilization of coastal and marine spatial planning with consideration of the potential impacts of climate change g. Increase the skills of coastal communities with training and mentoring h. Trainings on climate change adaptation and disaster risk management at the community level
2.	*Hard Intervention*	a. Rehabilitation and expansion of mangroves, coral reefs, and seagrasses habitat conservation areas b. Upgrading of fishing boats c. Residential relocation due to the danger of tidal flooding d. Construction of dams to suppress coastal erosion e. Biophysical environment improvement f. Diversification of sources of income g. Extension of business h. Application of efficient technology for agriculture and fisheries;

Furthermore, recommendations for intervention action can be viewed from the potential problems of threats to the Coral Triangle region. Intervention recommendations based on the potential problems are shown in Table 4.3. The intervention recommendations based on the level of intervention, variables, and responsible institutions are shown in table 4.4. Recommendations for specific interventions in three priority ecoregions (Sulu Sulawesi, Bismarck Solomon, and Lesser Sunda) are shown in Box 3 and Appendix 2.

Table 4.3 Recommendations for action based on potential problems from the threats in Indonesian Triangle Region

No.	Indicator	Potential Issues	Intervention	Executor
1	Air temperature, sea surface temperature, ocean acidification	1. Unpredictable weather conditions 2. Season shifting 3. Reduction of catchment size	1. Increase the availability and the easiness of data and weather information access, especially those related to coastal and sea 2. Upgrade fishing boats and fishing gear 3. increase the conservation area for coral reefs, mangroves, and seagrass beds 4. Diversification of livelihoods 5. Commodities diversification based on weather forecasts 6. Increase the coastal communities skills	1. Related M/A 2. Regional government 3. NGOs
2	Sea surface height	1. Tidal flood (rob)	1. Design flood-resistant infrastructure (for example: higher foundation of a house or stage-house) 2. Relocate settlements in danger area 3. Arrange coastal spatial planning by considering the risk 4. Build a coastal embankment 5. Mangrove rehabilitation based on community involvement to foster community responsibility	1. Public Work and Housing 2. MMAF 3. MoEF 4. Regional government 5. NGOs 6. Community
3	Rainfall, seawater intrusion, water availability	1. Seawater intrusion to groundwater 2. Threatened clean water sources	1. Utilization of deep ground water with optimal management 2. Development of appropriate	1. Regional government 2. Salt farmer

No.	Indicator	Potential Issues	Intervention	Executor
		3. Reduction of salt production and quality	technology for salt farming	
4	Geomorphology and Physical Environment Changes	1. Increasing of coastal erosion 2. Depreciation of productive land (ponds) 3. Conflict of interest in coastal land use	1. Making embankments 2. Mangrove planting and / or rehabilitation 3. mutually beneficial management of the area (co-management) 4. Law enforcement against illegal activities like illegal mining and violations of RTRW	1. Public Work and Housing 2. MMAF 3. MoEF 4. Regional government 5. Businessman

It is necessary to implement interventions by prioritizing areas and sectors based on the status of target areas. Furthermore, interventions must also be in line and support development planning. Interventions at the local level require more study. The preparation of intervention options for risk management of climate change impacts in the Coral Triangle area can refer to the Minister of Environment and Forestry Regulation No. 33/2016 about Guidelines for Formulating Climate Change Adaptation Actions. Climate change adaptation actions must be formulated by considering the vulnerability and risk of climate change impacts in order to identify problems at the site/location-scale. It is important to assess the vulnerability, risks, and impacts of climate change as a basis for preparing adaptation actions. The steps for conducting a vulnerability and risk assessment can refer to the Minister of Environment and Forestry Regulation No. 7/2018 about Guidelines for the Assessment of Vulnerability, Risk and Impact of Climate Change.

Table 4.4 Intervention recommendations based on the level of intervention and vulnerability variables

No.	Variable	Criteria	Intervention	Low Intervention	Moderate Intervention	High Intervention
1	Climate Hotspot	Future Temperature Projections >35°C	Soft	1. Strengthening literacy of temperature rise potential risk[1] 2. Determination of potentially vulnerable and risk areas[1]	1. Strengthening literacy of temperature rise potential risk[1] 2. Determination of potentially vulnerable and risk areas[1] 3. Determination of adaptation patterns to high risk[1] 4. Setting up short and long term adaptation programs[1]	1. Strengthening literacy of temperature rise potential risk[1] 2. Determination of potentially vulnerable and risk areas[1] 3. Determination of adaptation patterns to high risk[1] 4. Setting up adaptive logistic system for high risk[1] 5. Preparing short and long term adaptation program[1] 6. Development of risk control priorities[1] 7. Strengthening soft-hard infrastructure at high risk locations[1] 8. Allocation of priority funding[4]
			Hard			

		Temperature changes 1°C	Soft	1. Setting up an adaptation pattern for increased risk potential[1] 2. Increasing the role of sister village for medium and high intervention areas[1] 3. Preparing short-term adaptation measures[1]	1. Setting up an adaptation pattern for increased risk potential[1] 2. Increasing the role of sister village for medium and high intervention areas[1] 3. Preparing short-term adaptation measures[1] 4. Strengthening soft and hard structure[1] 5. Strengthening high adaptability to increased risk potential[1]	1. Setting up an adaptation pattern for increased risk potential[1] 2. Increasing the role of sister village for medium and high intervention areas[1] 3. Preparing short-term adaptation measures[1] 4. Strengthening soft and hard structures against high risks both to the environment and private facilities[1] 5. Strengthening high adaptability for a increased risk potential [1] 6. Strengthening funding allocation[4] 7. Preparing the latest innovations in reducing risks that have the potential to increase rapidly[1]
			Hard			

2	Socio-Economic Vulnerability (SIDIK)	The ratio of the number of the household on the riverbank	Soft	1. Preventing the increasing[5] 2. Mapping the distribution of low-high vulnerable households [6]	1. Preventing the increasing[5]Mapping the distribution of low-high vulnerable households[6] 2. Provide adaptation room for high-risk households when risks increase[6]	1. Preventing the increasing[5]Mapping the distribution of low-high vulnerable households[6] 2. Provide adaptation room for high-risk households when risks increase[6] 3. Strengthening a better capacity of personal and group [6]
			Hard			Shifting the new spatial pattern from the riverbank [7]
		The ratio of the number of buildings on the riverbank	Soft	Preventing the expansion of developed area[7]	1. Preventing the expansion of developed area[7]Limiting the land load of buildings[7]	1. Preventing the expansion of developed area[7]Limiting the land load of buildings[7]
			Hard			Preparing alternative area for buildings outside the river bank[7]
		Types of drinking water source	Soft	Protecting natural water sources[8]	Protecting natural water sources[8]	1. Protecting natural water sources[8] 2. Mapping and preparing the adaptation of areas prone to water sources[8]
			Hard		Preparing artificial sources when natural sources are in decline[8]	Preparing artificial sources when natural sources are in decline[8]

		The ratio of the number of poor people	Soft	Mapping the distribution and the ratio of the poor resident[9]	1. Mapping the distribution and the ratio of the poor resident[9] 2. Reducing the ratio of the poor resident[9]	1. Mapping the distribution and the ratio of the poor resident[9] 2. Reducing the ratio of the poor resident[9] 3. Strengthen the suppression of the causes of absolute or structural poverty[9]
			Hard			Preparing alternative sources of food and the other needs for the poor resident[9]
		Type of income source	Soft	Maintaining a balance of community income sources[10]	Maintaining a balance of community income sources[10]	1. Maintaining a balance of community income sources[10] 2. Preparing a scenario for the distribution of sources of income to vulnerable groups[10]
			Hard		Preparing other formal and informal alternative sources of income[10]	Preparing other formal and informal alternative sources of income[10]
		Ratio of families to electricity service	Soft		1. Ensuring that the service ratio does not decrease[11] 2. Prioritizing services for vulnerable and high-risk groups[11]	1. Ensuring that the service ratio does not decrease[11] 2. Prioritizing services for vulnerable and high-risk groups[11]
			Hard			Preparing alternative backups and sources of electrical energy when the risk increases[11]

		Ratio of population attending school	Soft	Maintaining the school ratio among the resident [9]	Maintaining the school n ratio among the resident [9]	1. Maintaining the school ratio among the resident[9] 2. Preparing educational schemes and affordable schools for the community[12]
			Hard		Preparing informal education for strengthening and accelerating risk knowledge[12]	Preparing informal education for strengthening and accelerating risk knowledge[12]
		Ratio of population to health facilities	Soft	Maintaining a minimum service level ratio[13]	1. Maintaining a minimum service level ratio[13] 2. Improving service quality[13]	1. Maintaining a minimum service level ratio[13] 2. Improving service quality[13] 3. Increasing the easy access to services[13] 4. The role of the servant in the human mission of the administrative mission[13]
			Hard			
		Types of road infrastructure	Soft		Strengthening the guarantees of road infrastructures, while increasing transportation capacity[14]	Strengthening the guarantees of road infrastructures,, while increasing transportation capacity[14]
			Hard	Setting up a standard infrastructure for minimal services [8]	Setting up a standard infrastructure for minimal services[8]	1. Setting up a standard infrastructure for minimal services[8] 2. Increasing the quantity of road infrastructure types for various modes[8]

3	Coastal Vurnabeility Index	Coastal slope	Soft	Maintain coastal slope conditions[2]	Maintain coastal slope conditions[2]	1. Maintain coastal slope conditions[2] 2. Preparing hard structures or mitigation measures to anticipate changes in the slope[2]
			Hard		Repairing the damaged slopes[2]	Repairing the damaged slopes[2]
		Maximum tide range	Soft	Reinforcing information on the maximum potential tide risk[2, 3, 15]	1. Reinforcing information on the maximum potential tide risk[2, 3, 15] 2. Mapping the main stress areas and the potential for increased risk[2, 3, 15]	1. Reinforcing information on the maximum potential tide risk[2, 3, 15] 2. Mapping the main stress areas and the potential for increased risk[2, 3, 15]
			Hard			Preparing a high tide risk adaptation and mitigation area[2, 15]
		Wave height	Soft	Strengthening information about the risk of high waves[2, 3, 15]	1. Strengthening information about the risk of high waves[2, 3, 15] 2. Preparing adaptation and mitigation for high wave risk [2, 15]	1. Strengthening information about the risk of high waves[2, 3, 15] 2. Preparing adaptation and mitigation for high wave risk [2, 15]
			Hard			Prepare mitigation and evacuation routes from the risk of high waves[7]
		Sea Level Rise	Soft	Strengthening information on the impact of sea level rise[2, 3, 15]	1. Strengthening information on the impact of sea level rise[2, 3, 15] 2. Strengthen public literacy regarding the	1. Strengthening information on the impact of sea level rise[2, 3, 15] 2. Strengthen public literacy regarding the

					risks and dangers of rising sea level[12]	risks and dangers of rising sea level[12] 3. Preparing a mitigation system for the impact of rising sea water[2, 15]
			Hard			
		Coastal geomorphology	Soft	Mapping coastal geomorophology[16]	1. Mapping coastal geomorophology[16] 2. Strengthening risk information from coastal geomorphology[2, 15]	1. Mapping coastal geomorophology[16] 2. Strengthening risk information from coastal geomorphology[2, 15]
			Hard			Restricting activities in high-risk morphological areas[2, 15]
		Erosion/accretion	Soft	Conducting literacy review on the potential dangers of accretion and abrasion[12]	1. Conducting literacy review on the potential dangers of accretion and abrasion[12] 2. Preparing adaptation strategies for abrasion and accretion hazards[2]	1. Conducting literacy rewiew on the potential dangers of accretion and abrasion[12] 2. Preparing adaptation strategies for abrasion and accretion hazards[2] 3. Preparing mitigation measures (soft and hard structures) abrasion and accretion control[2]
			Hard			
4	Mangrove ecosystem	Status	Soft	Preserving good and healthy mangrove status[1, 2]	Preserving good and healthy mangrove status[1, 2]	Preserving good and healthy mangrove status[1, 2]
			Hard		Making efforts to improve the quality of damaged mangroves[1, 2]	1. Making efforts to improve the quality of damaged mangroves[1, 2]

						2. Reconstructing critical land in the mangrove areas[1, 2]
		Productivity	Soft	Protecting the natural productivity within the carrying capacity limit[1, 2]	1. Protecting the natural productivity within the carrying capacity limit[1, 2] 2. Increasing natural productivity by increasing health status[1, 2]	1. Protecting the natural productivity within the carrying capacity limit[1, 2] 2. Increased natural productivity by increasing health status[1, 2] 3. Strengthening the community role in the protection and preservation of the mangroves[1, 2]
			Hard			
		Carbon Protection	Soft	Quality and quantity protection[1, 2]	1. Quality and quantity protection[1, 2] 2. Quality and Health Improvement[1, 2]	1. Quality and quantity protection[1, 2] 2. Quality and Health Improvement[1, 2] 3. Enrichment and increase in the area of absorbance types[1, 2]
			Hard			
		Economic buffer	Soft	Preserving the quality and quantity[1, 2]	1. Preserving the quality and quantity[1, 2] 2. Increasing biodiversity wealth[1, 2]	1. Preserving the quality and quantity[1, 2] 2. Increasing biodiversity wealth[1, 2] 3. Designing a system of co-economic optional activities that accompany protection[1, 2]
			Hard			

5	Coral reefs	Status	Soft	Maintaining the status of the coral reef ecosystem[17]	Maintaining the status of the coral reef ecosystem[17]	Maintaining the status of the coral reef ecosystem[17]
			Hard		Performing rehabilitation of damaged ecosystems[17]	1. Performing rehabilitation of damaged ecosystems[17] 2. Reconstructing degraded ecosystems [17]
		Productivity	Soft	Maintaining productivity and natural food chains[17]	Maintaining productivity and natural food chains[17]	Maintaining productivity and natural food chains[17]
			Hard		Structural engineering in rehabilitation[17]	1. Structural engineering in rehabilitation[17] 2. Reconstruction and rehabilitation structural engineering[17]

Annotation:

1. Ministry of Environment and Forestry
2. Ministry of Maritime Affairs and Fisheries
3. Meteorological, Climatological, and Geophysical Agency
4. Environmental Fund Management Agency
5. National Population and Family Planning Board
6. National Board for Disaster Management
7. Ministry of Agrarian Affairs and Spatial Planning
8. Ministry of Public Works and Public Housing
9. Ministry of Social Affairs
10. Ministry of Labour
11. Ministry of Energy and Mineral Resources
12. Ministry of Education and Culture
13. Ministry of Health
14. Ministry of Transportation
15. Ministry of National Development Planning (Bappenas)
16. Geospatial Information Agency
17. Indonesian Institute of Sciences

BOX 3

INTERVENTION RECOMMENDATIONS BASED ON INTERVENTION LEVELS IN THREE PRIORITY ECOREGIONS

Sulu Sulawesi

Ecosystem
1. Maintain the extent and status of coastal and marine ecosystems (L, M, H)
2. Promote shared commitments related to ecosystems and biota in the ecoregion (M, H)
3. Look for various options of financing schemes, programs and strengthen the quality and quantity of regional ecosystems (H)

Fisheries
1. Assess the status of fish stocks in the ecoregion area (L, M, H)
2. Strengthen protection and supervision of illegal fishing practices (M, H)
3. Strengthen the commitment of each country to reduce illegal fishing practices (H)

Lesser Sunda

Ecosystem
1. Maintain the extent and status of coastal and marine ecosystems (L, M, H)
2. Promote shared commitments related to ecosystems and biota in the ecoregion (M, H)
3. Look for various options of financing schemes, programs and strengthen the quality and quantity of regional ecosystems (H)

Fisheries
1. Assess the status of fish stocks in the ecoregion area (L, M, H)
2. Develop Ecosystem-based fisheries management practices (*Transboundary*-EAFM) (L, M, H)
3. Strengthen protection and supervision of illegal fishing practices (M, H)
4. Strengthen the commitment of each country to reduce illegal fishing practices (H)

Bismarck Solomon

Ecosystem
1. Maintain the extent and status of coastal and marine ecosystems (L, M, H)
2. Promote shared commitments related to ecosystems and biota in the ecoregion (M, H)
3. Look for various options of financing schemes, programs and strengthen the quality and quantity of regional ecosystems (H)

Fisheries
1. Assess the status of fish stocks in the ecoregion area (L, M, H)
2. Strengthen protection and supervision of illegal fishing practices (M, H)
3. Strengthen the commitment of each country to reduce illegal fishing practices (H)

Social and Ecological resilience
1. Strengthen the local wisdom value system (L, M, H)
2. Transform the CTI regional to adapt to local values (M, H)
3. Strengthen local socio-ecological practices into regional values for the Coral Triangle region (H)

Keterangan:
L = Low Intervention
M = Moderate Intervention
H = High Intervention

Low and moderate interventions also need to be carried out in areas that require high intervention. A more detailed table is in Appendix 2

BOX 4

THE MANAGEMENT ACTION OF THREE PRIORITY ECOREGION AREAS BY THE GOVERNMENT

- Strengthen the role of multi-stakeholders through the Bunaken co-management mechanism
- Funding system through decentralization of entrance fees and trust funds
- Marine tourism, transportation, restaurants, seaweed, and fisheries
- Formed the Bunaken Park Management Board

- Mangrove rehabilitation in Remu Ransiki and Memberano
- Aquatic Tourism Park in 2020 as wide as:
  - 60,000 ha in KKPN SAP Kep. Raja Ampat)
  - 271,630 ha in KKPN SAP Kep. Waigeo
  - 353,287 ha in KKPD Pulau Kolepom
  - 1,026,540 in di KKPD Kep. Raja Ampat
  - 1,453,500 ha in Marine Natinal Park Teluk Cendrawasih
  - 499,804 ha in KKPD Kaimana
  - 346,807 ha in KKPD Teluk Berau dan Teluk Nusalasi
  - 360,000 ha in KKPD Kep. Fam
  - 338,323 ha in KKPD Laut Seribu Satu Sungai Teo Enobikia
  - 135,300 ha in KKPD Maksegara

- Environmental health assessment for lobster life
- Ecological assessment for lobster seed restocking
- Lobster conservation areas
- Limitation on the number and size of lobsters that may be caught

- Inventory of resources and sharks
- Inventory of shark protection measures

- Building infrastructure hybrid struct along the 275 m in 2019 and 75m in 2020

- Assessment of the suitability of the Savu Sea National Park regarding the distribution of cetaceans

- Mangrove rehabilitation

- Coral reef rehabilitation program
- Sustainable conservation areas

- Culture Based Fisheries in Haekrit, Tilong, Heliwen, Tulamaae, and Oelpuah basin for fisheries stock recovery

MMAF

Bunaken National Park

COREMAP-CTI

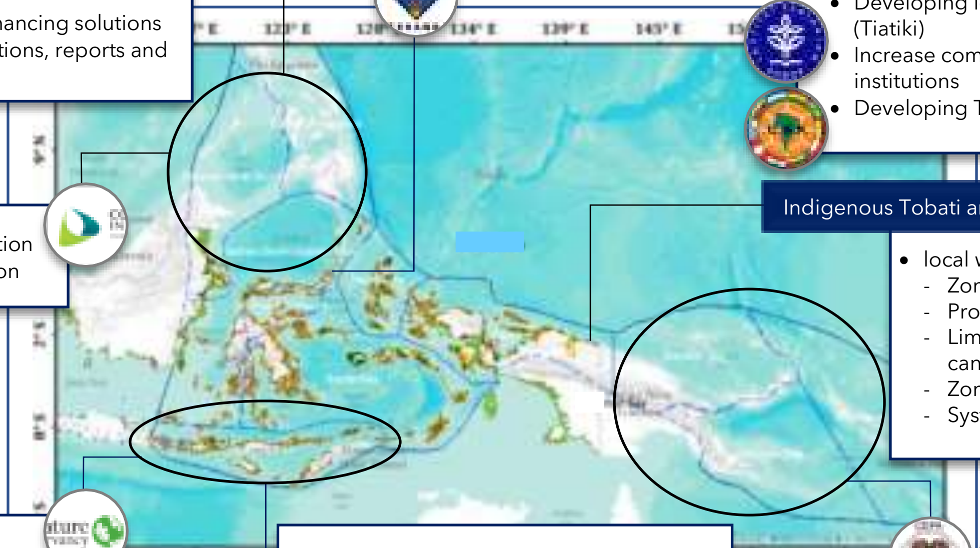
BOX 5

THE MANAGEMENT ACTION OF THREE PRIORITY ECOREGION AREAS BY THE NON-GOVERNMENT INSTITUTION

- Pioneering cross-sector and trilateral conservation
- Facilitate the development and adoption of ecoregional conservation plans by three countries
- Developing the MPA network framework
- Protection of the reefs of Tubbbataha and Bunaken
- Tri-National turtle conservation program
- Developing an ecotourism model in line with sustainable livelihoods
- Pioneer of investment and private financing solutions
- Knowledge sharing through publications, reports and websites

- Increase community resilience in facing disasters and climate change

- Developing local wisdom-based management (Tiatiki)
- Increase community participation and local institutions
- Developing Tiatiki as a basis for co-management



- Ecosystem-based fisheries conservation
- Conservation area for turtle protection

Indigenous Tobati and Enggros communities

- local wisdom of the Manjo tradition:
  - Zoning system based on natural signs
  - Prohibition of damaging fish
  - Limit the quota for Fish resources that can be used
  - Zoning system based on fishing location
  - System shut down

- Workshop on marine conservation areas
- MPA technical training with participants from various institutions

- Conservation with a cluster approach based on ecosystem characteristics so that the response is more precise

- Collaborate in area and natural resource management with local communities

WWF | CTI-CFF | Terangi Foundation | TNC | CSF | IPB | PNG-CEPA | East New Britain | West New Britain | CSIRO

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APPENDICES

Appendix 1 Compilation of data related to Indonesian coral triangle region

	Official Agency							
	Agency	Variable	Spatial level	Tempo-ral level	Type	Periode	Sharing mecha-nisme	Website
E	LIPI (Coremap)	Coral reefs condition category		Annual	Report	1993-2019	Open Access	https://www.researchgate.net/publication/342663285_The_Status_of_Indonesian_Coral_Reefs_2019
E		Coral reefs area	30 m		Vector	2007	Limited Access	http://lipi.go.id/publikasi
E		Location of coral reefs habitat distribution	10 m		Vector	2015-2019	Limited Access	http://lipi.go.id/publikasi
V	Bappenas	Coastal vulnerability			Vector		Limited Access	http://geoservices.bappenas.go.id/arcgis/rest/services/Produksi/Dit_LH_Kaji_Ulang_RAN_API/FeatureServer/5
E	MoEF (Dit. PIKA)	Area and location of the national park distribution	1:5.000.000		Vector	2020	Limited Access	http://pika.ksdae.menlhk.go.id/
E	MoEF (DJPPI)	ProKlim			Point	2012-2020	Limited Access	http://ditjenppi.menlhk.go.id/
V	MoEF	National vulnerability (SIDIK)			Map	2019	Limited Access	http://sidik.menlhk.go.id/

E	MMAF (Dit. JPRL)	Conservation area			Deter-mination Decree	2009-2019	Open Access	https://kkp.go.id/djprl/kkhl/page/2107-sk-penetapan
E	MMAF (Pusrikan)	Research			Journal and publication		Open Access	http://ejournal-balitbang.kkp.go.id/
E	Local Govern-ment	RZWP3K	1:50.000 dan 1:250.000		Map, Local regula-tion, Final docu-ment	2007-2020	Limited Access	https://seanode.id/maps/?limit=100&offset=0
E	Coral Triangle Center (2020)	Program achievement		Quarter and Annual	Report	2013-2020	Open Access	https://www.coraltrianglecenter.org/financials-and-reports/
	Non-Official Agency							
	Agency	Variable	Spatial level	Tempo-ral level	Type	Periode	Sharing mecha-nisme	Website
E	NOAA *Coral Reef Watch*	[a]Bleach alert area (stress max in 7 day)	Satelite (5 km)	Daily	Map	1985-present	Open Access	https://coralreefwatch.noaa.gov/product/5km/index_5km_baa_max_r07d.php
E		[a]Coral bleaching hotspot	Satelite (5 km)	Daily	Map	1985-present	Open Access	https://coralreefwatch.noaa.gov/product/5km/index_5km_hs.php

E		[a]Weekly heat stress degrees (accumulation)	Satelite (5 km)	Daily	Map	1985-present	Open Access	https://coralreefwatch.noaa.gov/product/5km/index_5km_dhw.php
E		[a]SST (*CoralTemp*)	Satelite (5 km)	Daily	Map	1985-present	Open Access	https://coralreefwatch.noaa.gov/product/5km/index_5km_sst.php
E		[a]SST Anomalies	Satelite (5 km)	Daily	Map	1985-present	Open Access	https://coralreefwatch.noaa.gov/product/5km/index_5km_ssta.php
E		[a]SST trend in 7 day	Satelite (5 km)	Daily	Map	1985-present	Open Access	https://coralreefwatch.noaa.gov/product/5km/index_5km_ssttrend_7d.php
E		Dataset variables (a)	Station	Daily	Tabular	1985-present	Open Access	https://coralreefwatch.noaa.gov/product/vs/data.php
E	WorldFish (Project CT Atlas)	[b]MPA (Marine Protected Areas)			Interacti-ve map		Open Access	http://ctatlas.reefbase.org/atlas/default.aspx?layers=8,68&zoom=5&lat=-2&lng=115&maptype=terrain
V		[b]Coral disease					Open Access	
H		[b]Coral bleaching					Open Access	
E		[b]SST Max				1985-2005	Open Access	
E		[b]SST Min				1985-2005	Open Access	
E		[b]SST Range				1985-2005	Open Access	

E		[b]Average annual maximum degree of heat stress				1986-2005	Open Access	
E		[b]10-year average Projection of annual degree heat stress				2091-2100	Open Access	
E		[b]Marine population connectivity					Open Access	
E		[b]Marine ecoregion					Limited Access	
E		Dataset variables (b)					Limited Access	http://ctatlas.reefbase.org/ctdataset.aspx
V	WorldFish (Project ReefBase)	Bleaching severity		Monthly	Tabular		Limited Access	http://www.reefbase.org/gis_maps/datasets.aspx
E		Coral reef species and families		Monthly	Tabular		Limited Access	
V		Percentage of coral reefs affected by bleaching		Monthly	Tabular		Limited Access	
E		Duration of the bleaching event		Monthly	Tabular		Limited Access	
V		Percentage of coral mortality due to bleaching		Monthly	Tabular		Limited Access	
E		Coral recovery rate		Monthly	Tabular		Limited Access	

E		Sea Surface Temperature (SST)		Monthly	Tabular		Limited Access	
E		The area observed		Monthly	Tabular		Limited Access	
E		Extent of coral reefs in protected areas		Annual	Tabular		Limited Access	
E		Water depth		Annual	Tabular		Limited Access	
V		Percentage of coral disease incidence		Annual	Tabular		Limited Access	
V		Percentage of coral area affected by disease		Annual	Tabular		Limited Access	
V		Percentage of coral mortality due to disease		Annual	Tabular		Limited Access	
E	WCMC	Famili, genus, and species in the distribution of global coral reefs	Variable		Vector, KML, WMS	1954-2018	Open Access	https://data.unep-wcmc.org/datasets/1
E		Maximum/minimum depth coral reefs location	Variable		Vector, KML, WMS	1954-2018	Open Access	
E		Famili, genus, dan spesies terumbu karang air dingin			Vector, KML, WMS	1915-2014	Open Access	https://data.unep-wcmc.org/datasets/3

E		Maximum/minimum depth of cold water coral reefs location			Vector, KML, WMS	1915-2014	Open Access	https://data.unep-wcmc.org/datasets/3
E		Biodiversity of marie species level	880 km		Vector	1900-2009	Open Access	https://data.unep-wcmc.org/datasets/17
V		Tingkat risiko terumbu karang	500 m		KML, Tabular, Vector	2011	Open Access	https://data.unep-wcmc.org/datasets/42
E	UNESCO (OBIS)	Location of marine biodiversity distribution based on taxonomy			CSV (tabular)	2000-2020	Open Access	https://obis.org/manual/access/
E		Maximum/minimum depth of marine biodiversity distribution			CSV (tabular)	2000-2020	Open Access	https://obis.org/manual/access/
E	WRI	Location of tropical coral reefs distribution	500 m		Grid	2011	Open Access	https://datasets.wri.org/dataset/tropical-coral-reefs-of-the-world-500-m-resolution-grid
V		The social and economic vulnerability of countries with coral reefs at risk			Vector (Polygon)	2011	Open Access	https://datasets.wri.org/dataset/reefs-at-risk-revisited-social-vulnerability-data
V		Disease type and severity in the coral reef species attacked			SHP	1963-2010	Open Access	https://datasets.wri.org/dataset/bleaching-observations-1963-2010

Annotation: E=Exposure; V=Vulnerability; H=Hazard

Appendix 2 Intervention recommendations based on intervention levels in the three priority ecoregions

Ecoregion	Criteria	Low intervention	moderate intervention	High intervention
Sulu Sulawesi Marine Ecoregion	Ecosystem	Maintain the extent and status of coastal and marine ecosystems	1. Maintain the extent and status of coastal and marine ecosystems 2. Promote shared commitments related to ecosystems and biota in the ecoregion	1. Maintain the extent and status of coastal and marine ecosystems 2. Promote shared commitments related to ecosystems and biota in the ecoregion 3. Look for various options of financing schemes, programs and strengthen the quality and quantity of regional ecosystems
	Fisheries	Assess the status of fish stocks in the ecoregion area	1. Assess the status of fish stocks in the ecoregion area 2. Strengthen protection and supervision of illegal fishing practices	1. Assess the status of fish stocks in the ecoregion area 2. Strengthen protection and supervision of illegal fishing practices 3. Strengthen the commitment of each country to reduce illegal fishing practices
Leser Sunda Ecoregion	Ecosystem	Maintain the extent and status of coastal and marine ecosystems	1. Maintain the extent and status of coastal and marine ecosystems 2. Promote shared commitments related to ecosystems and biota in the ecoregion	1. Maintain the extent and status of coastal and marine ecosystems 2. Promote shared commitments related to ecosystems and biota in the ecoregion 3. Look for various options of financing schemes, programs and strengthen the quality and quantity of regional ecosystems
	Fisheries	1. Assess the status of fish stocks in the ecoregion area 2. Develop Ecosystem-based fisheries management practices (Transboundary Ecosystem Approach	1. Assess the status of fish stocks in the ecoregion area. 2. Develop Ecosystem-based fisheries management practices (Transboundary Ecosystem Approach	1. Assess the status of fish stocks in the ecoregion area 2. Develop Ecosystem-based fisheries management practices (Transboundary Ecosystem Approach Fisheries Management/T-EAFM) 3. Strengthen protection and supervision of illegal fishing practices

Ecoregion	Criteria	Low intervention	moderate intervention	High intervention
		Fisheries Management/T-EAFM)	Fisheries Management/T-EAFM) 3. Strengthen protection and supervision of illegal fishing practices	4. Strengthen the commitment of each country to reduce illegal fishing practices
Bismarck Solomon Sea Ecoregion	Ecosystem	Maintain the extent and status of coastal and marine ecosystems	1. Maintain the extent and status of coastal and marine ecosystems 2. Promote shared commitments related to ecosystems and biota in the ecoregion	1. Maintain the extent and status of coastal and marine ecosystems. 2. Promote shared commitments related to ecosystems and biota in the ecoregion 3. Look for various options of financing schemes, programs and strengthen the quality and quantity of regional ecosystems
	Fisheries	Assess the status of fish stocks in the ecoregion area	1. Assess the status of fish stocks in the ecoregion area. 2. Strengthen protection and supervision of illegal fishing practices	1. Assess the status of fish stocks in the ecoregion area 2. Strengthen protection and supervision of illegal fishing practices 3. Strengthen the commitment of each country to reduce illegal fishing practices
	Social-Ecological resilience	Strengthen the local wisdom value system (Sasi and Tiatiki)	1. Strengthen the local wisdom value system (Sasi and Tiatiki) 2. Transform the CTI regional to adapt to local values	1. Strengthen the local wisdom value system (Sasi and Tiatiki) 2. Transform the CTI regional to adapt to local values 3. Strengthen local socio-ecological practices into regional values for the Coral Triangle region

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