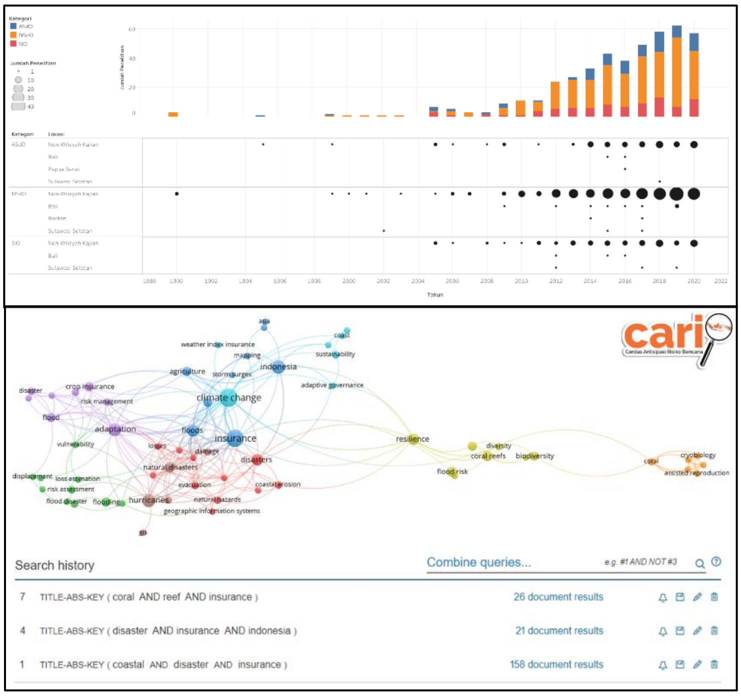
Baseline Disaster Risk Assessment in Coastal Areas of Indonesia for Insurance Program Piloting

Executive Summary

Baseline Disaster Risk Assessment in Coastal Areas of Indonesia (Baseline report) is a part of the Feasibility Study for developing a coral reef insurance scheme, currently undertaken by *Yayasan Konservasi Alam Nusantara* (YKAN). The objective of this assessment is to identify historical events and damages caused by disasters – natural phenomenon and human activities, assess the scope, frequency, and severity of the disaster, and build map of stakeholders relevant to contribute to disaster preparedness and responses in seven sites, namely Pandeglang (Banten), Makassar (South Sulawesi), Klungkung (Bali), Wakatobi (South East Sulawesi), Berau (East Kalimantan), Raja Ampat (West Papua), dan Rote (East Nusa Tenggara).

The context of this baseline risk assessment is on a risk insurance formulation, hence a rapid systematic literature review (SLR) in related subject-matters preceded the technical analysis. It shows that explicit knowledge record (research) is complete and more structured for natural hazards, and generally found dated for the period of 2010-2020. See the clear image in Section 2.1.



SLR also resulted in a knowledge network showcasing the inter-relationships between the subject-matters on coastal areas and coral reefs, disaster risk reduction, and insurance. The network suggests that risk assessment and its subsequent use for insurance product formulation could learn from the processes and outputs linking insurance with climate change topic and in the agriculture sector. Please refer to Section 2.1 for further explanation and information on how it affects the revised steps in data collection (Section 2.2-2.4).

The Final Report consolidates various disaster-related databases and enlisted disaster events caused by natural hazards (i.e., floods, coastal surge, earthquake, tsunami, strong wind, and tropical cyclone); disaster events caused by anthropogenic hazards (i.e. grounding, destructive fishing, and oil spill); as well as negative gradual changes due to natural cause affected by climate change and human activities (i.e. sea level rise, coastal bleaching induced by the increase in sea surface temperature, as well as coastal reclamation). A coastal disaster-events database is created as part of this report, using the official Indonesian Disaster Data and Information Database (DIBI) as the basis, supplemented, and verified using entries from ASEAN Disaster Information Network, EM-DAT, GLIDE, and UNDRR's database. A total of 1,823 events caused by natural hazards and 124 events caused by anthropogenic hazards across the seven locations were identified between 2000-2020.

The Final Report consists of 10 chapters. Chapter 1 describes the background, objectives, and scope of report. Chapter 2 elaborates the synthesis of rapid Systematic Literature Review of the subject-matter and methodologies of data collection and analysis. Chapter 3 until chapter 9 elaborates the risk profile of each location consist of a general overview, historical record of disaster events 2000-2020, stakeholder mapping and local capacity analysis, risk analysis and potential damages and losses estimation. Chapter 10 provides the initial conclusions based on comparison of risk profiles across locations as well as recommendations for prioritized locations based on quick-win programming scenario.

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List of Abbreviations and Terminologies

ADINet	: ASEAN Disaster Information Network
ADRC (GLIDE)	: Asian Disaster Reduction Center (Global Indentifier Number)
AHA Centre	: ASEAN Coordinating Center on Humanitarian Assistance on disaster management
AMSA	: Australian Maritime Safety Authority
ASdO	: Antrophogenic Sudden Onset
BAPPENAS	: National Development Planning Agency (*Badan Perencanan Pembangunan Indonesia*)
BNPB	: National Disaster Management Agency (*Badan Nasional Penanggulangan Bencana*)
BPBD	: Local Disaster Management Office (*Badan Penanggulangan Bencana Daerah*)
BPS	: Central Bureau of Statistics (*Badan Pusat Statistik*)
CCA	: Climate Change Adaptation
CI	: Conservation International
CRED	: Center for Research on the Epidemiology of Disasters
CSIPA	: Coastal and Small Islands Protected Areas
DIBI	: Indonesian Disasters Data and Information (*Data dan Informasi Bencana Indonesia*)
District	: *Kecamatan*
DRR	: Disaster Risk Reduction
EM-DAT	: Emergency Events Database
GDRP	: Gross Domestic Regional Product
GIS	: Geospatial Information System
ICCSR	: Indonesian Climate Change Sectoral Roadmap
IRBI	: Disaster Risk Index (*Indeks Resiko Bencana*)
ITF	: Indonesia Throgh Flow
MoU	: Memorandum of Understanding
MPA	: Marine Protected Area
NMPA	: National Marine Protected Area
KNST	: Specific National Strategic Areas (*Kawasan National Strategis Tertentu*)
KPU	: General Allocation Area (*Kawasan Peruntukan Umum*)
KSK	: City/Regency Strategic Areas (*Kawasan Strategis Kota/Kabupaten*)
KSN	: National Strategic Area (*Kawasan Strategis Nasional*)
KSP	: Provincial Strategic Areas (*Kawasan Strategis Provinsi*)
LIPI	: Indonesian Institute of Sciences (*Lembaga Ilmu Pengetahuan Indonesia*)
Mamminasata	: Makassar-Sungguminasa-Takalar-Maros Metropolitan Area
MRAP	: Marine-Rapid Assessment

NSdO	: Natural-hazard Sudden Onset
PF	: Protected Forest
PKL	: Local Activity Center (*Pusat Kegiatan Lokal*)
PKLP	: Local Promotion Activity Center (*Pusat Kegiatan Lokal Promosi*)
PKN	: National Activity Center (*Pusat Kegiatan Nasional*)
PKW	: Regional Activity Center (*Pusat Kegiatan Wilayah*)
PKWP	: Promotion Area Activity Center (*Pusat Kegiatan Wilayah Promosi*)
PTTEP AA	: The Petroleum Authority of Thailand Exploration and Production Australasia
RAN-API	: Indonesia Climate Change Adaptation Action Plan (*Rencana Aksi Nasional Adaptasi Perubahan Iklim*)
RCM	: Regional Climate Change
Regency	: *Kabupaten*
RTRW	: Regional Spatial Plan (*Rencana Tata Ruang Wilayah*)
RPJMD	: Regional Mid-term Development Plan (*Rencana Pembangunan Jangka Menengah Daerah*)
SlO	: Slow Onset
SLR	: Rapid Systematic Literature Review
SPEI	: Standardized Precipitation Evapotranspiration Index
SPI	: Standard Precipitation Index
Sub-district	: Village within a City (*Kelurahan*)
TNC	: The Natural Conservancy
TNL	: Marine National Park (*Taman Nasional Laut*)
TNP	: Marine National Park (*Taman Nasional Perairan*)
TOR	: Terms of Reference
TPI	: Fish Auction Place (*Tempat Pelelangan Ikan*)
TWA	: Nature Park (*Taman Wisata Alam*)
UPT	: Technical Implementation Unit (*Unit Pelaksana Teknis*)
Village	: Village within a Regency (*Desa*)
WKOPP	: Fishery Port Operational Work Area (*Wilayah Kerja Operasional Pelabuhan Perikanan*)
WKP	: Development Working Area (*Wilayah Kerja Pembangunan*)
WPP	: Fishery Management Area (*Wilayah Pengelolaan Perikanan*)
WPPNRI	: Fisheries Management Territory of the Republic of Indonesia (*Wilayah Pengelolaan Perikanan Negara Republik Indonesia*)
WWF	: World Wild Fund

1. Introduction

1.1 Background

Coral reefs have a huge and critical role in providing services of ecosystems (ecosystem services), including for Disaster Risk Reduction (DRR), reducing the risk and impact of flooding and coastal erosion, and social and economic benefits for the coastal society. In a state of good and healthy, coral reefs can reduce up to 97% power of the waves the sea before reaching the coastline, which may cause loss and damage to the people of coastal (Secaira, McLeod, & Tassoulas, 2019). Although coral reefs have the potential as nature-based protection for DRR, they are also assets that are exposed to various hazards of nature and the danger of natural and human-made hazards. When the current regeneration capacity is lost or damaged significantly, the protection function that may be granted is also missing. One study estimated that losing one meter of top coral reef could double the economic losses and significantly increase number of exposed populations when extreme weather on the coast occurs (Secaira, McLeod, & Tassoulas, 2019).

Coral reefs may also experience severe damage due to the tsunami, sedimentation, bleaching, oil spills, ship anchoring, and others, which reduces the environmental services they provide. However, local businesses and local governments have yet to invest in coral reef restoration for many reasons, including for its knowledge limitations of the disaster risk, the potential protections, and potential damages of coral reef for the ecosystem and coastal communities.

Considering the gap between the benefits and existing threats on the natural coral reefs, there are initiatives to protect coral reefs as part of DRR and development. One of them is being explored by The Natural Conservancy (TNC) through a feasibility study to develop a coral reef insurance scheme to protect and increase the resilience of ecosystems and coastal communities. The initiative is aimed to replicate a product of parametric insurance with the inclusion of trust fund by stakeholders that is already applied in Quintana Roo, Mexico (Fajardo, McLeod, & Tassoulas, 2019; Reguero, et al., 2019). However, one of the issues for the implementation is the lack of data on the incidence of disasters, including the disaster risk that could become the cornerstone of investment and protection of coral reefs. Therefore, it is crucial to conduct a disaster risk assessment as a baseline to show the potential damage and risks that may occur and consider them in the programs and activities planning.

The Quintana Roo model deliberately designed an insurance product that is specifically addressed damages caused by the cyclone tropical (referred to as hurricane) and for one location only[1] (Fajardo, McLeod, & Tassoulas, 2019). In formulating the insurance product, Fajardo *et al.* (2019) do not carry out methods for deciding the priority of coastal disaster risk (if more than one risk is identified). Consequently, the Quintana Roo model may not be fully applicable in Indonesia. Hence, there is a need for consideration and analysis on the coastal disaster risk due to the nature and human-made hazards.

1.2 Objectives

This study aims to identify the incidence of disasters and damages caused by them in the past. This includes identifying disaster incidents caused by natural phenomenon and human activities, assessing the scope, frequency, and damages caused by the disasters, and mapping stakeholders relevant to disaster prevention and management in seven coastal cities and regencies in Indonesia.

1.3 Scope of Works

In accordance with the Terms of Reference, in general, there are three main scopes of the study: 1) Assessments of coastal disasters risk analysis, 2) Stakeholder mapping of actors in relevant sectors and businesses, and 3) Recommendation of the priority locations for implementation.

The final report is a comprehensive report of an assessment of risk analysis for seven study sites, which includes:

1. Collect and identify natural hazard disaster events (sudden and slow onset events) and its impact damages on coastal communities and ecosystem, especially coral reef in seven study sites. These disasters are tsunami, volcano eruptions, tropical cyclone, floods, earthquake, strong wind, coastal surge as well as extreme increase in sea surface temperature which could lead to coral bleaching.
2. Collect and identify anthropogenic disaster events and its impact damages on coastal communities and ecosystem, especially coral reef in seven study sites. These anthropogenic disasters include marine accidents, destructive fishing, oil spills and land reclamation.

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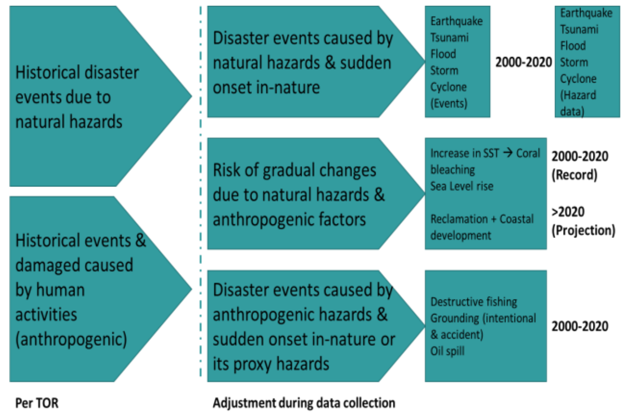
[1]See further in sub-chapter 2.1, specifically review from Reguero *et al* (2019) and Reguero *et al* (2020) Quintana Roo.

3. Assess risk and damage (scope, frequency, and severity) of disasters relevant for the coastal ecosystem and communities at seven locations.
4. Produce disaster risk related maps in seven locations.



The classification of the hazards was initially divided into two categories: natural and man-made. **Natural hazard** in simple term is an event of natural processes which possesses a threat to human population. This threat and its negative effect on population is called a natural disaster. While **man-made hazard** is an event induced by human activity which possesses a threat to human population and the surrounding environment. During the the study, another category was added according to the structure of the available events disasters database. As such, the hazards are classified into three categories: 1) disasters due to natural hazards, 2) disasters due to human activities (henceforth are called anthropogenic hazard), and 3) disasters due to gradual or **slow onset** natural hazards or human activities.

Disaster is an event or a series of events that threatens and disrupts the life and livelihood of the community, which is caused, either by natural factors and / or non-natural factors as well as human factors, resulting in human casualties, environmental damage, loss of objects, and psychological impacts. Disasters are commonly caused by natural, non-natural, and anthropogenic factors. In Indonesia, Law 24/2007 on Disaster Management explicitly classifies natural disasters and social disasters. This law defines natural disaster as a disaster caused by events or series of events caused by nature which include, among others, earthquakes, tsunamis, volcanic eruptions, floods, droughts, hurricanes, and landslides. Non-natural disasters or anthropogenic disasters are disasters caused by non-natural events or series of events, which include human factor such as technological failure, development failure, epidemics, and disease outbreaks.

Natural disaster events which threaten coastal communities and ecosystems that includes coral reefs could be classified into geological and hydrometeorological hazard. This study incorporated earthquake, tsunamis, and volcano eruptions into **geological hazards**, while tropical cyclone, rainstorm, flood and strong wind as **hydrometeorological hazards.** Below is a simple definition of hazards discussed in this study.

Earthquakes are vibration on the earth's surface, mainly caused by the movement of tectonic plates. Other sources of earthquake such as volcanic activity or even a bomb could also result in a relatively small earthquake. These tectonic plates are constantly moving in slow speed due to the mass and friction with other tectonic plates. This friction is mainly occurred in the edge of the plates which causes stress or tension and eventually release its energy in the form of earthquake. This energy is released in the form of waves that travel through the earth's crust and could reach distant places on earth's surface. The energy of an earthquake is so strong and could trigger other hazards such as tsunami and landslide.

Volcanic eruptions are part of volcanic activity which caused by increasing pressure in the magma chamber inside an active volcano. Some of the magma pushes through vents and fissures to the Earth's surface. Magma that has erupted is called lava. Some volcanic eruptions are explosive, and others are not. The explosivity of an eruption depends on the composition of the magma. If magma is thin and runny, gases can escape easily from it. When this type of magma erupts, it flows out of the volcano. Explosive volcanic eruptions can be dangerous and deadly. They can blast out clouds of hot tephra from the side or top of a volcano. These fiery clouds race down mountainsides destroying almost everything in their path. Ash erupted into the sky falls back to Earth like powdery snow. If thick enough, blankets of ash can suffocate plants, animals, and humans. When hot, volcanic materials mix with water from streams or melted snow and ice, mudflows form. Mudflows have buried entire communities located near erupting volcanoes. Eruptions often force people living near volcanoes to abandon their land and homes, sometimes forever. Those living farther away are likely to avoid complete destruction, but their cities and towns, crops, industrial plants, transportation systems, and electrical grids can still be damaged by tephra, ash, lahars, and flooding. The dangers of a volcanic eruption can be in the form of hot clouds, throwing material (incandescent), heavy ash rain, lava, poison gas, tsunamis, and lava floods.

Tsunami is a syllable of Japanese words "tsu" (wave) and "nami" (harbor) which means harbor wave, which is a series of long waves that occur due to changes in water bodies which are cause by deformation of the seabed or changes that occur suddenly and impulsively by earthquakes, volcanic eruptions, underwater landslides, and even as a result meteorite impact to the ocean. In deep water, tsunamis can travel at speeds of 500 to 1,000 kilometers per hour. Whereas in shallow water, the speed slows down to several tens of kilometers per hour due to bottom friction. The height of the tsunami depends on the depth of the water. Tsunami waves that are only one meter high in deep water can rise to tens of meters on the coastline due to shoaling effects. In the study of tsunami, tsunami magnitude is classified based on the tsunami height. Meanwhile, tsunami Intensity is measured based on observations of the impact of the tsunami on humans, buildings, and other objects including ships of various sizes.

Floods is the most common disaster in the world and are highly related to meteorological factors, on the hydrological cycle, water comes from and to the ocean. Human population is also dependent by water source, such as rivers, lakes and the ocean. Flood is the most frequent type of natural disaster and occurs when there is an overflow abundance of water which inundated parts of the land that is usually dry. Floods are the effect of extreme meteorological phenomena such as the changing of season which often cause heavy rainfall, rapid snowmelt or a storm surge resulted from a tropical cyclone and even from tsunami in coastal areas.

Floods can cause widespread devastation, resulting in loss of life and damages to personal property and critical public health infrastructure. People who live in floodplains or non-resistant buildings, or lack warning systems and awareness of flooding hazard, are most vulnerable to floods. Floods are also increasing in frequency and intensity, and the frequency and intensity of extreme precipitation is expected to continue to increase due to climate change. There are three common types of floods:

- Flash floods are caused by rapid and excessive rainfall that raises water heights quickly and rivers, streams, channels, or roads may be overtaken.
- River floods are caused when consistent rain or snow melt forces a river to exceed capacity.
- Coastal floods are caused by storm surges associated with tropical cyclones and tsunami.

Tropical cyclones are storms of great force. It is also known as hurricane and typhoon in other part of the world. The average radius of a tropical cyclone is 150 to 200 km. Tropical cyclones generally form over large surface of oceans that have warm sea surface temperatures of more than 26,5 °C. Strong winds formed around its center have wind speeds at least 63 km/hr. The lifespan of a tropical cyclone ranges from 3 to 18 days on average. Because tropical cyclone energy is obtained from warm oceans, tropical cyclones will weaken or become extinct when moving and entering cold water areas or entering land.

Strong winds are winds that prevail by various factors such as seasonal monsoon factors, tropical cyclones, pseudo movement of the sun to local weather responses especially in mountains. Strong winds travel at speeds well below the speed of cyclones, yet the effect can still damage trees and some light structures. Thus, in this study, an occurrence of strong winds is distinguished from tropical cyclones according to their impact and their wind scale. This study incorporated strong winds events caused by heavy rainstorm and **whirlwind (locally known as *Puting Beliung*)** and **waterspouts** (occurred above the water surface). Whirlwind and waterspouts are often called mini tornado as they are similar in character but in smaller scale.

Coastal surge are extreme waves events that is used in this study which include tidal waves, storm surges, swell and other extreme non-tsunami waves that causes water overtopping on land. A storm surge can be defined as the rise in water levels due to a combination of storm waves plus astronomical tidal waves. This rise in water levels can cause extreme flooding in coastal areas especially when storm surges coincide with sea water under astronomically high tide, resulting in tidal waves that can reach up to 6 meters more in some cases at high latitudes. Storm waves are generated by water being pushed towards the shore by wind forces moving cyclonically around the storm.

Anthropogenic disaster events which threaten coastal communities and ecosystems, including coral reefs could be classified into four main activities, namely destructive fishing, marine accidents, oil spills and reclamation. These types of activities have been known to change or disrupt the natural environment with various impact which will be discussed in the next chapter.

Destructive fishing is the use of fishing gear in ways or in places such that one or more key components of an ecosystem are obliterated, devastated, or rendered useless. Destructive fishing causes harm to marine life and often results in long-term damage to the physical structure of habitats in regards of disproportion of the seafood production. Type of destructive fishing in this study includes illegal fishing as well as practices such as shark finning, blast fishing, poison fishing, muro-ami (reef hunters), and push netting.

Marine Accidents is a general term adopted that cover broad range of incidents taking place in ocean and coast and causing casualties. However, marine accidents in this study does not include a deliberate act with intention to harm the safety of a ship, individual or the environment. Marine accidents could be classified according to their casualties from the loss of a person, a ship or a severe damages and loss to the environment. This act of accidents in this study includes, **ships collision, grounding, accidents**

associated with extreme weathers, and hull cracking. A special inclusion to marine accident record is given to the impact of grounding and sinking ships that may cause harm to the coral reefs.

Oil spills can be defined as the release of liquid raw/natural petroleum hydrocarbons into the environment, especially into the ocean. Most of these spills are small, for example when oil spills while refueling a ship. But these spills can still cause damage, especially if they happen in sensitive environments, like beaches, mangroves, and wetlands. Extensive oil spills are major, dangerous disasters. These tend to happen when pipelines break, big oil tanker ships sink, or drilling operations go wrong. Consequences to ecosystems and economies can be felt for decades following a large oil spill.[2]

Slow-onset disaster events is defined as a disaster that does not emerge from a single, distinct event but emerges gradually over time, often based on a confluence of different events. This study discussed slow onset hazards that are mainly related to climate change as well as development activities changing the features of coastal areas (e.g., coastal reclamation), and are expected to have an impact both on coastal community and the coral reef environment.[3]

Types and classification of hazards in this study has an implication to the governmental affairs or sectors that should be considered as part of the stakeholder identification and mapping, particularly on its the intergovernmental relations. Figure 1 below indicates the hierarchy of law, governmental levels, and inter-related governmental affairs surrounding the subject-matters of this study.

[2] See https://www.noaa.gov/education/resource-collections/ocean-coasts/oil-spills

[3] See http://www.ciesin.org/documents/Adamo_CCMig_cuny_april2011.pdf

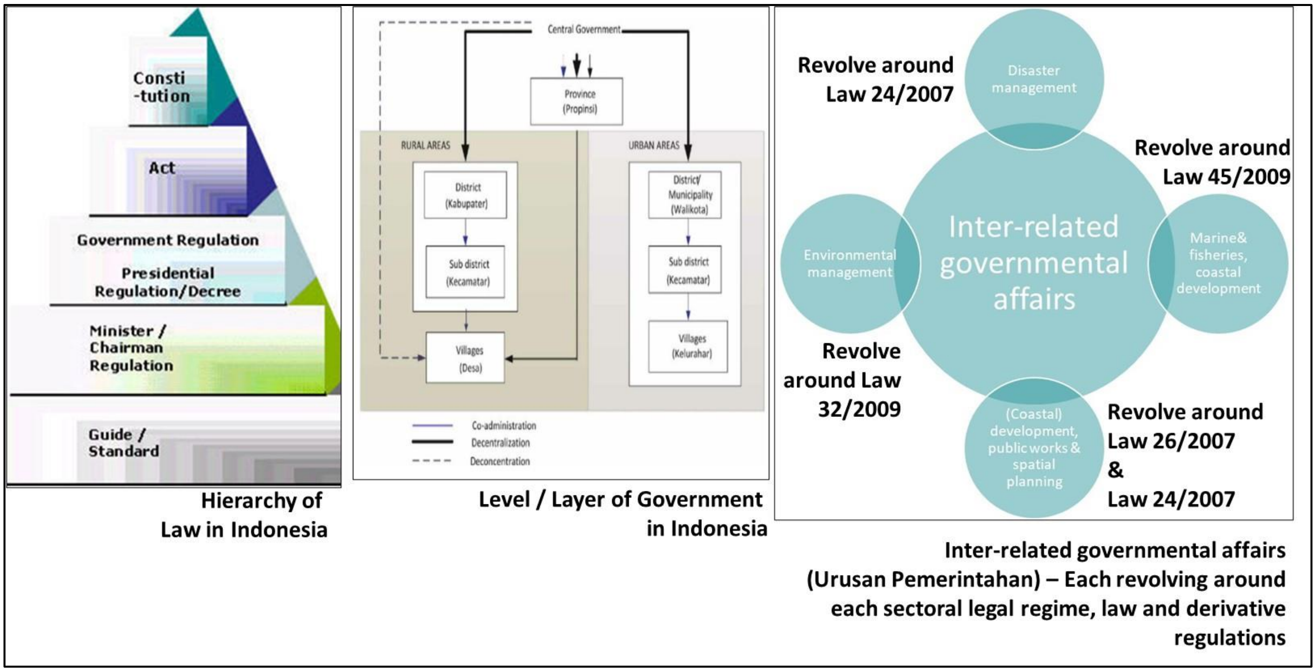


Figure 1 Context and Scope of the Study: hierarchy of law, layer of government levels and governmental affairs in Indonesia

As can be seen in Figure 1 above, the substance of the basic disaster risk assessment and identification of its stakeholders in the context of the formulation of an insurance program for coral reefs and/or coastal communities, as well as disaster risk reduction support in general, needs to consider the following aspects: local governance, management disaster, fisheries, management of coastal areas and small islands, spatial planning, and the environment. Each governmental affair has a reference law and its derivative regulations. This can be a factor that can explain the relationship between stakeholders which will be described later and should be taken into consideration in selecting locations or further program formulations.

The seven locations in Indonesia that are part of this study include Pandeglang Regency (Banten Province), Makassar City (South Sulawesi Province), Klungkung Regency (Bali Province), Wakatobi Regency (Southeast Sulawesi Province), Berau Regency (East Kalimantan Province), Raja Ampat Regency (West Papua Province), and Rote Regency (East Nusa Tenggara Province). The indicative locations of the seven city and regencies is shown in the image below Figure 2, which is overlayed with the multi-hazards index of Indonesia (BNPB, 2018).

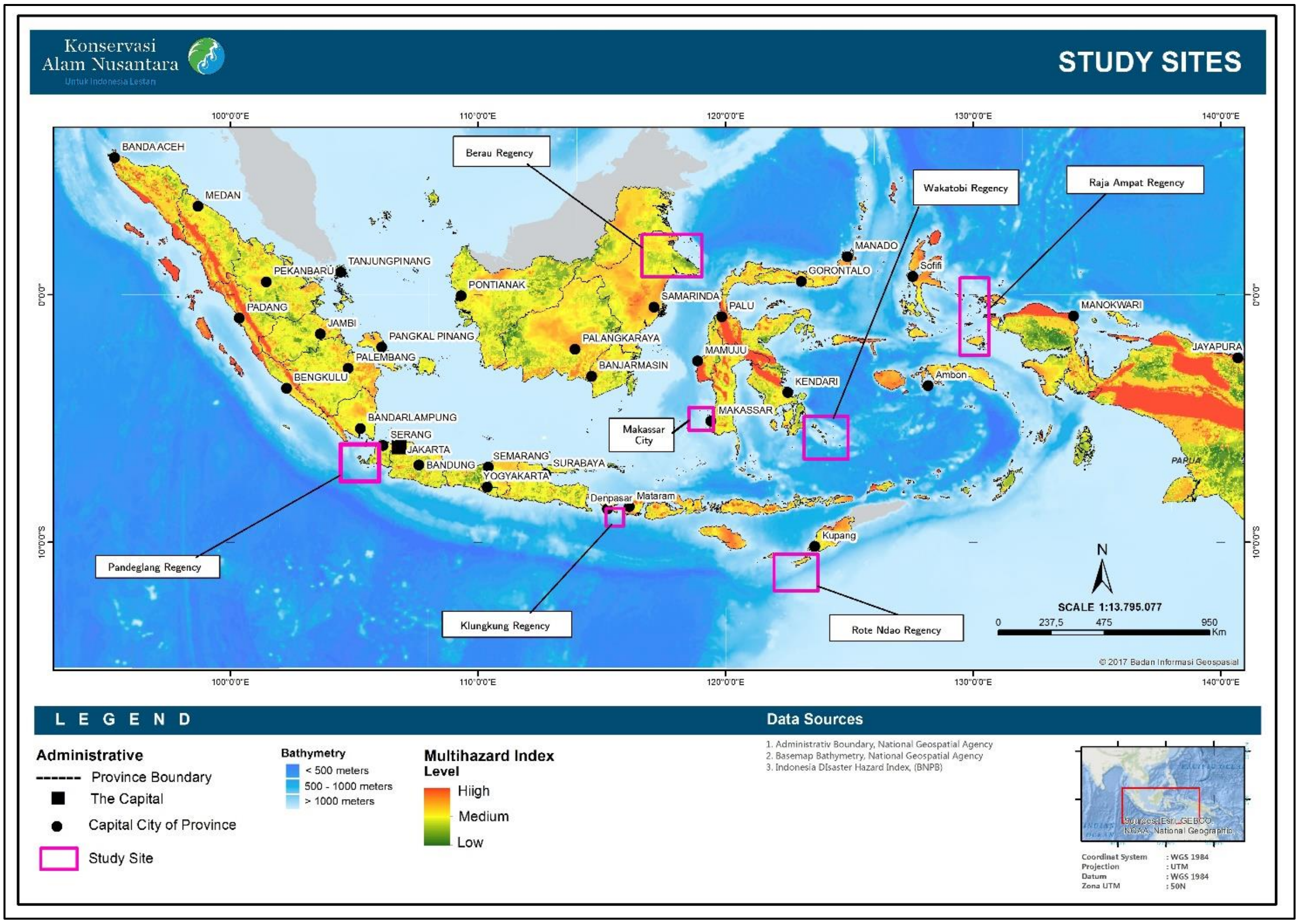


Figure 2 Study area sites.

2. Methodology

2.1 Rapid systematic literature review

Following the Workplan, a rapid systematic literature review (SLR) was conducted on the literature and previous studies on the subjects related to the topic of study. This includes research on disaster management, coastal and environmental ecosystems management, coastal communities, and the impacts of climate change. The keywords are set together with the YKAN team and can be accessed at the following link: https://bit.ly/3ry6HLO.

CARI! provides access to real-time released studies archived in Scopus, WebOfScience, Open Access Journal directories, and GoogleScholar. As the first step of the rapid SLR, data extraction from CARI! (https://caribencana.id/maps/) was conducted. Free version of CARI! search engine provides a compilation of the search results of research related to the disaster risk and resilience in Indonesia, both at the national and sub-national level. The algorithms can as well be replicated in other countries. Search results of research products relevant to this baseline assessment, as of December 2020, can be accessed at the link below: https://bit.ly/38EBjCz. Furthermore, the SLR process is fast assisted using Tableu and VosViewer.

Each region of the study has a diverse and unique research theme following their characteristics and regional development priorities. Understanding this pattern can give a better picture on the wealth of data, information, and knowledge collected and utilized in each region. Popular topics and regional development priorities will certainly have implications on the wealth of data and information that tend to be more abundant than the themes that are not a priority nor popular in the regions. Themes of the research patterns by hazard category and study location in the recent 30 years are as shown in Figure 3.

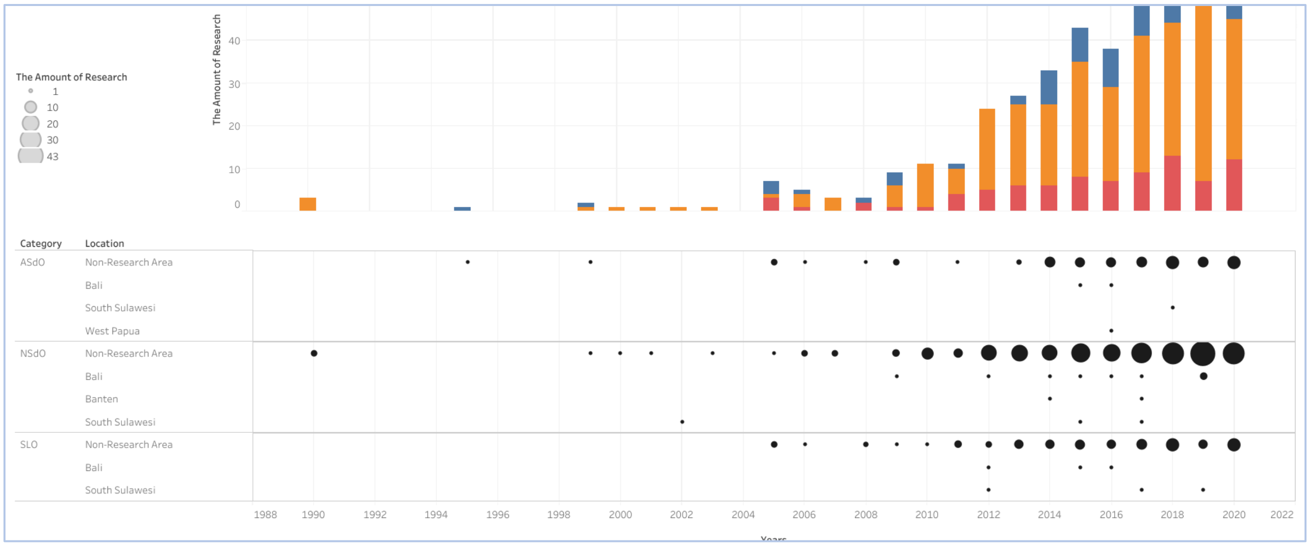


Figure 3 Themes of the Research by Hazard Category and Study Location in the last 30 Years.

Abbreviations in Figure 3:

- ASdO (Antrophogenic Sudden Onset): Disasters caused by human activities and take place within a short duration
- NSdO (Natural-hazard Sudden Onset): Disasters that occur in nature (phenomena of nature) and take place within a short duration
- SLO (Slow Onset): Disasters that are natural or by human activities that take place within a long duration

Approximately 63% from the total 1,019 research publications collected by CARI! engine and associated with the coastal disaster and the study areas were related to natural-hazard induced and sudden onset (NSdO) disasters. Earthquakes, floods, tsunamis and coastal surges have been studied more than any other theme category. Figure 3 shows the identified researcher papers were mostly based on cases outside of the study areas and more general in nature (e.g., a conceptual or theoretical research). The study area with the highest number of studies was Bali Province at 4%. This shows that the wealth of data, information and knowledge related to disasters in coastal areas in Bali will be relatively easier to find compared to other areas. This also means that the areas of Banten, South Sulawesi, Southeast Sulawesi, East Kalimantan, West Papua and East Nusa Tenggara are lacking in the availability of research. Hence, data, information and specific knowledge related to specific coastal disasters will be more difficult to find.

In the last 30 years the number of studies produced has an increasing trend. The NSdO disaster theme category has the largest increasing trend compared to other categories, namely 1.5 times per year (150% increase). The significant increase in this theme shows that the interest in the NSdO category is more popular and resulted in more research products when compared to the SLO category of 70% per year and ASdO of 47% per year. The ASdO disaster theme is still largely understudied, i.e., research that examines disasters caused by human activities within short duration. This will have implications for the relatively small amount of information and knowledge related to this category. The high increasing trend of research is crucial for data collection and information related to coastal disaster categories themes, especially those related to ASdO.

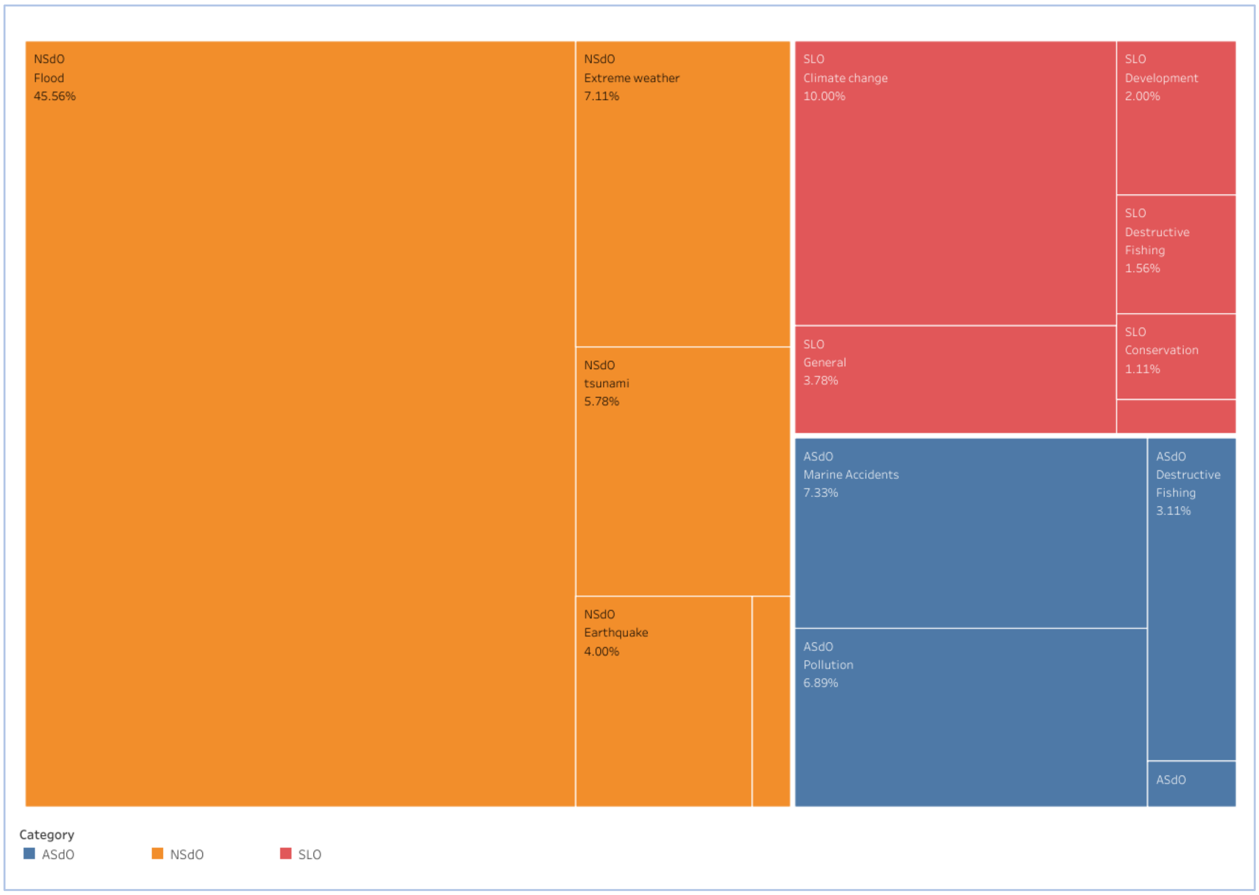


Figure 4 Theme of Research in Study areas.

As shown in Figure 4, 63% research products identified were within the NSdO category whereas the majority is related to hydrometeorological hazards, i.e., 45.56% related to floods, 7.11% related to extreme weathers. Meanwhile only 5.70% research products related to tsunami and 4.00% related to earthquake. SLO Category which refers to slow onset disasters caused by natural phenomenon or triggered by human activities accounted for 19% of the research products identified. Among them, the most dominant themes included in this category are those related to climate change (10%). The AsdO category is the least theme with recorded research products, i.e., only a total of 18% of the research. The most explored research topics are related to ship activity by 7%, both for fisheries and transportation.

Furthermore, the rapid SLR process and visualization of the knowledge network model was then reduced into results from Scopus repository using steps and the keywords in the below figure. After the filtration process and removal of duplication, 192 research products examined further. The figure below shows the networking of knowledge relevant to this study as part of a baseline risk assessment in coastal areas in the context of insurance formulation.

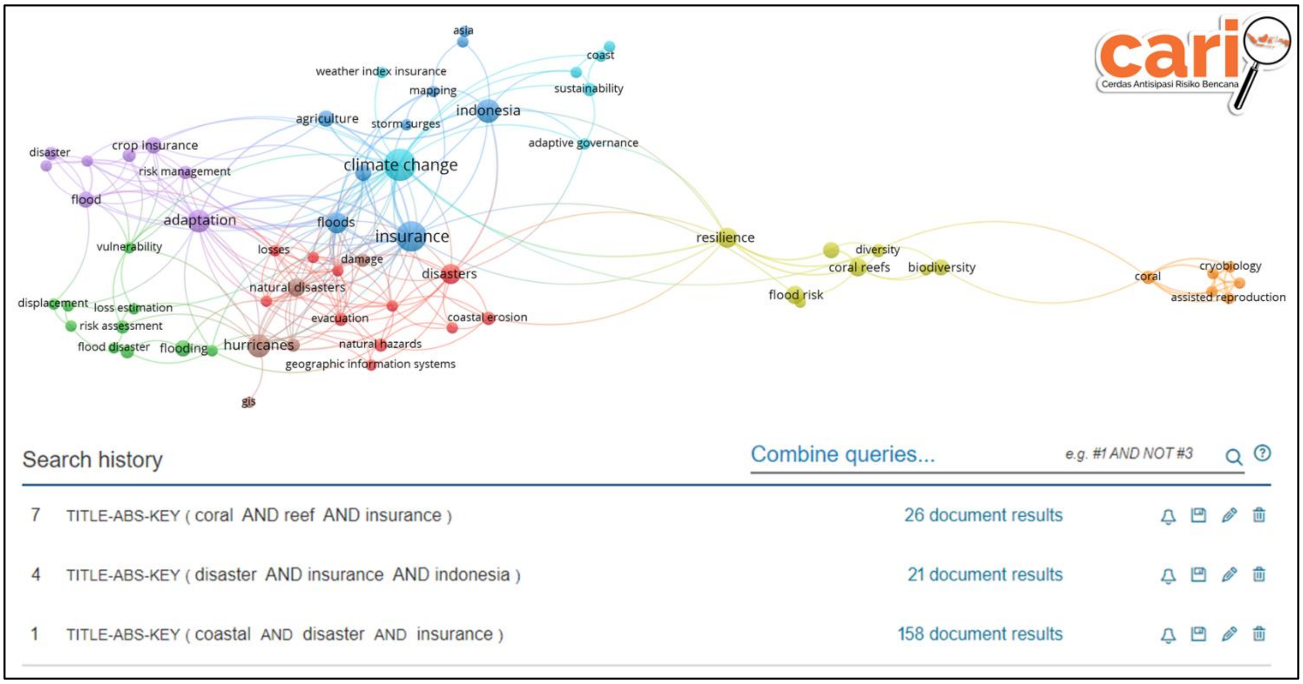
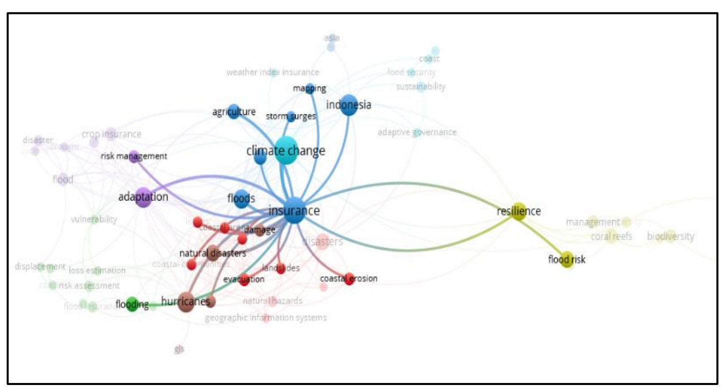


Figure 5 Knowledge Network on Disaster Risk, Coastal, and Insurance.

When the analysis above is focused on the term "insurance", the research topic on disaster management and insurance still has some distance in terms of the discourse in relation to other themes such as coral reefs and biodiversity. In particular, clustering coral reefs and biodiversity has a bearing on disaster



insurance when it is placed in the context of flood risk and increased resilience to climate change.

One of the key studies describing the development of disaster insurance products in Indonesia (Soetanto, et al., 2020) examines DRR financing at the local government level, barriers to the adoption of disaster insurance, and the presence/absence of education and policies that enable the transformation of reactive DRR to be proactive. In general, the research confirms that local governments are still too dependent on On-Call Budget (*Dana Siap Pakai*) and rehabilitation-reconstruction financing which are often late. Also, there has not been any significant adoption/purchase of disaster insurance products. This is due to several obstacles in terms of governance, culture, ability to pay, lack of awareness and knowledge of disaster insurance products, and low trust in disaster insurance management in Indonesia (Soetanto, et al., 2020).

Based on the rapid SLR, it is known that the development of insurance products for coral reefs in particular, or coastal hazards in general, needs to learn from the development of drought protection in the agricultural sector, specifically in relation to Climate Change Adaptation (CCA) efforts, both in Indonesia and globally. One of them is the usual use of the regional climate model (RCM) output, the use of the Standard Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI), which are combined with the GIS application for the designation of drought insurance products (Hohl, Jiang, Tue, Vijayaraghavan, & Liong, 2020). One of the agricultural insurance program schemes (for rice commodities) has an insurance indemnity of 6 million rupiah per hectare for one planting season, with a premium set at 3% (Pasaribu & Sudiyanto, 2016). The insurance payment scheme itself is borne 80% by the Government (in this case the Ministry of Agriculture) and 20% by farmers. In addition, farmers who buy this insurance product must also follow agricultural practice guidelines, as a term/condition for their participation in an insurance scheme that protects from flood, drought, pests, and plant diseases. One of the good factors of this program is the partnership between the government as regulator, insurance company, and farmer groups.

However, in another case in Indonesia, the existence of a technical basis for calculating risk index and insurance premium does not mean that it will immediately lead to willingness-to-pay for insurance products from the exposed community groups (Suryanto, Daerobi, & Susilowati, 2020). The absence of this action still occurs even though there is additional knowledge and changes in the community's risk perception (Fadhliani, Yustika, Nugroho, & Hamid, 2019). This shows the importance of socio-technical-political-economic understanding of disaster insurance product formulations. More specifically, the role of farmer groups and cooperatives has a documented role in increasing the willingness to buy agricultural insurance products (Lopulisa, Rismaneswati, & Suryani, 2018), and it may also apply to the context of fishermen. In the context of financing for climate change adaptation, insurance concepts and schemes are often combined with micro-financing for the entire agricultural sector chain (Budiman, Takama, Pratiwi, & Soeprastowo, 2016).

A study related to insurance that already exists in the study area, namely in Bali, which describes the analysis and utilization of air electricity observation data (i.e., lightning detector) available at BMKG Denpasar for the purposes of analyzing lightning strike patterns recorded by cloud-to-ground (CG) by sensors and comparisons with satellite imagery (Pramana & Negara, 2017). The CG lightning strike data provides evidence on direct impact on human life from a lightning strike. Spatial mapping is good in determining the location of the CG strike on insurance claims. Based on this research, it was found that medium-scale weather phenomena such as tropical cyclones and changes in the Nino 3.4 Index greatly affect the lightning strike activity in Bali region. In the rainy season, the lightning chart shows a semidiurnal pattern with two peaks in the afternoon and early morning. During the transition season, the graph of the peak of the lightning strike in the early morning weakens so that a pattern of one diurnal peak appears. Meanwhile, in the dry season the lightning strike graph shows a random pattern.

Disaster insurance schemes and programs have started to be applied for the context of flood risk, such as those analyzed for the cases of the Bengawan Solo Watershed (Kawanishi & Mimura, 2015) and Citarum (Sidi, Mamat, & Sukono, 2017). Kawanishi & Mimura (2015) conducted an analysis of the eligibility level of weather index-based insurance through correlation and statistical tests of the monthly harvest data of 29 regencies / cities along Bengawan Solo with rainfall, over a period of 10 years. However, they found that the spatial pattern factor determines the flood risk profile more than the weather factor in causing floods. A similar conclusion was drawn in the context of the Citarum watershed after calculating the annual average compensation index, calculating the amount of the premium, and the need for re-insurance for the risk of house damage due to floods (Sidi, Mamat, & Sukono, 2017).

The rapid SLR process also finds research products that specifically analyze basic disaster risk assessments for insurance formulations, especially in the coastal context. This includes some examples from Australia (McCook, et al., 2009), South Africa (Attwood, Harris, & Williams, 1997), the Philippines (Beck *et al*., 2018; McCook *et al*., 2009), Indonesia (Beck, et al., 2018), Cuba (Beck *et al*., 2018), Malaysia (Beck *et al*, 2018), Mexico (Beck *et al*, 2018; Rugero, *et al*, 2019), Papua New Guinea (McCook *et al*, 2009), and countries in the Pacific (Horn, 2009). Beck *et al* (2018) conducted a global meta-analysis to evaluate the benefits of protecting coral reefs against flood risk. The study concluded that the magnitude of the annual damage due to flooding will be doubled and the costs of routine storm events will be tripled in the absence of coral reefs. Furthermore, in 100-year recurring storm events, the estimated flood damage could increase by 91% / 272 billion USD without coral reefs present. Across countries, it is estimated that the following countries will benefit significantly from sound coral reef protection and management: Indonesia, the Philippines, Malaysia, Mexico, and Cuba; estimated savings in annual flood costs of around USD 400 million for each country (Beck, *et al*., 2018).

As noted in Section 1.1, this study pay more attention to the notes and products of research related to the experience in Quintana Roo, Mexico. The formulation of insurance products in Quintana Roo is specifically carried out to protect the tourism sector, which generates foreign exchange amounting to 10 trillion USD. Quintana Roo's coral reef protection and insurance products are recognized as natural protection against floods caused by hurricanes. The benefits considered from this insurance product are for the community, buildings, and hospitality infrastructure. Since the insurance product was rolled out, protection from coral reefs protected 43% of the damage caused by Hurricane Dean in 2007. It is estimated that currently it directly protects disaster risk for 4.3% of the total coastal communities, 1.9% of built areas on the coast, and 2.4 % of hotel buildings, which per year or expressed in absolute numbers around 4,600 people, 42 million USD of prevention of damage to buildings in built-up areas, and 20.8 million USD of protection of hotel buildings (Reguero, et al., 2019).

At macro level, Rugero *et al*. (2020) underline the importance of increasing resilience through a combination of risk transfer (e.g., insurance) with DRR (e.g., disaster mitigation in general), which are often seen as two different things. This combination can help adapt and integrate environmental affairs with disaster management, as well as create investment opportunities between the public and the private sector in the context of nature-based solutions, especially coral reefs. It is estimated that with conservative assumptions, about 44% of the initial costs of restoration can be paid through insurance premiums in the first 5 years, with benefits of more than 6 times over the next 25 years (Reguero, et al., 2020). Furthermore, it is necessary to consider the determinants of the success of financing for the combination of the steps mentioned above, including project costs, potential risk reduction, insurance structure, exposure to the economy, and interest rates.

2.2 Data Collection Processes of Past Disaster Events

2.2.1 Natural Hazards

Based on the scope of work, CARI! collected the data and information needed from many credible parties, related institutes and ministries. The disaster data is collected through various disaster database engines (such as DIBI, DIBI, UNDRR, ADINET, EMDAT and GLIDE), journal or report studies and media sources. The collected data includes information regarding the historical damages caused by natural hazards, hydrometeorological, and extreme climate events. Furthermore, slow onset events that occurred in coastal communities particularly coral reefs were included. Type of disasters collected data and information from the seven research areas were: earthquake, volcano eruption, flood, coastal surge, strong wind, and tropical cyclone.

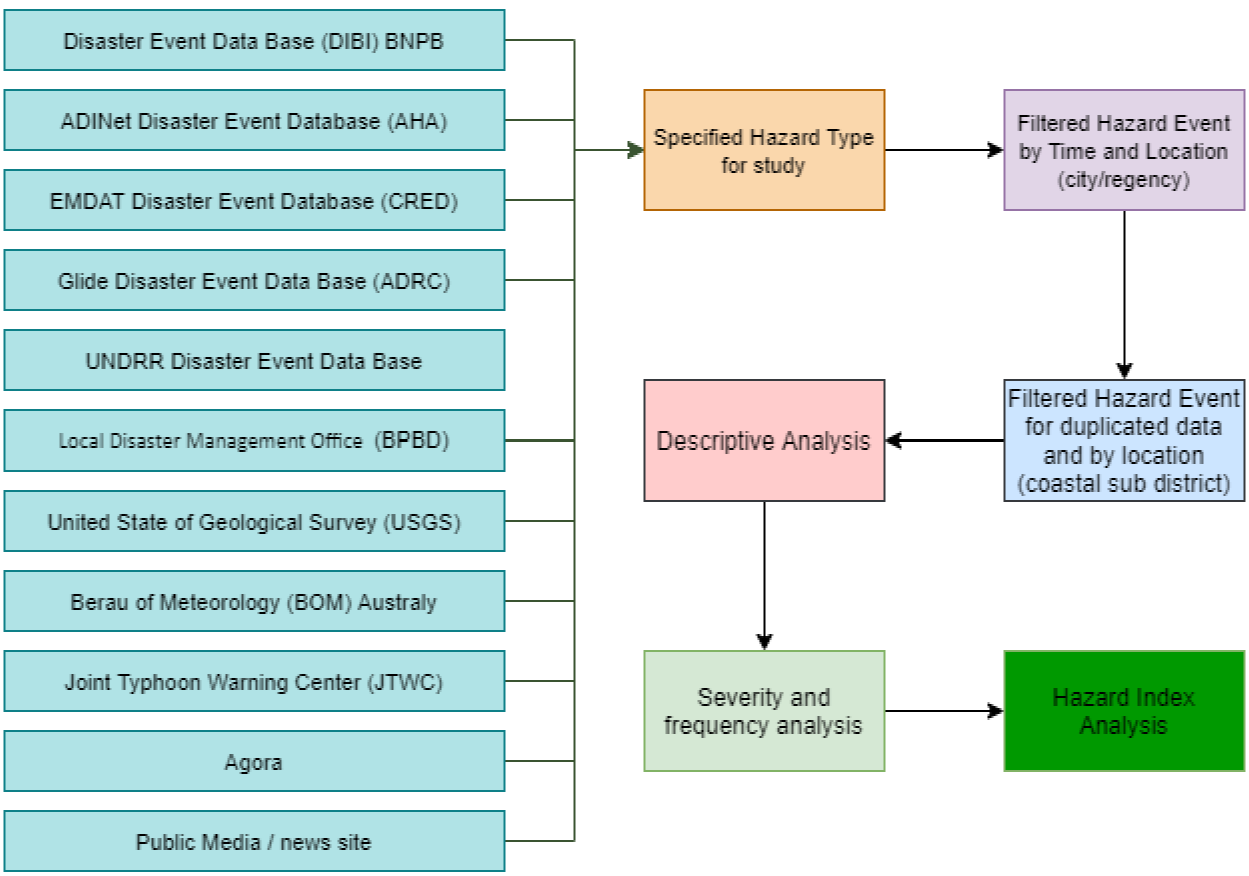


Figure 6 Data Compilation Workflow of natural hazard disaster events

Results from this compiling process are 1) List of historical natural disaster and its impacts and 2) Hazard indexes of natural hazard events in the coastal area based on its impacts (Figure 6).

Natural hazard disaster events that are fairly massive and cause many losses and impacts will always recorded on every existing disaster database. Hence, the data collected for one massive disaster event will also be recorded in various database machines. For example, the Krakatau volcano and tsunami disaster in 2018 will be recorded on various database engines such as DIBI, UNDRR, ADINET, EMDAT and GLIDE. To eliminate unnecessary and incomplete data duplication, CARI! chose DIBI (BNPB) disaster database system as the main reference database for natural hazard disasters that occur in seven study. The DIBI disaster database has a complete data throughout Indonesia from 1815 to 2020, with total data on disaster events recorded throughout Indonesia as many as 33,007 data.

From the various databases that were searched, in the beginnings there were 1,523 total data collected at 7 study locations (Table 1). At this stage, data from various disaster databases have different metadata and need to be put together in the same metadata for suitability of this study hence, it eliminates the events data into 234 events (Table 1). To equalize the metadata, several columns from each database are sampled and selected into the new database. Apart from selecting the relevant columns from each database, the next step is to check the suitability of the location and time that each database has.

Table 1 Comparison of total natural hazard disaster events in seven research location 2000-2020.

Number of disaster events	**Pandeglang**	**Klungkung**	**Makassar**	**Wakatobi**	**Berau**	**Raja Ampat**	**Rote Ndao**
Number of all disaster events**	362	168	328	128	9	86	442
Number of disaster events in coastal area*	107	28	34	23	7	12	23

(*) includes earthquake, tsunami, volcano, flood, strong wind, coastal surge, dan tropical cyclone.

(**) in broader area of study locations which includes earthquake, tsunami, volcano, flood, strong wind, coastal surge, tropical cyclone, drought, landslide, and other type of hazard recorded in DIBI.

However, not all the natural hazard disaster in the database has recorded losses or damages data. From prior databases engines sources, details of impact and damages of natural hazard disaster were already unrecorded. This is probably, due to mis informed data recording or data losses. Hence, in the filtration process, data need to be verified particularly about the losses, damages, deaths, severed population and relocated population. Furthermore, in the next step, this study will verify with hazard factor and the record of the natural events with or without the disaster occurrences.

As a metadata, this study selected and determined columns from the existing disaster databases sources into new disaster database for YKAN. The data also needs to be crosschecked to match into the proposed seven locations and within time range of the study. Detail of the corresponding metadata for disaster database in this study is shown in Table 2 below.

Table 2 Table header for YKAN disaster database events.

No.	**Metadata**	**No.**	**Metadata**
1	No	20	Injured
2	No Data	21	Missing
3	ID Disaster	22	Affected People
4	Event	23	Displaced
5	Event Name	24	Damaged houses
6	Event date	25	Education Facilities
7	Year	26	Health Facilities
8	Month	27	Buildings (Offices, markets, factories, and other non settlement buildings)
9	Day	28	Public and Social Facilities
10	Hazard Latitude	29	Impacted Roads
11	Hazard Longitude	30	Affected Infrastructures
12	City/Regency	31	Loss of Livelihood (Paddy Field Area (ha))
13	Sub-district	32	Loss of Livelihood Plantation Area (ha)
14	Village	33	Loss of Livelihood Fish Pond Area (ha)
15	Impact Latitude	34	Loss of Livelihood Irrigation (ha)
16	Impact longitude	35	Total Loss of Livelihood (tot)
17	ID Village	36	Damages Losses Estimation (IDR million)
18	Impact area (ha)	37	Hazard detail
19	Fatalities		

In the following analysis, each parameter in Table 2 above help to assess and analyze the severity of every disaster events. Column *No. Data* and *Disaster ID* are information regarding database numbering. *Event* column explains type of hazard, which mainly divided into two categories that is geological or hydrometeorological event. While the *Event Name* is the name of the disaster event. *Event Date* followed by column, *Year*, *Month* and *Day* gives information regarding the time of disaster events and the beginning of the disaster events. The duration of each disaster events lies in the column of hazard detail, which annotate all available information during the disaster event.

The next column is the hazard source coordinates (*Hazard Latitude/Longitude*) which are the epicenter of the hazard. While the column of *City/regency, District*, and *Village* explain the affected area of the disaster and impact coordinates (*Impact Latitude/Longitude*) gives information about approximate impact area that is represented by a single coordinate. Information regarding impact area (if any) is given in column 18 to illustrate the size of impacted area. *Village ID* is the national code for regional identification number.

Differences in coordinate between source and impacted area is useful to separate specific hazard disaster such as earthquake, far field/regional tsunami, volcano eruption and tropical cyclone which sometimes occurred in different area but have an impact in the study sites.

As for the rest of the parameters, column 19 (*Fatalities*) through column 36 (*Damages Losses Estimation*), gives information regarding the specific impact of each disaster onto communities lives or assets.

2.2.2 Anthropogenic Hazard

Destructive human activities can ultimately disrupt environmental equilibrium and cause damage to ecosystems that are difficult to repair. Information which indicate historical direct damages caused by human activities which make coastal communities suffered and damages the ecosystem, particularly coral reefs is regarded as anthropogenic hazard. In this study, destructive anthropogenic hazards are focused on activities that destroy coral reefs. As previously mentioned, these activities include destructive fishing, marine accidents and oil spills. Destructive fishing exist occurs as a result of a combination of an underequipped fishers and missing knowledge of the benefits of good marine ecosystem. While, the causes for marine accident such as ship grounding can be on purposes such as loading and unloading activities or it can be not on purpose such as an accident (Mzaheri, Montewka, & Kujala, 2014). This study also considers the growth of coastal communities and marine tourism which directly increase human activities in the marine area which also increasing the traffic intensity of the ship.

Human population, which is generally located in coastal areas, requires high carrying capacity to survive. The carrying capacity includes connectivity and resources. Populated coastal environment, with its strategic location, has a high connectivity between communities and this high level of movement requires a very large amount of energy resources. In turns, this activities possess a threat to environment especially, in this study, a threat towards coral reefs ecosystems. The growth of coastal areas cannot be separated from shipping activities. The growth of coastal areas requires shipping support facilities such as ports and very important fuel storage facilities. Threat from shipping and fuel (oil) infrastructure includes ships grounding, sinking ships and marine pollution from oil and human activities. Based on that fact, the higher number of human activities on coastal and ship traffic the higher the threat potential to coral reefs.

The shipping lane traffic data comes from the marine traffic website (https://www.marinetraffic.com/) reanalysis, while the oil infrastructures data comes from the Ministry of Energy and Mineral Resources Republic Indonesia. This report adapted WRI study in 2011 which utilize 5% of every ship traffic intensity for every port as a threat to the coral reefs ecosystem and use a 0-4 km radius from every oil-related infrastructure as a threat to the coral reefs ecosystem. The threats potential is different due to the probability of its occurrence. The ship traffic intensity are diverse and dynamic, thus various fishing activities give a high threat probability to the marine ecosystem instead of the oil spill. While oil spill is rarely happening due to its high environmental safety standard procedures possessed by every oil companies in its infrastructure.

By constructing the matrix of the number of disasters caused by human activities along with its potential threat in the research area this study has succeeded in analyzing events which could cause anthropogenic disaster in the seven study location. Result of this analysis is also shown on the map of the anthropogenic disaster event in the annexes. The data and information utilized in this study is provided by YKAN and other working partners.

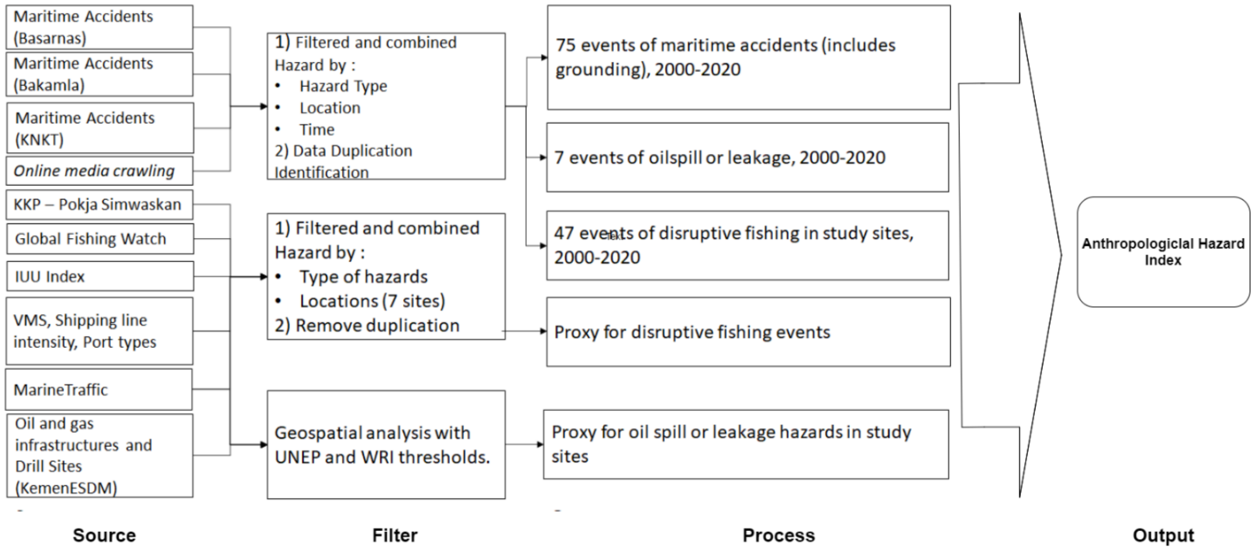


Figure 7 Compilation process of disasters events database cause by anthropogenic hazards.

Figure 7 illustrates about the compiling and integrating process from all data sources to become an anthropogenic disaster events database in seven locations of the research area.

2.2.3 Slow Onset Hazard

Slow onset or long-term natural hazards is triggered by environmental degradation that occurs slowly and accumulatively over long period of time. Climate change generally causes two types of hazards in the coastal sector, namely coastal inundation and coastal instability related to the process of abrasion / erosion and coastal accretion / sedimentation. The danger of climate change in coastal areas is related to many other sectors or sub-sectors, such as transportation, marine and coastal tourism which affects the comfort of traveling and building on the beach. Thus, climate change is disrupting the environment in which coral reefs are in a long process.

This study analysis the dangers of slow onset (long term) changes in the climate, such as rising sea surface temperatures and rising sea levels, which will have a broad and massive impact on marine ecosystems such as coral reef ecosystems and eventually on coastal communities. With the disturbance of these environmental factors, the growth or development of coral reefs can be disrupted for a long range of time while immediate natural disasters such as earthquakes, tsunamis, storm surges and volcanoes change rapidly the coral reef environment. The coral reef ecosystem is an ecosystem that is located in an area with underlying support of environmental factors such as warm, clear water that has a high level of sedimentation and is still under the influence of sunlight. In further analysis, this study review and analysis scientific literature to observe and analysis past or ongoing research in 7 study sites regarding slow onset hazards, especially sea surface temperature conditions in each site.

2.3 Risk Analysis

2.3.1 Risk Analysis and Valuation Methodology

Disaster could be defined in various ways and in various level of analysis. This also means, that some disasters often affected every location differently, a local disaster in a village may not have an impact on a nation as whole. These "dimensions" of disasters need to be addressed respectively with consideration in the uniqueness of each region. Risk assessment is a methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods, and the environment on which they depend.

By investigating disaster risk, the potential losses in each region could be minimize over a planned future period. The following equation is used in this assessment to quantify the risk.

$$R = H \; X \; V$$

Disaster Risk Assessment is carried out by calculating the hazard, vulnerabilities, and capacities components in each province and district / city. Hazard components are natural phenomena that can cause disasters. The components of vulnerability are (1) physical condition, (2) socio-cultural, (3) economy, and (4) environment prone to disaster. Meanwhile, the capacity component consists of regional resilience elements such as institutions, mitigation capacity, prevention, and others. In the risk index, the level of disaster is assessed based on its constituent components, namely danger, exposure, and the capacity of the government and community in dealing with disasters. This study uses risk index to quantify the magnitude of the risk. The risk index level based on the potential loss above allows for calculation disaster risk reduction efforts in an area.

In this study, coastal area at risk is to be calculated, using results of hazard or vulnerability, which varies independently by the available data. Some area that has minimum data or not affected by the hazard are given an index of zero (0). By using zero (0) for indexes, in later calculation, by using simple formula above, the risk index would also become zero. These zero indices, however, does not mean it does not have any risk. Zero index is present due to there are no inundation provided by the hazard maps, however its vulnerability is still presence. Thus, all in all, a potentially minimum risk still applied to the area with a designated risk index 0.

As per scope work, a monetary valuation is required for both past disaster events and future risk. The valuation is undertaken by combining the steps of the Indonesian version of post-disaster needs assessment (Head of BNPB Regulation 15/2011 Damage, both the modules and applied unit costs as the proxy)[4] and Step 4.3 of TNC's own BlueGuide (The Nature Conservation, 2020). Specifically, the following steps have been taken:

1. Damage and loss data validation from the disaster event database for twenty years, divided into two periods, i.e., 2000-2010 and 2011-2020.
2. Aggregation of available damage and loss data, based on hazards type.
3. Estimation of the monetary value of damage and loss types for each hazard. This step used unit cost from the Jitupasna's calculator deployed in the 2018 Central Sulawesi Earthquake and Pandeglang Tsunami. For major disasters where BNPB's released a specific **JITUPASNA** Report, the damage and loss figures were adopted, e.g., the 2018 Krakatau Tsunami affecting Pandeglang.
4. Calculation of past damage and loss monetary valuation as well as future scenario using BlueGuide.

The caveat of this step was disaster events have asymmetric and different damage and loss data availability. BNPB's Jitupasna estimation only available after 2011, and not all disasters have been measured systematically using the tool. Prior to 2011, only disasters with deployment of recovery experts (e.g., from UNDP or development banks) have reported the damage and loss data. Unfortunately, until now, there is also no reliable sources to estimates damages and losses of the environments from each disaster. In addition, it should be noted that the consolidated databases have various meanings in terms of degree of severity of damages, e.g., only in some databases and in recent years disaster event entries clearly disaggregated between affected, damaged, and destroyed houses. Therefore, this risk monetary valuation should be treated as a gross figure.

The table below (Table 3) describes the availability of disaster damage data and losses in each location.

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[4] See here: https://bnpb.go.id/produk-hukum/peraturan-kepala-bnpb/peraturan-kepala-bnpb-no-15-tahun-2011

Table 3 Damage and Loss Data Availability within Disaster events database 2000-2020.

Location Damage & loss type	Pandeglang	Makassar	Klungkung	Wakatobi	Berau	Raja Ampat	Rote Ndao
Housing	Available	Available	Available	Available	Available	Available	Available
Roads	N/A	N/A	N/A	N/A	Available	N/A	Available
Bridges	N/A	N/A	N/A	N/A	N/A	N/A	N/A
School building	Available	Available	Available	Available	Available	Available	Available
Health facilities	Available	Available	Available	Available	N/A	N/A	N/A
Place of worship	N/A	N/A	Available	N/A	N/A	N/A	N/A
Office buildings	Available	N/A	Available	N/A	Available	Available	Available
Government buildings	Available	N/A	N/A	N/A	N/A	N/A	N/A
Paddy fields	Available	Available	N/A	Available	N/A	N/A	Available
Pond	N/A	N/A	Available	N/A	N/A	N/A	Available

2.3.2 Hazard Analysis Methodology

Natural Hazard analysis calculation is based on spatial probability, frequency, and power (magnitude) of a natural hazard phenomenon. In this study, the magnitude of natural hazard disaster is represented in severity level. From collected data, details of data gives more accurate hazard analyses. For risk assessment analysis in each study site, natural hazard parameters will be translated into a hazard index shown as:

$$HI = \sqrt{FI * SI}$$

Where: HI = Hazard Index

FI = Frequency Index

SI = Severity Index

The Frequency Index comes from the summation of occurred disaster events in one district in the research time frame (2000-2020) to quantify its frequency, this data is translated into an index from 0-1 as Table 4 shows below:

Table 4 Frequency Index.

Events Frequency	Frequency Index
0	0
1-5	0.2
6-10	0.4

Events Frequency	Frequency Index
11-15	0.6
16-20	0.8
>20	1

Severity index comes from the losses and damage induced by disasters in each districts, development of severity index comes from each parameter from Table 2 in column 19 -36 and summarized into five main severity parameters for each district in the research time frame (2000-2020):

1. Total fatalities and missing
2. Total affected people
3. Total displaced
4. Total estimation of Economic losses
5. Total damaged infrastructure

Due to variation of information data collected in each disasters database engines, each subdistrict in every districts in the seven study location have different quality of data. Not all of losses and damaged data in each subdistrict is well recorded. To quantify its severity, for each fulfilled parameter from number 1 to 5 is translated into an index from 0-1 similar with frequency indexing. If one disaster in one subdistrict haves all parameter from 1-5 the given index is one, whilst if one disaster does not have a well recorded loss and damages its index is nol. From frequency and severity index, hazard index as formulated above is developed as shown by Table 5 below. Results of hazard index will then be used to calculate risk index to develop risk profile for every district.

Table 5 Example of Hazard Index Table.

District Name	Events Freq	Freq Index	Severity					Severity Index	Haz Index
			Fatalities / missing	Affected people	Displaced	Economic losses	Impacted Infras		
District A	0	0.2	100	-	-	-	-	0.2	0.20
District B	13	0.6	1	1000	10000	200000	400	1	0.77
District C	28	1	5	1000	-	-	-	0.4	0.63

Similar index method is also used to quantify anthropogenic hazard analysis. The collected anthropogenic hazards were divided into three type of anthropogenic activities, namely: 1) destructive fishing; 2) Marine Accidents; 3) Oil spill. Anthropogenic events probability is then use as weight to determine the anthropogenic hazard index (henceforth called AHI) as seen in table 4 above. Weights of AHI probability is calculated by calculating frequency of hazard in each subdistrict during the last 20 years and divide it with its total occurences in all seven location. From this weight (probability) values, anthropogenic hazard index is calculated by summation of number each anthropogenic of events times its weight events as seen in Table 6 below. The resulting value of weight events summation is then normalized to 0-1 index for simplication in analysis.

Table 6 Example of Anthropogenic Hazard Index table.

District	Num of Destructive Fishing events	Num of Marine Accidents events	Num of Oil Spill Events	Anthropogenic Hazard Index
District A	1	0	0	0.11
District B	0	0	0	0.00
District C	2	0	0	0.22

2.3.3 Vulnerability Analysis Methodology

Among the three risk components, the hazard component is a component which is very unlikely to be diminished due to the nature of the hazard. For example, until now, an earthquake is highly unlikely to be predicted in regard of its time or its magnitude. Thus, the only possible way to minimize risk is by reducing the vulnerability component. Vulnerability is divided into three indicators, namely **Exposure**, **Sensitivity**, and **Adaptive Capacity**. The formulation of vulnerability in this study is calculated as:

$$V = \frac{E\ X\ S}{AC}$$

Where:

V = Vulnerability

E = Exposure

S = Sensitivity

AC = Adaptive Capacity

A. Exposure

Exposure represents the degree of which an area is affected by the climate change variability or coastal disaster. This study adapted Coastal Vulnerability Index (CVI) analysis as an exposure index which was conducted by the Ministry of Marine Affair and Fisheries (Bappenas, 2018). Coastal Vulnerability Index was initially introduced by the United States Geological Survey (USGS) in 2001. It was used to map the relative vulnerability of the coast to future sea-level rise. The CVI ranks coastal instability, mean tidal range, and mean significant wave height in terms of their physical contribution to sea-level rise-related coastal change. This approach combines the coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions.

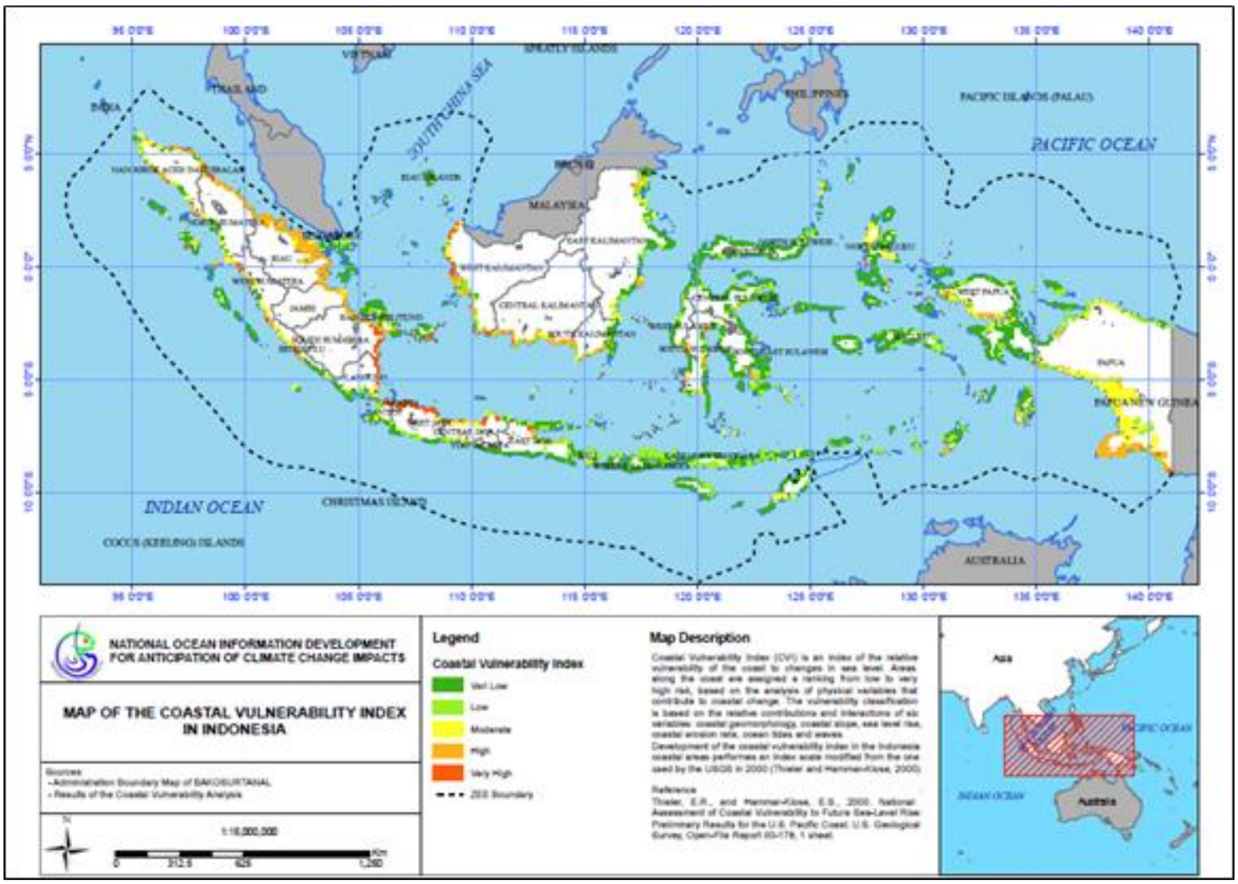


Figure 8 Coastal Vulnerability Index Map (MMAF in Bappenas, 2018).

In this context, the results of the CVI represent the physical vulnerability of the coastal areas as well as hazards. The CVI is calculated along the coastline of Indonesia which are then classified into 5 classes from very low to very high (Figure 8).

To give context, Table 7 Example of Exposure Index Adapted from CVI Bappenas 2018 below shows an example of Pandeglang coastal subdistrit class, ranked on a linear scale from 1-5 in order of its increasing vulnerability. In this study, a value of 1 represents the lowest level of vulnerability, while 5 represents the highest level of vulnerability. This value is then transformed into an index ranging from 0 to 1 to be used for comparison with the hazard index and risk index.

Table 7 Example of Exposure Index Adapted from CVI Bappenas 2018.

District Name	CVI Index	Exposure Index
District A	1	0.2
District B	3	0.6
District C	2	0.4

B. Sensitivity

Another important aspect of the vulnerability analysis is the sensitivity, which explains how much the system is affected by the climate variability or change (IPCC, 2014), in both direct (e.g., uprooted coral reef substrate by the earthquake vibration) or indirect effect (e.g., coral bleaching by the El-Niño Southern Oscillation events). Sensitivity was also described as tendency/degree of elements at risk that can come to any harm as a result of the hazard (Birkmann, et al., 2013). Similar to that of exposure, parameter scoring was done prior to the calculation of the sensitivity index. There are four main aspects to be evaluated in the sensitivity scoring calculation; Social, Physical, Environment, and Economy (Table 8).

Social aspect explains the degree of socio-demography that is affected by the hazard, which includes the population profile and the education level of an area. Here, a total of four indicators were calculated and normalized, where the population density indicator holds the highest weight. Unlike the exposure scoring steps, all the score in the sensitivity calculation was normalized from the start. In such case, for example, the number of populations for all districts within a city/regency were statistically analyzed and scored each by the degree of normality (0-1) where 0 and 1 account for the least and the most prone area, respectively. The same goes for population density (number of populations compared by the district area), sex ratio (number of males compared to females), and the education level. Specifically, for the education level, only a number of populations that have completed the high school level were assessed. For the rest of the indicators, the normalized score was calculated from the percentage of them by the number of populations.

Physical aspect assesses the number of important infrastructures found in the study area, such as health and education facility. Building density for each district, which will also be used in the scoring of environment aspect, was calculated by comparing the total building area with the following district area.

The same goes with the number of buildings. As large settlements has many buildings or homes thus building density weighted the most, followed by the length of road, while the number of airports and harbors/ports weighted the least.

Environment aspect covers the extent of a land coverage affected by the hazard. The building density that was calculated from physical aspect will be used in the developed area calculation, along with the reclamation area and the percentage of settlement area per sub district area. The rest of the indicators were made into percentage over the district area and normalized directly. Among the eight indicators listed, building density and settlement area topped the weight, followed by reclamation area.

Economy counts the Gross Domestic Product (GDP) of the productive area and the number of economic centers in the location of study. The GDP scoring for each district based on the value of total GDP in the city/regency divided by the district area. Economy aspect also includes Tourism and Fisheries GDP calculations, which account as the highest weight in the economy Index. The rest of the indicators were normalized directly before weighted for the final score of economy aspect.

Table 8 Element classification for Sensitivity Index.

<table>
<tr><th></th><th>Element</th><th>Indicator</th><th>Description and Unit</th></tr>
<tr><td rowspan="5">Social</td><td rowspan="5">Sosio-demo-graphy</td><td>Population</td><td>Number of Population</td></tr>
<tr><td>Population Density</td><td>Population Density</td></tr>
<tr><td rowspan="2">Demography Structure</td><td>Elderly and underage group</td></tr>
<tr><td>Sex Ratio</td></tr>
<tr><td>Education Level</td><td>Education Level</td></tr>
<tr><td rowspan="7">Physical</td><td>Building</td><td>Building Density</td><td>Building (Ha)</td></tr>
<tr><td>Road</td><td>Road Availability</td><td>Length of road (km)</td></tr>
<tr><td rowspan="5">Critical Facility</td><td>Health/Medical Facility</td><td>Number of Health Facility (Hospital, Puskesmas/Poliklinik)</td></tr>
<tr><td>Education Facility</td><td>Number of Education Facility (Elementary to Higher Education)</td></tr>
<tr><td rowspan="2">Accessibility Facility</td><td>Number of Port/Harbour</td></tr>
<tr><td>Number of Airport</td></tr>
<tr><td>Energy Related Facility</td><td>Number of Oil Depot/refinery, Power plants</td></tr>
</table>

	Element	Indicator	Description and Unit
	Lifeline Facility	Electrical Facility	Number of Power Substations (*Gardu Induk*)
		Clean Water Facility	Number of Water Processing Facility (*PDAM/Mata Air*)
		Telecommunication	Number of Communication Tower and transmission/receiver station
Environmental	Land Coverage	Developed Area	Building Density (Ha)
			Settlement area (Ha)
			Reclamation (Ha)
		Under Developed Area	Marshes and or Mangroves (Ha)
			Forest area (Ha)
			Coral Reefs (Ha per regency, divided by subdistrict area)
			Fields and unoccupied land (Ha)
			Bush and shrub (Ha)
Economy	Productive Land Area	Productive land area	Paddy Field Area (Ha)
			Plantation Area (Ha)
			Fish Pond (Ha Rp)
			Seasonal Horticulture crops area (Ha)
			Mining (Ha)
	GDP of Productive Sector	GDP of Productive area	GDP (Billion Rp)
			GDP of Tourism (Billion Rp)
			GDP of Fisheries (Billion Rp)
	Economic Centers	Mall, Markets	Number of tourism sites
			Number of markets/Mall

The final sensitivity index was calculated using the vulnerability scoring approach provided by IRBI BNPB for geological and hydrometeorological hazard score. The coefficient for each of the aspects were; 0.4 for social, 0.25 for physical; 0.25 for environment; and 0.1 for economy. As seen by the scoring weight, the social aspect holds the most in the sensitivity index, thus having a large number of populations can solely increase the sensitivity of an area. Thus, the higher the sensitivity index, the more attributes can be affected by the hazard, resulting in the higher vulnerability index for the area.

Data for each of the indicators were coming from different sources. *Yayasan Konservasi Alam Nusantara* (YKAN) provide most of the data and thus were used a lot in sensitivity index. The study also used some dataset from Geospatial Information Agency (*Badan Informasi Geospasial* or BIG), Central Bureau of Statistics (*Badan Pusat Statistik* or BPS), MMAF (Ministries of Marine Affairs and Fisheries), and the Google Maps/Google Earth.

C. Adaptive Capacity

Capacity is a component of risk which refers to the ability of a person or group to act and react in reducing a danger so that there is no big loss. Resilience is a component of risk which refers to the ability of a person or group to be exposed to a hazard, so that they can recover or recover quickly so that they can reduce losses that will occur.

Vulnerability in a community or a region can be reduced through increasing resilience or capacity to cope with a disaster event. Identifying government's abilities to cope with disasters can be done by using an approach with the concept of sustainable living. This can be done by identifying that the government a have a range / ability of assets which can be referred to as 'capital / resources' which forms a buffer layer to protect themselves or groups from a disaster. Further methodology and analysis in accordance with risk assessment could be found in subchapter 2.5.

2.3.4 Overview and analysis of Natural Hazard and Slow Onset hazard

A. Earthquake analysis

Indonesia is surrounded by four main plates, namely the Eurasian Plate, the Indo-Australian Plate, the Philippine Sea Plate and the Pacific Plate. Of the four main plates, there are also small plates that are formed due to the movement of these main plates. As a result of these tectonic movement processes, earthquake events often occur in most parts of Indonesia. One of the sources of the earthquake that has been clearly identified is the active subduction zone in the western to eastern parts of Indonesia. The energy from the collisions between these plates will result in faults on land or oceans in several Indonesian islands and seas.

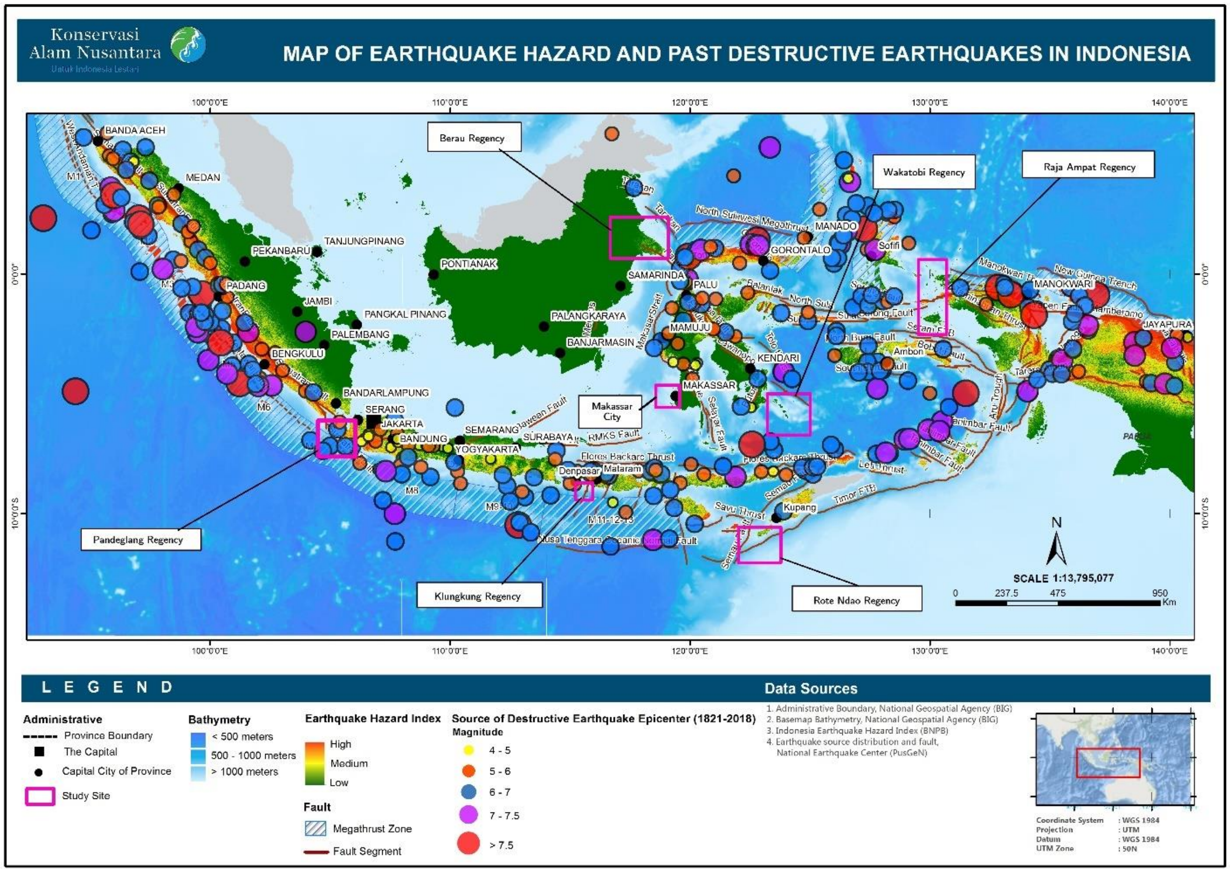


Figure 9 Destructive earthquake events in Indonesia from 2000 to 2020 (Analysis, 2021).

Therefore, it is well understood that the Indonesian archipelago is an earthquake prone area as seen in Figure 9 above. The earthquakes that occur are often destructive and cause harm to the community. In coastal communities, the impact of earthquake shocks on coastal areas is often more pronounced due to the condition of the area which often lies on an alluvial plain. Such plain condition can be found in the study areas of Makassar, mainland Berau, mainland Klungkung and Pandeglang. Tsunami also often occur as a results of a specific earthquake mechanisms that can sweep the entire coastal area if the tsunami is large enough, as occurred previously in the 2004 Aceh tsunami. Other than losses and damages for communities, earthquakes can also cause damage to coral reefs, Moreover, vibration effect of the seabed could break the corals easily, especially hard and firm corals and branching corals. These type of corals absorbs the vibration energy which fragmented and break down corals to pieces. Whilst due to its physical characters, soft coral is able to absorb vibration energy by its elasticity. (WWF Australia, 2009); (Prayuda & Avianto, 2017); (Tito & Ampou, 2020). In general, coral destruction due to earthquake which could occur according to two main causes of damage, namely:

1. Mechanical Damage: Many of the problems caused by tsunamis and earthquakes are caused by mechanical damage to the corals. Coral that break off from earthquake action is caused by uplift or downlift of the main seabed in which coral reef resides. The movements in seabed or the base of the reef could uprooted coral reefs breaks off in pieces. Some corals, such as brain corals, are more susceptible to mechanical damage than many other species of corals. Movements in uplift/downlift of the seabed could cause changes in coral reef depth. Uplifted seabed could lift coral reef above the water surface which would exposed it direcly to the sun, while downlift of the seabed could cause coral reef to be out of reach from the sun, preventing it for photosynthesis. The seabed movement could also trigger changes in sedimentation which lead to increased turbidity.

2. Damages Due to Changes in Sedimentation and Turbidity Processes: Mechanical damage to coral reefs during tsunamis and earthquakes causes an increase in coarse sedimentary material from broken corals and uprooted soft benthic organisms as well as a redistribution of existing sediments A decrease in sedimentation can also be problematic, because a lack of sediment can also deprive an ecosystem of the minerals, nutrients and organic matter needed to sustain production. Some corals have the ability to remove sediment from their outside coating, but this puts extra stress on the already harmed corals. One of the main requirements of healthy coral reefs is clear, clean water. This is essential to the important symbiosis between coral and zooxanthellae. The zooxanthellae uses photosynthesis to provide the coral with food. With decreased sunlight, it is harder for the zooxanthellae to produce food, essentially starving the corals. Also, if the corals become stressed from other factors such as decreased salinity in addition to a lack of sunlight, the coral polyp could expel the zooxanthellae, which in turn usually kills it. Earthquakes and tsunamis cause sediment to mix into the water, decreasing the amount of light that can reach the already damaged corals[5].

Earthquake Case Study

Earthquake and Tsunami Aceh 2004

The earthquake and tsunami of Aceh in 2004 was so powerful which shook all of Indian Ocean countries. Such energy and hard vibration could easily break up corals located near the earthquake source. From

[5] https://www.coraldigest.org/index.php/Earthquakes

Reef Check post disaster observation, it is likely that the toppled large coral heads and the large area of broken blue coral seen on reefs along the south coast of Pulau Weh were caused by the earthquakes. The Heliopora skeletons appeared to have been overturned in place. No other causes of such extensive damage were observed in the area such as large tree branches or boulders that could have been rolled across the reef by waves. The most dramatic damage to Aceh reefs was also caused by the earthquakes. Hectares of reef flat at Pulau Bangkaru Island and Simeulue were uplifted to a level above the high tide mark resulting in total mortality of corals and other attached organisms that were previously healthy and intact. Other reports indicate areas of uplift on many other islands (USGS, 2005 in Foster, et al., 2006). Searle (2005) state that Less extensive damage of a similar type was reported in the Andaman Islands (Foster, et al., 2006).

Nias Earthquake 2005

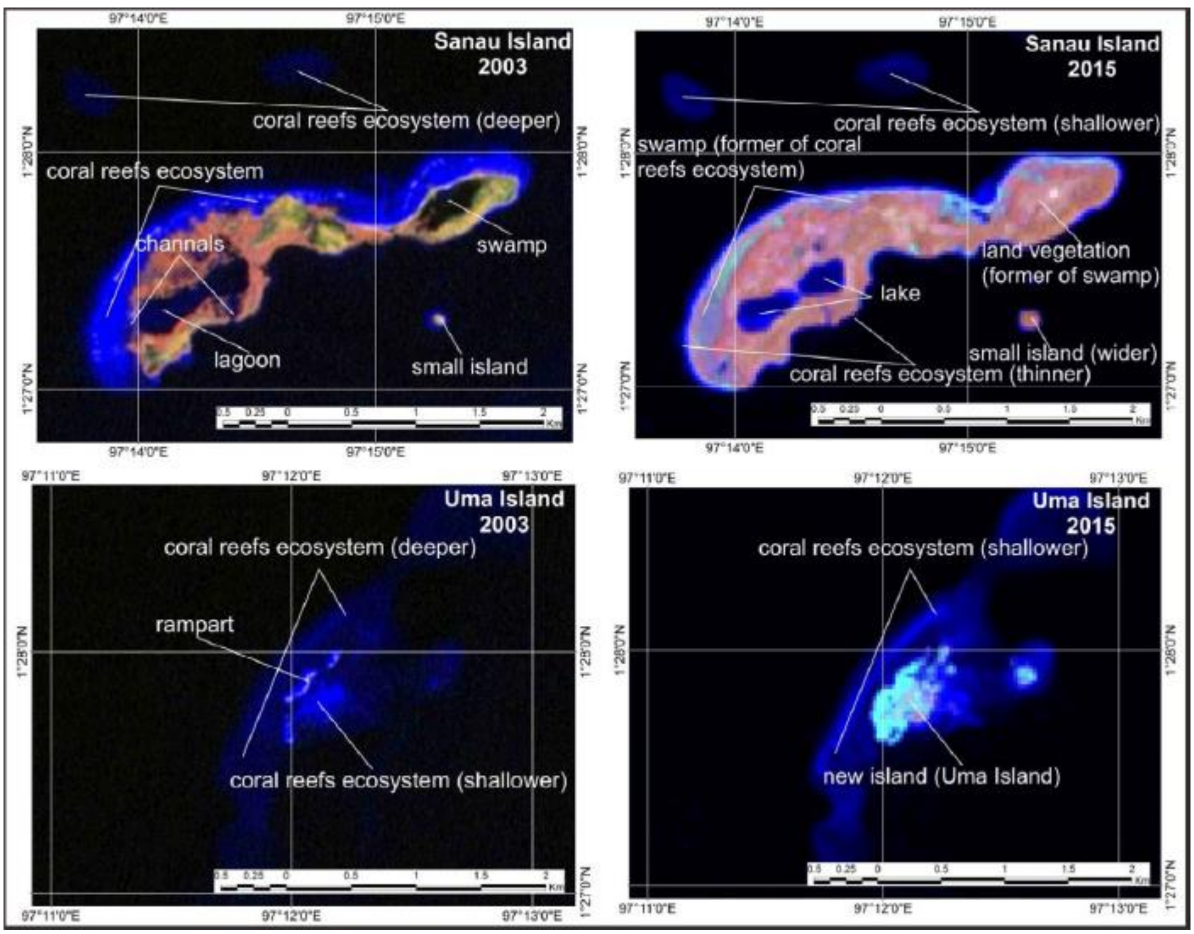


Figure 10 Satellite images of coral reefs and mangroves before and after Nias Earthquake 2005, left: coral reefs ecosystem and mangrove in 2003 (before the quake), right: coral reefs ecosystem and mangrove in 2015 (Suyarso, Prayuda, & Avianto, 2017).

The following year after the great Aceh Earthquake in 2004, located at the south of Aceh Province, Nias and Simeulue Island also experiences very strong earthquake with 8.6 magnitude. The earthquake was strongly felt across the island of Sumatra and caused widespread panic due to tsunami experiences in 2004. Although in Nias earthquake, the tsunami is relatively small compared to the 2004 tsunami. This earthquake also devastated coral reef ecosystem due to changes in enviromental aspect, especially in coastal morphology (Figure 11).

Suyarso and team (2017) explained that the Coral reefs ecosystem in North Nias on pre earthquake is wider than after earthquake (Figure 10). In Lahewa District, coral ecosystems reaches 1300 m wide from the coastline while in East Lahewa, Lotu and Sawo districts are only range in between 25 m up to 350 m. Since the Nias earthquake mostly coral ecosystems, particularly coral with the less than 2.5 m depth has been raised and transformed into the land. The waters north coast of Lahewa District, based on landsat imagery aquired 2003 were small islands surrounded by coral reefs. There are six islands in the area : Island of Sanau, Taliwaa, Makora, Lafau, Gito and Mause. On the Sanau Island, in the pre earthquake there was a lagoon, water mass circulation connected to the open sea through two canals. After the quake, canals were lifted and closed causing this lagoon changed become a saltwater lake with the salinity higher than the salinity of the sea water surroundings (Suyarso, Prayuda, & Avianto, 2017).

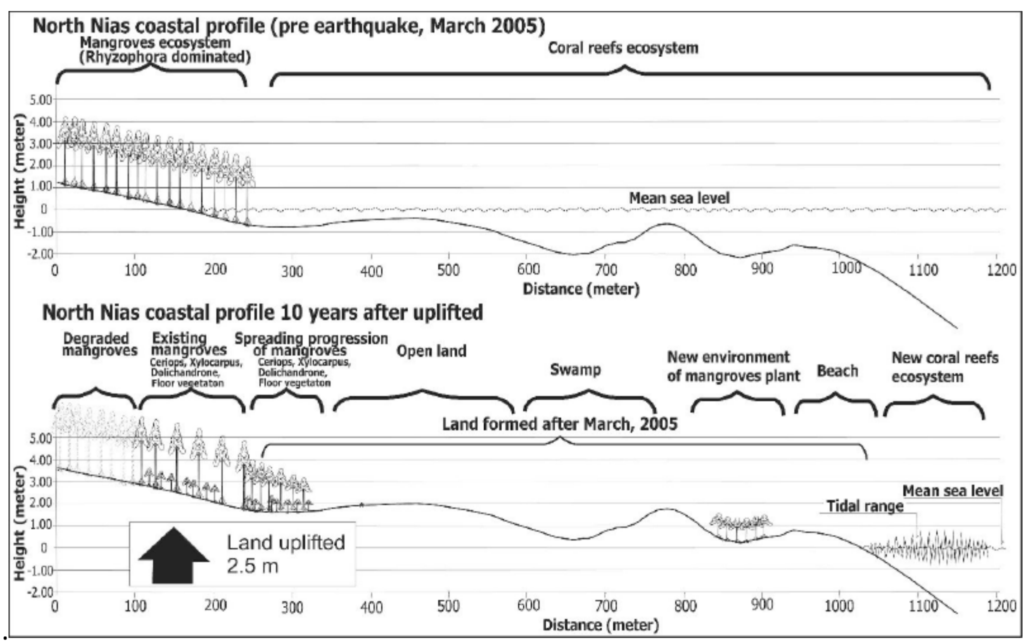


Figure 11 Coastal morphology changes in the west of Lahewa village due to Nias Earthquake, 2005 (Suyarso, Prayuda, & Avianto, 2017).

The Great Blue Hole of the Belizean Barrier Reef

In May of 2009, a powerful magnitude 7.3 earthquake hit Honduras and caused widespread damage as far as the Belizean Barrier Reef. Prior to this event, two dominant species of coral were completely eradicated from other causes but the loss of these species made the young, new dominant coral less resilient to the earthquake's destruction. The earthquake destroyed ten benthic assemblages in the Belizean Barrier Reef and destroyed another by causing avalanching of slopes within the reef. Avalanching of reef slopes is when reef debris attaches to another part of the reef, then breaks apart into many many pieces. The reef is then surrounded by a debris field, consisting of complied reef debris. During the earthquake, benthic organisms were removed and buried by the uplifted sediment. Only sediment and skeletal debris remained afterwards, and the living cover in coral decreased by sixty percent.This catastrophe caused an extreme change in the coral reef's ecology and community, causing widespread damage and dieoff within the reef. Scientists estimated the recovery time of approximately 2,000 years[6].

From literature reviews, this study has determined that earthquake with higher magnitude than 5 (Richter scale) or 4 MMI scale is potentially damaging for coastal communities and the ecosystem as a whole. This type of earthquake (5 SR or 4 MMI) is known to be felt by everyone and could cause minor damage to buildings, which would also potentially vibrate the seabed. From official sources such as BMKG or USGS, this study collects lists of corresponding earthquake hazard in the seven site. This study has collected 338 earthquakes event from 2000 to 2020 with 32 earthquakes affecting the coastal communities in the seven research areas.

[6] https://www.coraldigest.org/index.php/Earthquakes

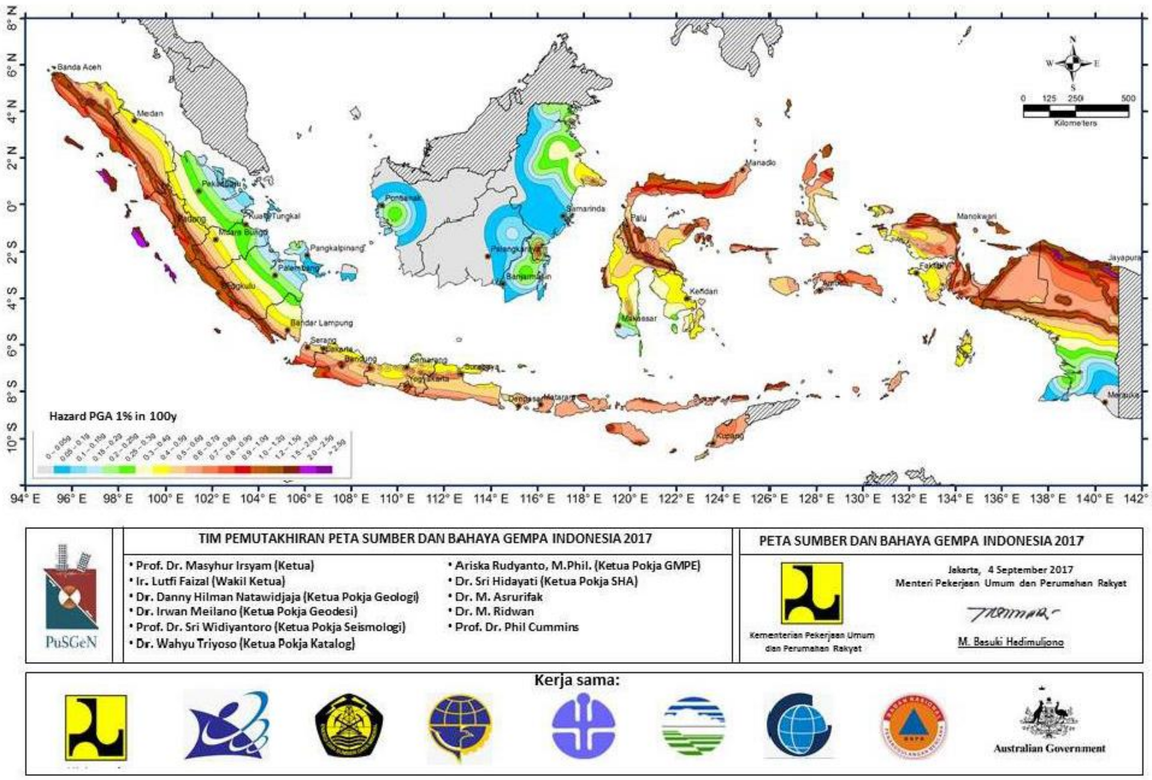


Figure 12 PGA Map of Indonesia (Ministry of Public Works, 2017).

With PGA analysis provided by PUSGEN (Figure 12), from the seven study locations, based on PGA analysis, Pandeglang, Rote, and Bali has high ground acceleration which could jeopardize both coastal communities and coral reef ecosystem. The highest ground acceleration is in Pandeglang area, followed by klungkung region and Rote. With such high acceleration, vibration cause by an earthquake could devastate the entire region, producing an upforce or downforce strong enough to alter the existing landscape.

Table 9 Peak ground acceleration for 1% exceeded in 100 year return period at the 7 study site location.

Study Site	**Hazard PGA 1% in 100y**
Pandeglang	0.8-1.0g
Klungkung	0.7-0.9g
Makassar	0.15-0.2g
Wakatobi	0.4-0,5g
Berau	0.3-0.4g
Raja Ampat	0.4-0.9g
Rote Ndao	0.7-0.9g

Mean while, according to PGA Analysis map, Makassar, Berau, Wakatobi and Raja Ampat has a relatively low to medium ground acceleration. Thus, the impact on those area when the earthquake is occurred will not as destructive as the area which posses high ground acceleration.

B. Tsunami analysis

A tsunami that strikes along a coastline produces damages depending on the morphological conditions of the coast. Tsunami hazard is evaluated based on the propagation and inundation height of the tsunami calculated from a reference point (usually sea level) when the tsunami arrives. Tsunamis across a large continental shelf break down into a series of solitary waves. These waves gradually propagate from its source in the deep ocean and reach its maximum run-up height at the beach At a steeper beach slope tsunami waves height becomes higher due to shoaling effects. The maximum tsunami height also depends on the sea level (tide) which mean that a small tsunami that occurs during high tide can reach a higher elevation than a larger tsunami that arrives at the lowest tide. This also means, in regard with climate change that would eventually rise up seawater level globally, in the event of tsunami, it would generate a higher tsunami which could propagate further inland.

In some cases, tsunamis only produce harmless flooding on low, sloping coastal areas, then head inland like fast tide. While in other cases a tsunami can strike in the form of a vertical wall of water that churns and carries debris that can kill and destroy buildings or land in its path. The damage and destruction caused by the tsunami is a direct result of three factors, namely flooding, the impact of the waves on the structure, and erosion. Meanwhile, casualties emerged due to drowning people. For the survivors, apart from the injuries, the mental impact in the form of trauma was caused by being trapped inside the churning seawater. The strong currents of tsunami caused erosion on foundations and collapses of bridges, sea walls, dragging houses and overturning vehicles. Tsunami wave pressure can also destroy building frames and other structures. Meanwhile, quite severe damage was also caused by the compressive force of floating debris including ships, cars and trees which could become dangerous objects when hitting buildings, docks and vehicles, even by a small tsunami.

A collateral potential hazard is fire, where typically fire originating from an oil spill from a destroyed ship at the port, rupture of an oil storage facility, or an oil refinery facility on the coast can cause damage that is sometimes more severe than the direct impact of a tsunami wave. Another concern that has also started to become a concern from the potential impact of a receding tsunami is that when the water recedes it will affect the cooling water supply at the power plant. Impact from tsunami could also cause destruction in ecosystems such as destruction in the mangrove which often facing the wave directly, toppling and destruction of coral reefs through breaking waves in the fringing or slope reef, erosion and strikes from tsunami debris.

Tsunami Case Study

Tsunami Krakatau 1883

Most notably effects of tsunami to destruction of coral reefs is seen by The Krakatau Tsunami in 1883. It's a major volcanic-tsunami event which brings catastrophic results to communities and the ecosystem. The huge tsunami lifted boulders of corals at the coast of Banten and Sumatra (Lampung). The largest coral boulder is still exist in the area of the new lighthouse, in Anyer, Banten.

Figure 13 Coral boulder from Krakatau 1883 in the new lighthouse area, Anyer-Banten (personal doc).

Photographs from the archives of the Royal Institute for the Tropics, Amsterdam, illustrate devastated landscapes covered by debris (coral boulders, pumices, fragments of buildings, trees, etc.). Remnants of a lighthouse (so-called 4th Point Java) were found up to 4 km inland along the Cikoneng River exactly near Anyer, Java (Paris, et al., 2014).

Tsunami Aceh 2004

Damage from a tsunami in Aceh Earthquake 2004 is devastating, there are evidence of coral reef destruction from both earthquake and tsunami. Along the mainland of Aceh, the highest frequency of overturned corals was found on fringing reefs inside bays while the reefs at adjacent headlands were mostly undamaged. This could be due to wave energy being concentrated by bathymetry or to more fragile corals growing in these locations. The tsunami may have been less damaging to the reefs of Aceh than initially expected for two reasons. First, the tsunami involved only three large waves. Once the waves had passed and receded the event was over. Secondly, there is evidence that tsunami damage is greater in areas with gently sloping bathymetry (Searle, 2005 in Foster, et al., 2006). According to eyewitness reports from the Reef Check team on Pulau Weh, the tsunami wave swiftly inundated the island rather than forming a breaking wave on the fringing reefs. In cases where tsunami waves can shoal and build up, they may break. Searle (2005) state that The weight of the falling water could crush and dislodge corals. In the Andaman Islands, for example, low lying islands with shallow shelving coasts suffered heavy damage while islands with steeper offshore bathymetry or outlying fringing reefs that absorbed some of the tsunami energy suffered much less damage (Foster, et al., 2006).

Figure 14 Overturned table coral at 10 m water depth, Pulau Rondo, 29 October 2005 (Foster, et al., 2006).

From this case study, it can be seen that the impact of the tsunami on coral reefs is quite large if the tsunami that hits the coast has the characteristics of plunging waves instead of surging waves supported by its bathymetric topology. Tsunami big energy and sometimes its debris can easily break the hard and firm coral leading to its death. Tsunami is also a very turbulent flow which brings a lot of sediments and covering the reefs, blocked from sun penetration. The coral reefs approximately will be restored from the tsunami damage in 5-10 years without any interference from anthropogenic causes (Wilkinson C. , 2005);

(Wilkinson, Souter, & Goldberg, 2005); (Morse, 2019); (Prayuda & Avianto, 2017); (Wiguna, Masithah, & Manan, 2018).

The real danger of a tsunami, both for coastal communities and for ecosystems, should be taken into account for planning disaster-safe coastal areas. From the calculation of the tsunami disaster that has been carried out previously through probabilistic analysis (Horspool, et al., 2014), it is found that almost all coastal areas in Indonesia are threatened by tsunami disaster for 500 years probability.

In PTHA study (Horspool, et al., 2014), from the seven study areas, Pandeglang area has the potential to experience a tsunami of more than 10 meters, while Rote area has potential to experience a tsunami of up to 10 meters and for Raja Ampat, Wakatobi and Berau has potential to experience a tsunami height of 2-5 meters. Makassar has the lowest potential for a tsunami, which is around 1 meter.

The most recent history of tsunami events in the Pandeglang area is the Krakatau tsunami in 2018 and the Krakatau tsunami in 1883, a small tsunami was also recorded in 1963 but did not cause any impact because it was a minor tsunami. In Klungkung Regency, a tsunami with a large enough impact occurred in 1917, with a tsunami height of up to two meters. In the Rote area, tsunami events that occurred in 1938, 1979 and 1982, could cause damage even though the written records only mention other cities that are close to the source of the tsunami. The Wakatobi Islands, which lie at the west of Banda Sea region, have at least experienced minor and major tsunamis due to tsunamis originating from Banda Sea, such as the tsunami in 1674, 1852 and most recently the 2006 tsunami. Tsunami events in the Berau region generally originate from tsunamis that spread in the Sulawesi Sea originating from Central Sulawesi, such as in 1968 and 1996 which has the potential to cause a tsunami with a height of 2-5 meters. The Raja Ampat Islands, which have a distinctive coastal morphology that can amplify tsunamis, can be threatened by a tsunami from the surrounding area. Although there is no specific record of impacts in Raja Ampat, the source of the 1899 tsunami on Seram Island and 2004 tsunami from Seram Island could reach Raja Ampat. Meanwhile, the Japanese tsunami in 2011 should be noted specifically, because long-distance tsunami can be a threat to the Raja Ampat coastal community, especially in the area of Waigeo Island which is directly adjacent to Pacific Ocean. Whereas in the coastal area of Makassar, there were not many tsunamis that occurred due to the lack of seismic activity in this area. There are records of tsunamis that occurred near Makassar in 1967 and 1969 which originated in the Makassar Strait. The impact of the tsunami is estimated to be quite large in the Sangkarang Islands area, however record of this impact in Sangkarang Islands is not recorded (BMKG, 2019).

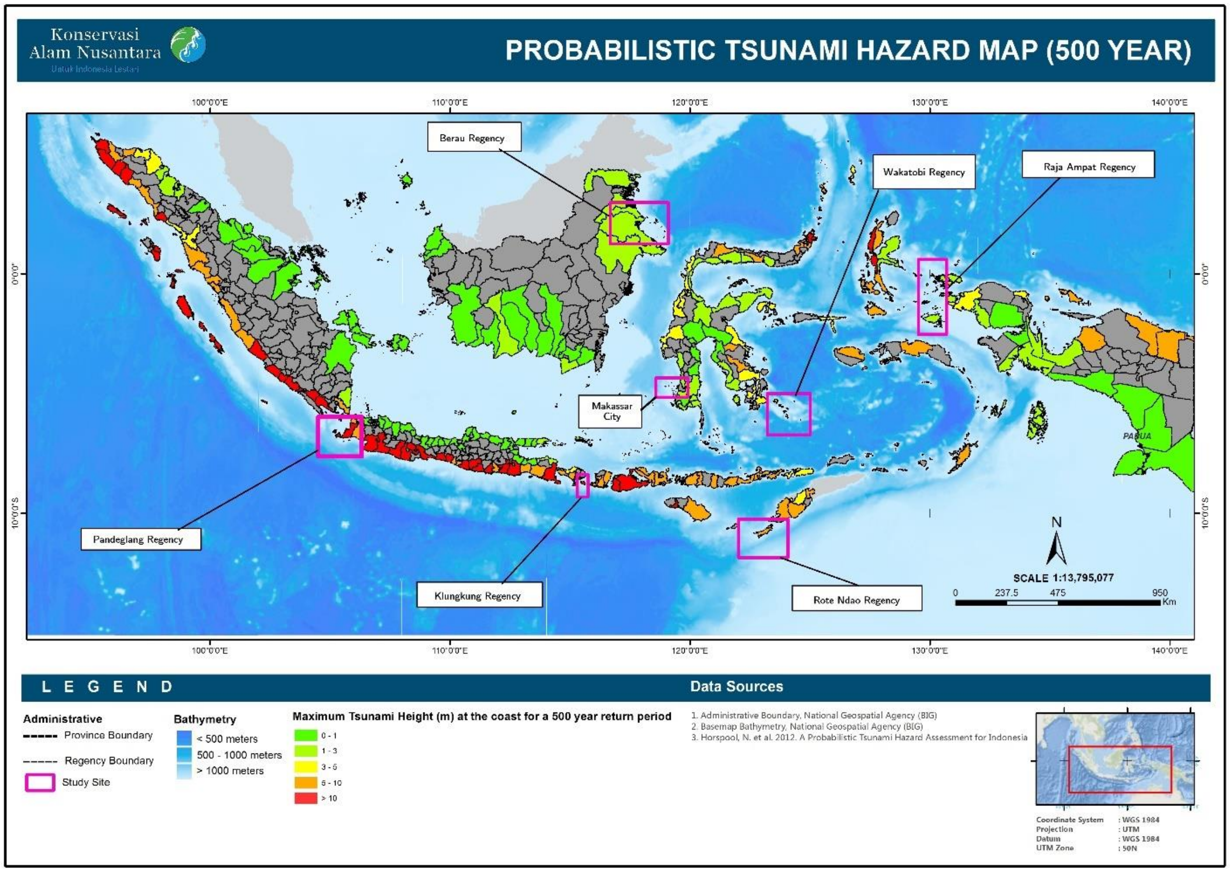


Figure 15 Tsunami Hazard Probabilistic Map (Modified from Horspool et al, 2014).

The real danger of a tsunami, both for coastal communities and for ecosystems, should be taken into account for planning disaster-safe coastal areas. From the calculation of the tsunami disaster that has been carried out previously through probabilistic analysis (Horspool, et al., 2014), it is found that almost all coastal areas in Indonesia are threatened by tsunami disaster for 500 years probability.

Table 10 Probability tsunami hazard analysis for 500 year return period at the 7 study site location .

Study Site	**Tsunami PTHA in 500y**
Pandeglang	5-10m
Klungkung	5-10m
Makassar	1-3m
Wakatobi	3-5m
Berau	1-3m
Raja Ampat	1-3m
Rote Ndao	5-10m

In PTHA study (Horspool, et al., 2014), from the seven study areas for a 500 year return period, Pandeglang area has the potential to experience a tsunami of more than 10 meters, while Rote area has potential to experience a tsunami of up to 10 meters and for Raja Ampat, Wakatobi and Berau has potential to experience a tsunami height of 2-5 meters. Makassar has the lowest potential for a tsunami, which is around 1 meter.

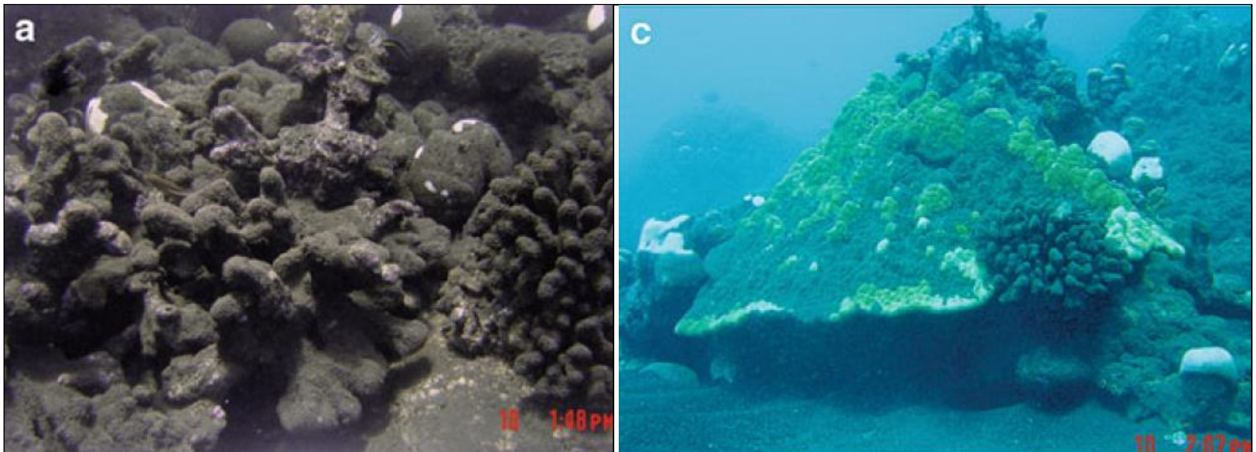
C. Volcano Analysis

In Indonesia, there are 146 volcanos and 76 of them are active volcanos and spread along Java, Lesser Sunda, Sumatera, and Celebes (Hariyono & S, 2017). Generally, there are two types of volcanic eruption, explosive and effusive eruption. Vulcanic hazard zone and its activity has been mapped and monitored by the Center for Volcanology and Geological Hazard Mitigation (PVMBG). Hazardous zone in volcano eruptions is defined within particular distance (radius) from the active crater. In general, the proximal area (< 5km) will suffer from the lava flow, lava, poisonous gas, hot pyroclastic flow (locally known as *wedus gembel*) and threats from falling rocks and volcanic ash or tephra. In the medial area (10-30 km), the threats is similar with additional lahar flow, however pyroclastic flows products are getting finer. In the distal areal (>30 km) fine size of pyroclastic fall or volcanic ash fall is the potential hazard.

Potential hazard from volcano eruptions can spread everywhere depending on its eruption type. However, on all type of eruption, volcanic ash fall is dependent by wind factor to spread further and wider. In this study, all seven research areas are relatively far from exisiting volcanos. However, there are two locations which are near in vicinities of neigbouring volcanos in Pandeglang Regency and Klungkung. The main threat for these areas from vulcanic eruption is mainly volcanic ash hazard and lahar flows. Although in rare cases, tsunami could also triggered by the collapsing flank of volcano crater into the sea, as seen in Pandeglang recently and in 1883 eruptions.

Volcano Eruption case study

On the Mariana Archipelago, in the island of Anatahan lies an active volcano which compose the Anatahan Island itself. This island is off limits from human interaction due to its increasing seismic or volcano activities. Since 2003 its mountain has erupted and the biggest eruption it has is in 2005, and through this time its volcano activity remain active. As a chain of island in subtropical latitude, Anatahan island has many coral reef surrounding its island. But due to its active Volcano activity, the reef is constantly changing. Studies conducted by Vroom & Zgliczynski, (2011), discovered that this vulcanic activities has changed the reef in different ways. First, deep penetration of Vulcanic ash (most likely a pyroclastic flow) has obliterated of any benthic substrate along the northeastern shore, while the suspended ash in the water column reduced visibility to 0.5- 2 meter in a 2003 survey. A more recent survey stated that Live coral cover around Anatahan following the eruption ranged from 0 to 35% (x = 7.9%, SE 0.6), with the majority of live corals exhibiting signs of stress (bleaching) likely because of the amount of ash on the substrate and in the water column. Differences in survival rates is believed because of differences in susceptibility to sedimentation among coral species



Corals covered with vulcanic ash	Surviving Porites colony, note non-surviving patches covered with ash and apparent bleaching around edges

Figure 16 example of impact damages of vulcanic ash to coral reefs (Vroom & Zgliczynski, 2011).

A similar study in 2012, in Pagan Island which is also a Vulcanic island located near the Anatahan Island also found that there are effects volcanic ash deposits which correspond to a bloom of cyanobacteria. This study concluded that there are trace elements in the volcanic deposits, particularly iron, spurred cyanobacterial growth and that the pre-reversal cyanobacterial bloom represented an early succession stage of reef degradation leading to less diverse benthic communities (Schils, 2012).

A more recent study suggest that when Vulcanic ash falls to the ocean surface and penetrated into the bottom of the sea, it can release amounts of acids and metals to the environment, leading to acidification and surface water contamination (Frogner et al., 2001). Such factors are among the main contributors to reef degradation and coral mortality (e.g., Anthony et al., 2008; Yu et al., 2004). Abundant ash which falls to the reefs also indicates that its cover would directly interfere with polyp respiration and decreasing photosynthesis by symbiotic zooanthellae. Ash suspended in the water column above would further stress the coral by reducing the amount of available light (Wu, et al., 2018).

However, due to the richness of the composition material of the Vulcanic deposits, the alteration of the marine ecosystem after the volcanic eruption can be restored in less than 5 years, and it will contribute to the reach of the biomass (high coral cover) and biodiversity in that area (Tomascik, Woesik, & Mah, 1996); (Vroom & Zgliczynski, 2011); (Houk, 2011).

D. Hydrometeorological Hazard Analysis (TC, Strong wind, flood)

Hydrometeorological hazard is a type of hazard which is the result of natural processes or phenomena of atmospheric, hydrological, or oceanographic nature[7]. Hazards related in this type are floods, tropical cyclone (henceforth to be called TC), drought, desertification, and strong wind. Although possible, it is very unlikely for drought and desertification to happen in a sudden-onset timeline. This study differentiates this hydrometeorological hazard into these three types of hazard (TC, Strong Wind and Flood).

Tropical cyclone is a massive weather system with strong rotating wind around a low-pressure center. A cyclone is formed by the presence of warm ocean waters over 26^{o} C followed by a deep convergence of the atmosphere with a massive formation of cloud. Once formed, it will generate a very strong wind within a radius surrounding the low-pressure area. (Montgomery, T., & Farrell, 1993); (Tory & Frank, 2010); (Henderson-Sellers, et al., 1998); (Azgha, 2019). The convergence slowly syphon all the surrounding clouds resulting heavy air filled with water that is ready to be dropped simultaneously in the form of moderate to heavy rain. A direct damage from cyclones felt by the people within the gale radius would be the high intensity rain above the normal rate within the radius of convergence, thunderstorms, and a very strong wind generating very rough waves above 4 m height, while the indirect damage would be the presence of low to medium intensity rain, strong winds over 40 km/h with high waves up to 4 m in the ocean (Puotinen, et al., 2020).

The coastal population will specifically receive the double damage as it gets a canal effect from both the land and the ocean. For the marine ecosystem such as coral reef, the inevitable damage from a very rough

[7] see http://www.unesco.org/new/en/natural-sciences/special-themes/disaster-risk-reduction/natural-hazards/hydro-meteorological-hazards/

wave counts from shattered reef branches to uprooted corals leading to dead ecosystem filled with rubbles of corals, sand, boulders and other types of sediments (Clifton, et al., 2003).

Cyclone Case Study

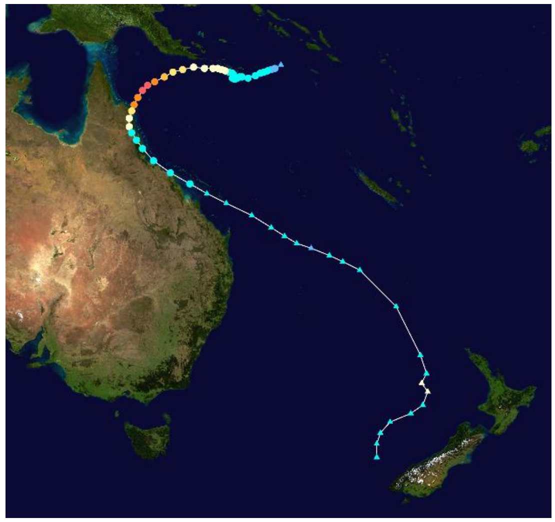


Figure 17 Cyclone Ita Track April 2014 (Marrero, 2015).

Severe Tropical Cyclone Ita was the strongest tropical cyclone in the Australian which strike eastern Australia and also the Great Barrier Reef. The system was first identified over the Solomon Islands as a tropical low on 1 April 2014, and gradually moved westward, eventually reaching cyclone intensity on 5 April. On 10 April, Ita intensified rapidly into a powerful Category 5 system on the Australian Scale, but it weakened to a Category 4 system in the hours immediately preceding landfall the following day. The greatest impact from Ita resulted from heavy rains and strong winds, with many areas receiving up to 300 mm (12 in) in 24 hours while the winds were estimated to have reached 220 km/h (140 mph) alongside a minimum central pressure of 922 mbar (hPa; 27.23 inHg). With an average water depth of 10 m and a cyclone wind speed of <28 m / s, damage to coral reefs due to cyclones reaches 40%. Reduced coral cover starts with waves as high as > 0.4 m high and continues with waves with height > 2 m (Marrero, 2015).

Other studies gives insight that for a given wave energy, communities dominated by fragile corals will have larger reductions in cover than those dominated by robust corals. From Cyclone Ita (big >=300 km, strong >= 33 m/s) observations and numerical model, sea condition are termed 'very rough' when Hs = 4 m. A very rough sea state is at least one-third more energetic than calm conditions and has been shown to move the entire reef blocks onto the reef flat. Damaging wind-sea local conditions extending nearly

1000 km from the storm centre. Coral reefs most affected at the most exposed sites: Acropora colonies (nearly 100%), massive Porites colonies (up to 50%). submerged shoals (~18, ~20, ~25 m) experienced considerable losses of hard coral cover (<13%) (Puotinen, et al., 2020).
From further literature reviews it is known that vulnerability of coral reefs to storm damage is likely related to the robustness and fragility of reefs, which varies according to (1) location, (2) coral community type, and (3) successional stage of coral development (Fabricius, et al., 2008).

Tropical cyclone formed mostly around the northern (refer to as 'Typhoon') and southern edges of the equator band, thus living in Indonesia have the benefit to be free from direct cyclone damages, almost. Sometimes due to the equator anomalies, low-pressure regions sometimes formed in the Indonesian area and thus forming a rather weak and small cyclone. The anomaly can be further investigated by the presence of Cyclone Kirrily (Mulyana, et al., 2018) in the southern hemisphere and Tropical Storm Vamei (Chang, et al., 2003) in the northern hemisphere, where the formation and track of the cyclones lies the closest to the equator. Due to the size and strength of the two cyclones, the direct impact to the environment is less and almost no record shown for these cyclones to damage Indonesian areas.

Regarding the effects, cyclones occurences in the south are causing more impacts to the Indonesian areas than the northern ones. This study has compiled a total of 49 cyclones that have direct or indirect impacts to the seven study areas while there were only 6 typhoons found to be indirectly damaging those areas so far (Figure 18). The effect of the cyclones sometimes can reach the furthest part of Indonesia (e.g., Tropical cyclone Kenanga[8] in 2018 which is formed in the southwest area of Bengkulu Province and moved southeast, caused indirect damage reaching Pandeglang and Berau). Further, a few of the tropical cyclones in southern and northern parts of Indonesia that have indirect damages in Indonesia is shown in Figure 18 below.

[8] See https://www.bmkg.go.id/press-release/?p=siklon-tropis-kenanga-tumbuh-di-samudera-hindia-selatan-sumatera&tag=press-release&lang=ID

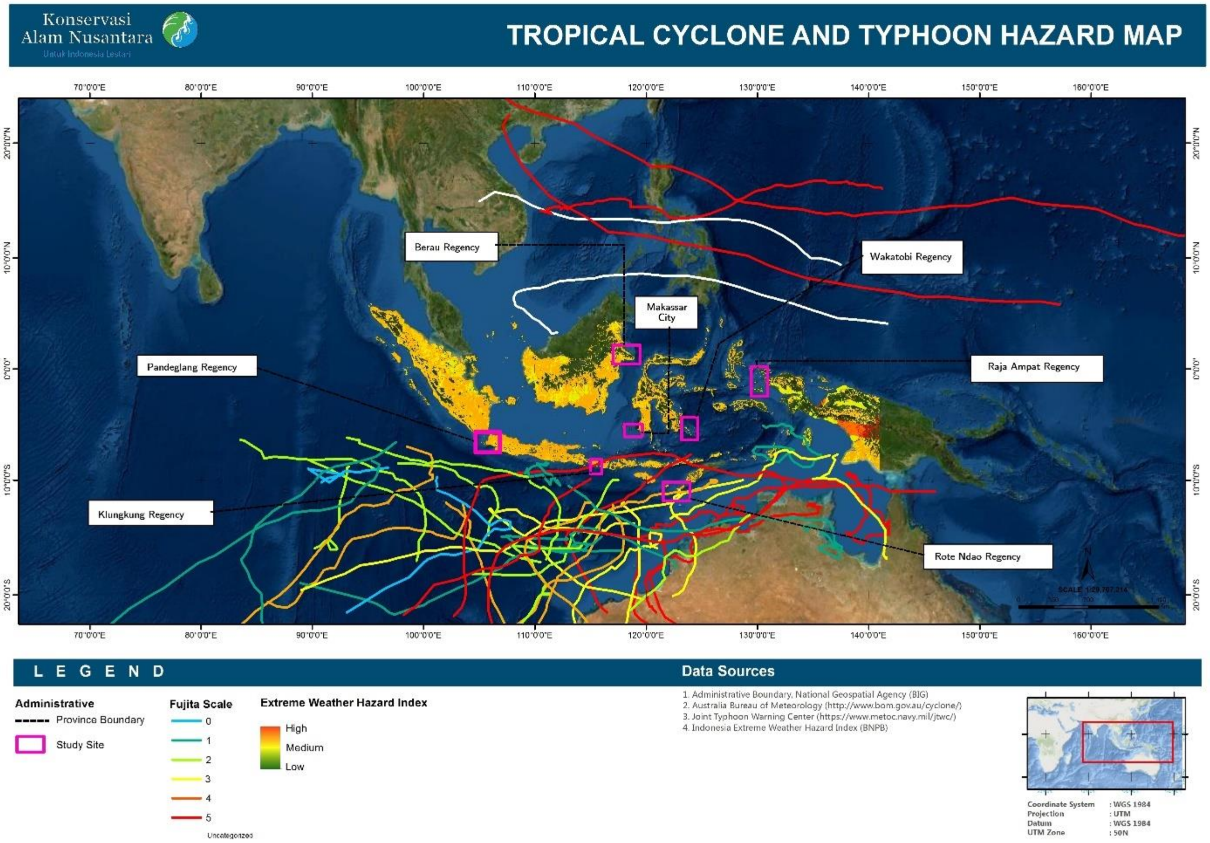


Figure 18 Map of Tropical Cyclones and Typhoons indirectly affecting Indonesian regions (Analysis, 2021).

For cyclones magnitude scale, people often compare their categories to some extent. All available magnitude scales were developed based on the sustained-wind speed and the damage that they're producing in the respective regions. The often used scale is the Saffir-Simpson Hurricane Wind Scale (SSHWS). Another widely used wind speed scale, Fujita Scale, are still used and after 2007 modified to new Enhanced Fujita Scale. Using the comparison in Table 11, this study utilised the Fujita Scale to better accommodate both for cyclones in the south and north of Indonesia.

Table 11 Comparison between wind scales according to the respective sustained-wind speed and the damage caused.

Saffir-Simpson	Australian Scale	Fujita Scale	Enhanced Fujita Scale
	Tropical Low No damage <63 km/h	F0 Tree branches down <116 km/h	EF0 Tree branches down 104-136 km/h
Category 1 Minimal damage 119-153 km/h	Category 1 Damage to crops and trees. 63-88 km/h	F1 Roof damage 117-180 km/h	EF1 Roof damage 137-177 km/h
Category 2	Category 2	F2	EF2

Saffir-Simpson	Australian Scale	Fujita Scale	Enhanched Fujita Scale
Moderate damage 154-177 km/h	Minor house damage 89-117 km/h	Houses damage 181-253 km/h	Houses damage 178-217 km/h
Category 3 Extensive damage 178-208 km/h	Category 3 Some roof and structural damage 118-159 km/h	F3 Buildings gone 254-330 km/h	EF3 Buildings gone 218-265 km/h
Category 4 Extreme damage 209-251 km/h	Category 4 Significant roofing loss and structural damage 160-199 km/h	F4 Trains flipped down/thrown 331-418 km/h	EF4 Trains flipped down/thrown 266-321 km/h
Category 5 Catastrophic 252 km/h and more	Category 5 Extremely dangerous with widespread destruction 200 km/h and more	F5 Whole town destroyed 419-512 km/h	EF5 Whole town destroyed 322 km/h and more

Source: Saffir-Simpson Hurricane Wind Speed NOAA[9]; Enhanced Fujita Scale NOAA[10]; Australian Scale Bureau of Meteorology Australia[11]; Kitamoto, 2017).

Within the land area, extreme winds from TC can leave damage in the infrastructure while heavy rain can lead to a runoff flood. The flood could also come in the form of coastal surge, an extreme high waves which strike the coastal area. The difference between this and tsunami mainly because of the formation and the energy released. A coastal surge often caused by a cyclone forms high speed wind that pushes massive amount of water over a long area of fetch (the distance traveled by wind or waves over an undisturbed open water). This kind of surge often cause huge fatalities and economic damages. While the damages to the coastal populations are visible, a long and repeated coastal surge can damage the surrounding coral reef by the effect of reduced sun penetration to depth and destructive waves. Increasing water level corresponds to depth reduction of coral reef, which moves the reef away from sunlight influence, hence the decline in temperature and eventually could lead to potential stress for the coral reefs. The destructive waves of the surge can also contribute to the stress by directly damaging the coral when the wave height is above 4 meters (Ningsih N. S., 2010); (Puotinen, et al., 2020).

Some confusion gathers while differentiating between cyclones, tornadoes and hurricanes. In technical terms they are very similar from its characteristics of its rotating form existence. While TC and hurricane is found originating in the ocean, tornado is found mainly on land area. Tornado terms is usually used in

[9] See https://www.nhc.noaa.gov/aboutsshws.php
[10] See https://www.spc.noaa.gov/faq/tornado/ef-scale.html
[11] See http://www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/understanding/tc-info/

the North American continents. While in Indonesia there is no tornado, instead, due to certain differences in local atmospheric pressures and wind condition, there is a local rotating strong wind forming a smaller tornado that locals call it a whirlwind (Meaden, 1985). Within this study, whirlwind is referred to the strong wind hazard category. While equally damaging, whirlwind is different from tropical cyclone in many ways. Table 12 below showing some differences between a tropical cyclone and a strong wind (whirlwind).

Table 12 Major difference between tropical cyclone and tornado.

Factors	Tropical cyclone	Tornado	Local Whirlwind
Forming zone	Over the warm water in the tropical ocean	Over the land and form within bigger storm like a cyclone	Over the land and water (called waterspout)
Size/ Radius	Up to several hundred km	Less than 0.5 km	Less than 0.5 km
Duration	Average of 9 days and up to 3 weeks	Usually no more than one hour	Usually not more than 5-10 minutes
Wind Strength	< 300 km/h	Up to 500 km/h	Up to Fujita Scale F0
Advance Warning System	Up to several days	Not more than 30 minutes before the event	Unpredicted
Damage	Land: Strong winds with thunderstorms and high waves reaching coastal population for several days. Water: coral damage by violent wave ranging from shattered reef branch to uprooted substrate and bleaching	Land: strong winds, when the lower rotating air touches the ground, everything within is almost wiped out immediately. Water: strong winds generate high waves, immediate damage to coral reef substrate	Land: strong winds, minor damage to well-constructed home, displaced car Water: minor damage to surface area

Source: Modified from Davis, (1884); Meaden, (1985); Azgha, (2019).

Strong wind category in the study's context is not only based on the wind caused by a tropical cyclone. The strategic location of Indonesia in the middle of two continents and two oceans carried out a special seasonal atmospheric flow called the monsoon. It mainly affected the precipitation of the Indonesian areas by the pressure difference between two continents. During the boreal winter (high pressure atmosphere) in the northern hemisphere, the southern hemisphere experiences summer with low pressure atmosphere, causing the wind current to flow from Asia to Australia. A vice versa situation happens when the Australian experiences winter while Asia experiences the boreal summer. The flow of this wind current accompanied by the cloud growth causing the rainy season during October to April and the dry season during March to September (Sprintall, et al., 1999). The dynamics of the Indonesian atmosphere sometimes produce a local convective storm, marked by the rapid growth of the cumulonimbus clouds. The strong wind came from this storm can be accompanied by thunderstorm, whirlwind, and heavy rain which can directly affect people living beneath the storm.

A river runoff can come as a result of a rainfall or a snowmelt, and in Indonesia, rainfall is likely to be the major source of the cause. As the changes in river runoff follows the change in precipitation, high precipitation could be something that needs to be anticipated. Flood that came from river runoff cannot be underestimated because it will bring forward a lot of sediment to the inundated coastal area and surrounding marine waters. Apart from damaging coastal population, Hoegh-Guldberg and team (2009) mentioned that the impact of flood indirectly threatening to approximately 21% of coral reefs in Southeast Asia where in Java, 35% coral reefs are threatened by nutrients and sediment from the flood.

The role of sediment in harming the marine and coral ecosystem lies to the fact that the sediment excess, especially one from the mud and clay type of cohesive sediment, will form flocs followed by aggregates and colloid in the water column. Once spread, it will block the sunlight that corals need for photosynthesis, thus a long-time sedimentation will kill corals and their zooxanthellae symbiosis. Other damages to coral reef caused by the suspended sediment lies also in the excess nutrients coming from the land which leads to the overgrowth of the algae (Hoegh-Guldberg, et al., 2009); (Risk & Edinger, 2011); (Prasetia I. N., 2017). The competition of the algae with the coral can harm them, leading to the destruction of the reef ecosystem. It is also mentioned that the increasing rate of sedimentation due to flood has a negative relationship with coral rate of growth in terms of coral disease (Risk & Edinger, 2011). Rapid sedimentation can bring out several diseases along with the excess of nutrient. Thus, by being high on competition with the algae, lack of sunlight, and coral disease increase, there is no wonder if at some point the reef will experience the bleaching.

E. Slow onset hazard analysis

Sea surface temperature (SST) is one of the physical parameters of oceanography which is used as a determining factor for the quality of a waters. SST is influenced by solar radiation, ocean currents, and vertical motion of sea water (upwelling and downwelling). The main factor in the danger of climate change is the increase in sea temperature. Increasing sea temperature causes stress for live coral larvae. Stressed coral larvae do not grow and do not attach to their coral structure and eventually die slowly turning white or commonly known as coral bleaching (Hadi, et al., 2019). Coral reefs can live well in sea temperatures between 26-30° C, an increase in sea surface temperature of 1-2° C from the mean annual temperature can trigger coral bleaching (Hoegh-Guldberg, 1999; Coles and Brown, 2003 in Bappenas, 2010). The increase in sea surface temperature could cause coral bleaching in a relatively short time, as fast in the span of 2-3 weeks (Bappenas, 2010).

In general, SST in Indonesian waters was above 28˚C in January and in August the SST was lower than 27˚C. Climate change, which causes an increase in sea surface temperature, results in decreasing ice cover changes in the north and south poles. Melting ice in the polar regions is one of the main contributors to rising sea levels around the world. The calculation of sea surface temperature rise has been calculated in numerous studies based on the IPCC scenarios.

The geomorphological conditions of the Indonesian archipelago vary widely, making the impact of rising sea surface temperatures different between reefs. The reefs along the Java coast are usually in the form of patches, such as in Banten Bay, Jakarta Bay, Jepara, Pasir Putih, Baluran, Nusa Kambangan, Wediombo and Prigi Bay. Coral reefs grow well off the north coast of Java Island and generally form in islands, such as the Thousand Islands, Karimun, Bawean, and Kangean Islands. The island of Kalimantan, which is dominated by peatlands and many large rivers, many coral reefs are not well developed. Close to the mainland, coral reefs are in the form of patches as seen in Sangkulirang reefs.

Well-developed coral reef is found especially those that grows separated off the coast of Kalimantan Island, such as in the Derawan Islands, Matasiri Islands and Karimata Islands. Coral reefs are well developed and reach the peak of its biodiversity in the coral triangle area, including Sulawesi, Maluku, Halmahera, West Papua, Raja Ampat Islands, Aru Islands, Kei Islands, East Nusa Tenggara, West Nusa Tenggara, and Bali. Coral reefs develop horizontally and vertically to a depth of more than 30 meters. These good conditions are caused by natural factors that are very supportive, one of which is warm temperature and clear water that flows continuously from the western Pacific to the Indian Ocean through these areas (known as Indonesian throughflow – ITF) and this flows make the coral grow better than other areas. However, coral reefs cannot develop properly along the southern coast of Papua due to high sedimentation resulting from river estuaries (Hadi, et al., 2019).

Data compiled by Marshall, 2006 (Figure 19) illustrates that coral bleaching has occurred in many coral reef locations in Indonesia. From this figure it is shown that almost of coral reefs in Indonesian waters had experiences coral bleaching. The coral reef damage rate in 1998/1999 due to ENSO events is the highest on record and affected a vast area. After 1998, the damage rate is lower, but with higher frequency so that additional locations were subject to bleaching (Bappenas, 2010)

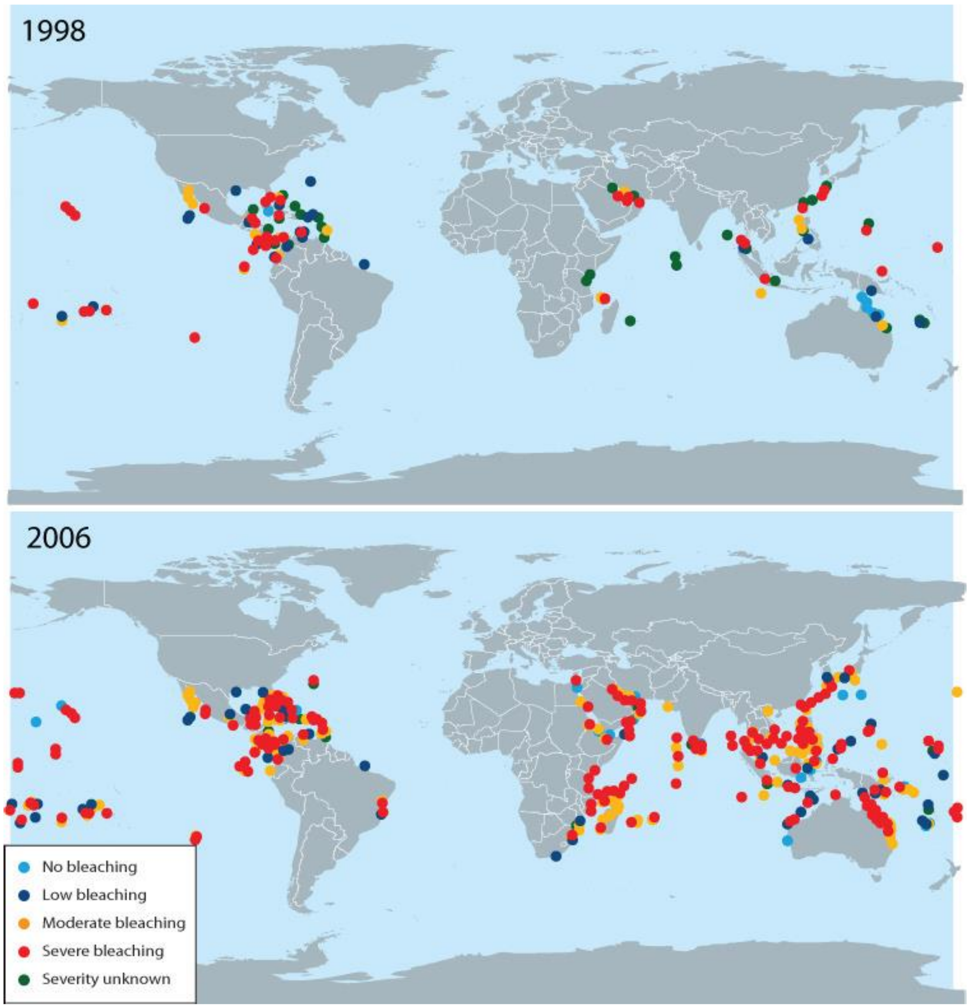


Figure 19 Confirmed coral bleaching events in Indonesia during ENSO Events in 1998/1199 and 2006/2007. (Bappenas, 2010).

Observed coral bleaching events can assist research on the effects of climate change on coral reefs, however data are still very limited and minimal. Donner (2017) helps compile some of the data obtained from various sources such as Reef Base which is compiled in his research database[12]. The database mostly documented the incidence of global coral bleaching while in Indonesia coral bleaching is recorded from 1998 to 2010 (Donner, Rickbeil, & Heron, 2017). Combining this database with observational data from

[12] http://www.simondonner.com/bleachingdatabase

conducted by The Nature Conservancy from 2009-2017 through the TNC PIT database provided historical data on the incidence of damage to coral reefs in seven study location (Table 13).

Table 13 Record of coral reef damages.

Location	Latitude	Longitude	Period	DD	MM	YY	Severity	Source
East Kalimantan	-1.0912	117.1308	Jan-98		1	1998	3	Donner SD *et al* (2017)
Lembongan	-7.6667	114	Jan-98		1	1998	1	Donner SD *et al* (2017)
Nusa Penida	-8.6667	115.4667	January' 1998		1	1998	1	Donner SD *et al* (2017)
Bali	-8.1036	115.0568	May-98		5	1998	3	Donner SD *et al* (2017)
Nusa Lembongan (Southeast Bali)	-8.6551	115.4559	Jun-98		6	1998	1	Donner SD *et al* (2017)
Nusa Penida	-8.7144	115.6085	Jun-98		6	1998	1	Donner SD *et al* (2017)
West Lombok, Bali	-8.7243	115.9421	Jun-98		6	1998	3	Donner SD *et al* (2017)
Wakatobi	-	-	May-09		5	2009	-	Donner SD *et al* (2017)
Wakatobi	-5.368	123.548	Apr-10		4	2010	3	Donner SD *et al* (2017)
Bali	-8.358	115.741	May-10		5	2010	-1	Donner SD *et al* (2017)
Kupang Beach	-10.152	123.595	May-10		5	2010	2	Donner SD *et al* (2017)
Spermonde	-4.972	119.284	May-10		5	2010	3	Donner SD *et al* (2017)
Badi Island	-4.96	119.28	May-10		5	2010	3	Donner SD *et al* (2017)
Southeast Misool	-	-	November 08 2010	8	11	2010	-	TNC_PIT4D atabase
Wakatobi	-	-	April – May 2010		4	2010	-	TNC_PIT4D atabase

Location	Latitude	Longitude	Period	DD	MM	YY	Severity	Source
Kofiau	-	-	March 22-30 2011		3	2011	-	TNC_PIT4D atabase
Wakatobi	-	-	February 01 2011	1	2	2011	-	TNC_PIT4D atabase
Wakatobi	-	-	January 26 2011	26	1	2011	-	TNC_PIT4D atabase
Wakatobi	-	-	May 03 2011	3	5	2011	-	TNC_PIT4D atabase
Wakatobi	-	-	May 23 2012	23	5	2012	-	TNC_PIT4D atabase
Southeast Misool	-	-	December 07 2013	7	12	2013	-	TNC_PIT4D atabase
Southeast Misool	-	-	October 19 2015	19	10	2015	-	TNC_PIT4D atabase
Rote Ndao	-	-	May 10 2016	10	5	2016	-	TNC_PIT4D atabase

Furthermore, in the results released by (Donner, Rickbeil, & Heron, 2017), using satellite analysis of sea surface temperature analysis, the temperature level of ocean sea surface temperature are determined by Degree Heating Week (DHW) method developed by NOAA's coral reef watch. In short, DHW is the level of heat stress accumulation in certain waters for a period of about 3 months by adding up any temperature exceeding the bleaching threshold during that time period.

When DHW reaches 4 °C-weeks significant coral bleaching is likely to occur, especially in more sensitive species. Meanwhile, severe bleaching heat stress occurs when DHW is at 8 °C-weeks. This method explains well the occurrence of global coral bleaching in the past (1985-2013) until the 2014-2017 period, where in the study conducted by Heron 2017, it was shown that in the 2014-2017 period there had also been coral bleaching events on corals in the Ujung Kulon National Park and Komodo National Park.

SST changes

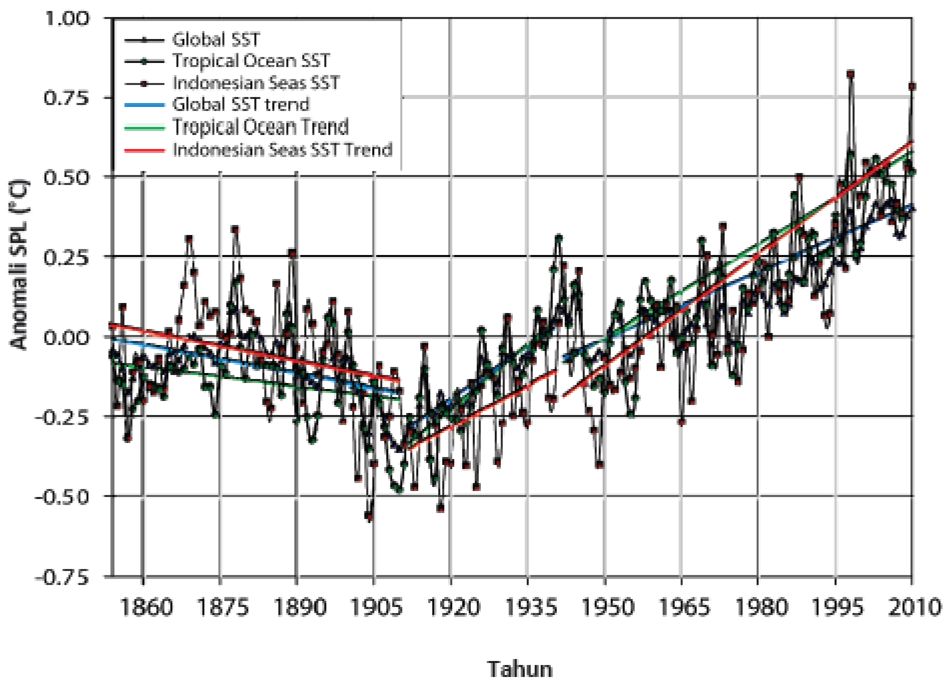


Figure 20 Changes of global sea surface temperature (Bappenas, 2018).

The increase in sea surface temperature in Indonesia in general still follows the pattern of global temperature increases. Although, from the analysis conducted by the Bappenas study, it was found that the rate of increase in SST in Indonesian waters was relatively higher than the increase in SST globally, which reached 0.78 ± 0.18 ° C during the 20th century since 1900 (Figure 20).

Spatially, a study conducted by Bappenas shows that the increase in SST in Indonesian waters has experienced a change of temperature increases from 0.075˚C / decade in the early 20th century to 0.22˚C / decade in the last decade. The variation of the increase in SST from 0.05 to 0.3 ˚C / decade is shown in the Figure 21 below, where the lowest temperature increase trend occurs in southern Java and west Sumatra and the highest occurs on the northern coast of Papua, which is directly adjacent to the Pacific Ocean.

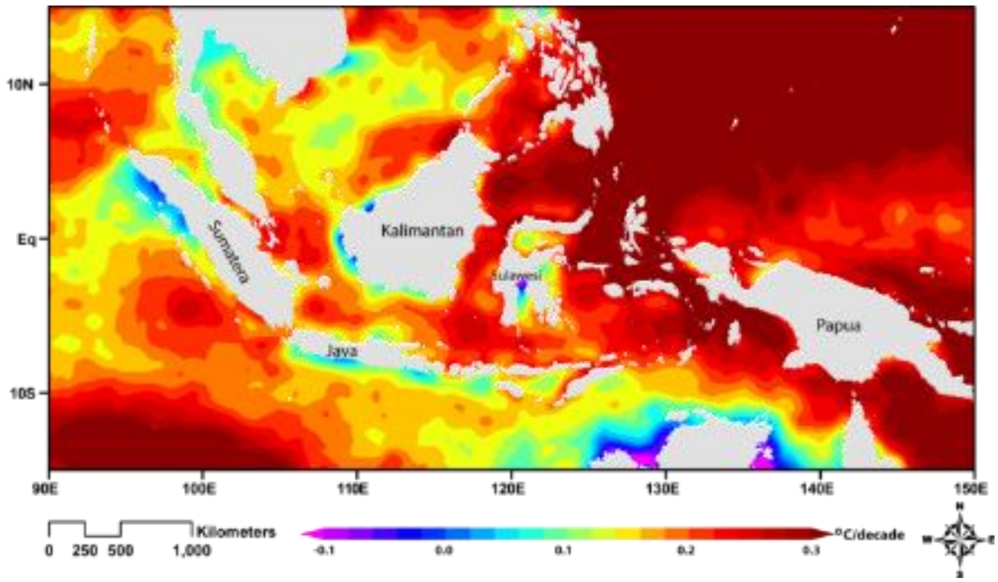


Figure 21 Rate of Increased Sea Surface Temperature 1990-2014 With An Average of 0.22°C Per Decade (Bappenas, 2018).

The results of this analysis indicate that on average, the increase in SST in Indonesian waters ranges from 0.2-0.23 ˚C/decade (Figure 21). If this rate of increase continues, then an increase in temperature of 0.6-0.7 ˚C and 1-1.2 ˚C in 2030 and 2050 calculated since 2000 will occur. This ongoing increase is even predicted to reach an increase of 1.6-1.8 ˚C in 2080 and even 2.3 ˚C in 2100. This increase will greatly affect the condition of the waters inhabited by coral reefs, which in turn caused coral mortality. Moreover, this condition could shift in many areas of coral reefs in Indonesia and could shift fishing area areas further than what is already known by the fisherman.

Figure 22 shows a map of differences in sea surface temperature in Indonesia at the 99 and 50 percentiles from 1991-2015, which provides an estimate of the distribution of locations for massive coral bleaching. Large differences (above 1.5 °C) will indicate locations that are prone to coral bleaching. From this figure, it can be seen that areas south of the equator will be more vulnerable than coral reef areas in the north. Examples of the vulnerability of coral bleaching can be seen in the Seribu Islands and Bali areas which have also undergone a recovery process. There is no guarantee that other areas suffering from coral bleaching will experience the same recovery.

In addition, it is important to note that a 2 °C rise in sea surface temperatures by 2100 will hinder the recovery process and even exacerbate coral bleaching. The intensive heating process until 2100 is also predicted to cause a high frequency of La Nina which can increase the frequency of changes in SST drastically and suddenly with a short period.

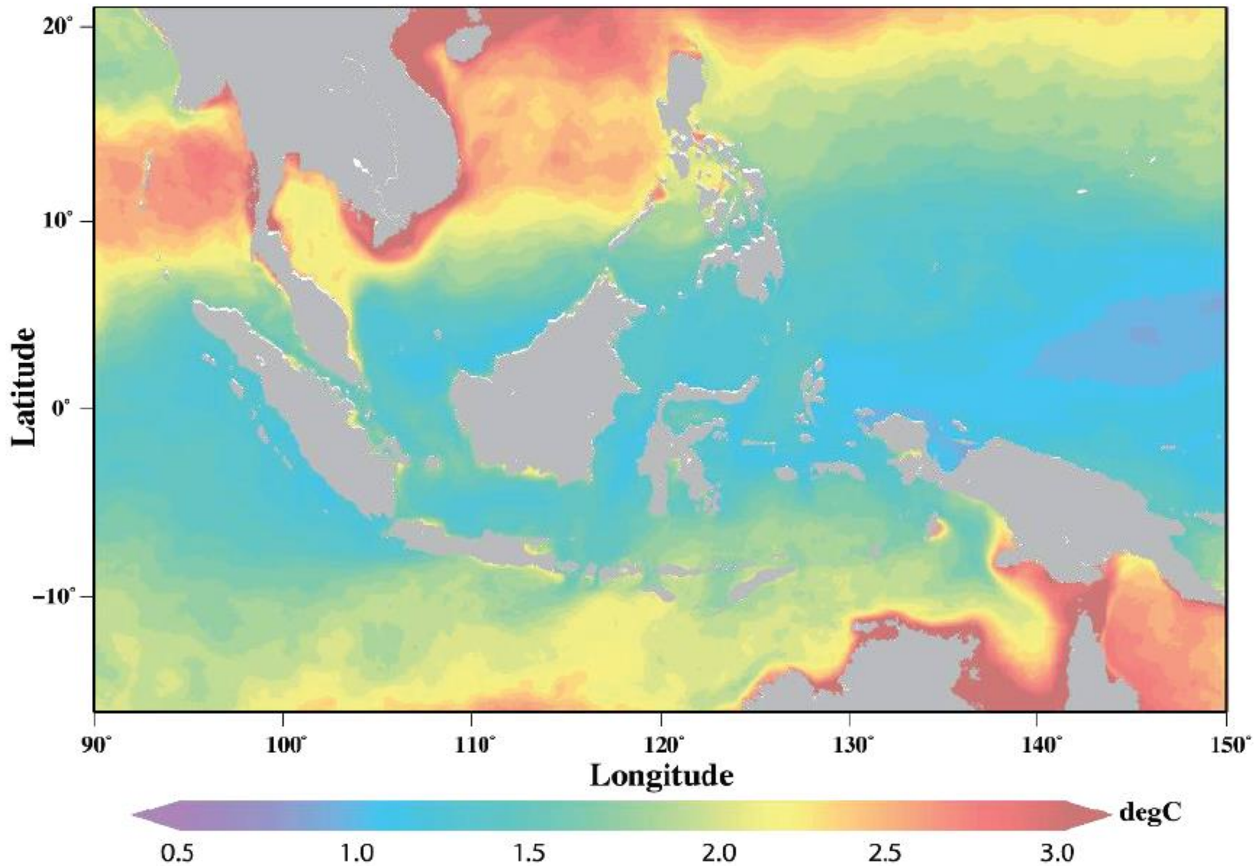


Figure 22 The difference in sea surface temperature values at 99 and 50 percent in 1991-2015 which indicates the location of coral reef bleaching in Indonesia (Bappenas, 2018).

ENSO

The El Niño–Southern Oscillation (ENSO) is a natural phenomenon in the Pacific Ocean related to ocean temperatures, equatorial trade winds blowing from the eastern Pacific to the western Pacific, and cloud forming over both areas[13]. The neutral phase of ENSO stands for the normal weather without anomalies, where the trade winds blow from the east to the west forming warmer ocean temperature in the Indonesian seas than the western South America waters. This promotes the regular cloud formation in the Indonesian waters. When the El Niño happens, a stronger blow from the trade winds leads to warmer

[13] See https://www.weather.gov/mhx/ensowhat

Indonesian waters which can promote more cloud formation, thus heavy rain can occur and flooding might happen. When the trade wind starts getting weaker, the warm water over Indonesian seas moved towards the east, making Indonesian water colder than average. This marked the start of La Niña event, where the lack of clouds leads to a drought condition in Indonesia (Goddard, L., Philander, & G., 2000).

This ENSO cycle usually lasts for several years before getting back to the neutral phase. A brief knowledge from ENSO can give a head start to prepare for the flood or drought season to come. From Figure 23 below, the effect of ENSO events occurred during the past 30 years can be known over Indonesia. An ONI Index is developed to indicate a weak or strong ENSO events, a strong event is mark by an index that is higher than a 0.5. A strong and very strong ENSO can incur drought/ flood, respectively. This, when combined by the superposition of other hydrometeorological hazards, will incur quite a disaster over Indonesia.

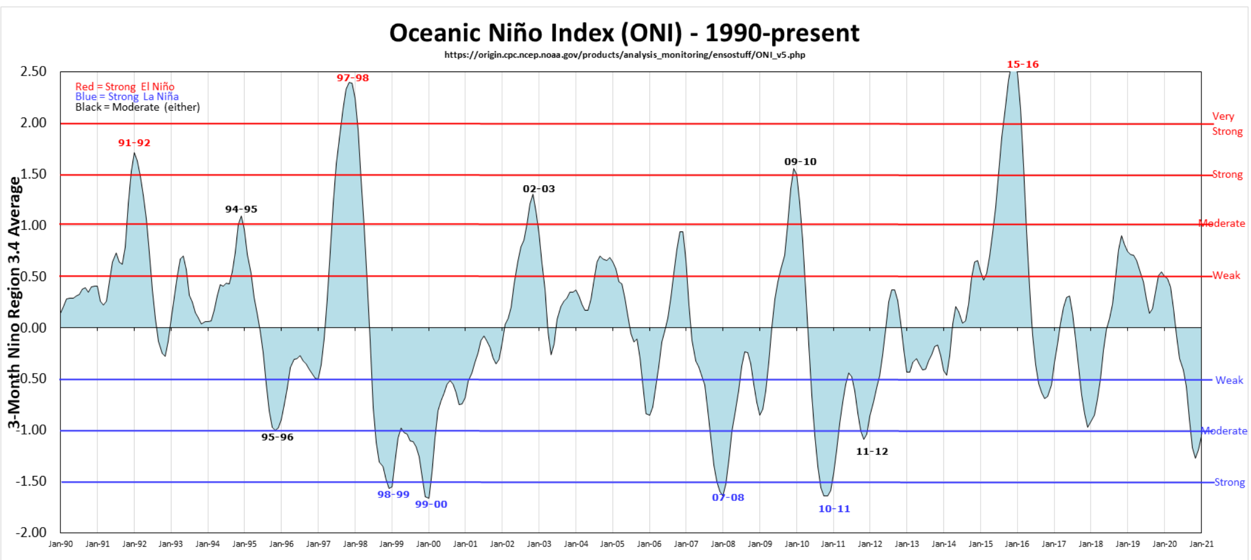


Figure 23 Historical ENSO events in from 1990 to present day. Red line represents strong El Nino Event and blue line represent strong La Nina events waters and red represents warmer Indonesian waters[14].

The warming and cooling of ocean water in ENSO events every few years also gives impact on coral reefs ecosystem. In El Niño years, water warms up quickly in the Pacific Ocean. While In La Niña years, the water cools down. The short-term warming during El Niño gives a big impact on coral reefs in the Pacific Ocean which often lead to coral bleaching.

[14] https://ggweather.com/enso/oni.htm

However, large scale bleaching event do not necessarily in conjunction with ENSO events (Heron, et al., 2017), resilience of coral reefs is different from one to another places. In other cases, depending on local condition and its exposures, reefs could recover with enough time. Even though the warming from El Niño is temporary and short term, it has a big impact, because nowadays coral reefs are already under pressure from climate change and anthropogenic factors. ENSO event could worsen long-term climate change effect to coral reefs.

As explained above, Major ENSO event at 1998/1999 and in 2010 gives a mass coral bleaching globally including in Indonesian waters. In climate change scenarios with an expected rise in temperature, ENSO events could double its occurrences, thus the probability of coral bleaching events could also increases (Cai, et al., 2014).

Projection analysis

A climate change projection scenario is a series of parameters that describes the activities undertaken to describe future climatic conditions according to a certain standard year. Projected stress exposure under different CO2 emissions trajectories (Representative Concentration Pathways, RCP28), as used by the Intergovernmental Panel on Climate Change (IPCC), indicate a range of projected impacts depending upon atmospheric greenhouse gas concentrations in the years to come. The climate change scenarios used to calculate the impact of climate change are the SRESA1B RCP 8.5 and RCP 4.5 emission scenarios.

These scenarios lead to projected global-mean temperature increases by 2100 of 4.3°C and 2.4°C, respectively, both of which well exceed the level of warming (1.5°C) beyond which severe degradation of the great majority of coral reefs is anticipated. Based on recent estimates, countries' emissions are likely to raise the global-mean temperature by around 3.6°C by 2100, whereas the aggregated effects of the pledges made by countries under the Paris Agreement so far would likely result in about 3°C warming globally (Heron, et al., 2017).

The RCP 4.5 scenario is a scenario that adequately reflects the current changing trend conditions, namely the increase in temperature corresponds to the trend of rising temperatures from 1990-2015, this adequate reflection of current condition makes this scenario is used in many simulation, including ones conducted by Bappenas in 2018.

From the RCP 4.5 projection simulation carried out by Bappenas in 2018 (Figure 22), sea surface temperatures will rise by 1 and 2 ˚C compared to SST in 2000 and 1961, sea level also responds with an increase of up to 50 cm from 2000.

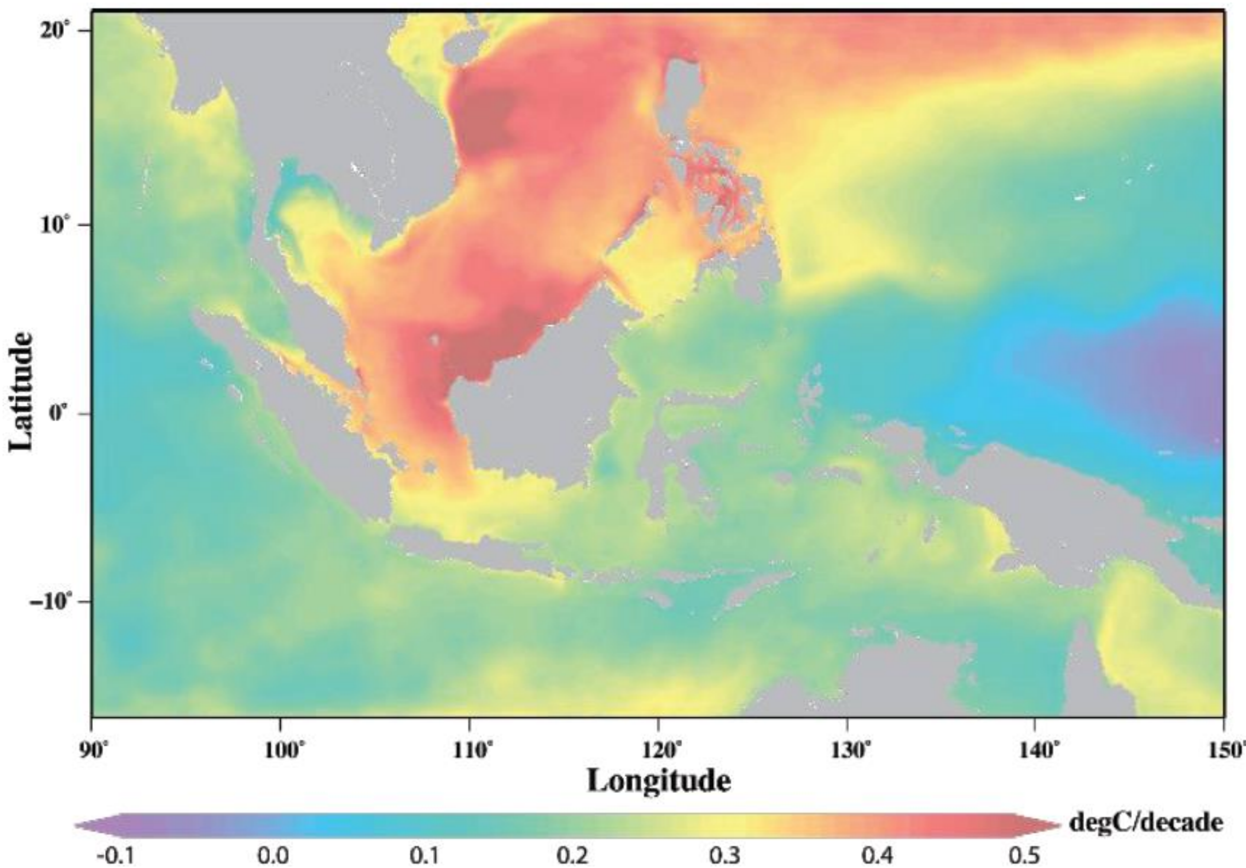


Figure 24 Projected rate of increase in SST based on the RCP4.5 scenario (Bappenas, 2018).

In this scenario projection, in Indonesian waters there will be an increase in sea surface temperature in the Java Sea, Banda Sea, Sulawesi Sea and the surrounding seas between 0.2-0.3 ˚C/decade (Figure 24). The highest rate of sea surface temperature rise is likely to occur in the South China Sea and the Karimata Sea which can reach up to 0.5 ˚C/decade. Meanwhile, the temperature increase in the northern waters of Papua rose quite low, around 0.1 ˚C/decade, which is the lowest increase when compared to other regions. With an increase like this, the threat factor for coral reef damage will be even stronger.

While in RCP8.5 scenario, in which emissions (and temperature) continue to rise through the 21^{st} century, similar to what was previously described as the "business as usual" scenario in earlier IPCC assessments. The projections under RCP8.5 represent the current condition of emissions trajectory without any changes to be made in the future. According to Heron, 2017, which uses 8 degree of DHW presents climate model projections under RCP8.5, twice-per-decade severe bleaching will be apparent at 25 of the 29 World Heritage reefs (86%) by 2040 (Table 14) which includes two marine park in Indonesia (Ujung Kulon and Komodo National Park).

Table 14 Onset of recurrent severe bleaching heat stress events under Representative Concentration Pathways (RCP) 8.5 and 4.5. Event frequencies are twice-per-decade and annually.

	Future Severe Stress - RCP8.5		Future Severe Stress - RCP4.5	
Reef-containing World Heritage site	**(a) Projected Year of 2x/decade**	**(b) Projected Year of Annual**	**(c) Projected Year of 2x/decade**	**(d) Projected Year of Annual**
Great Barrier Reef	2035	2044	2041	2051
Lord Howe Island Group	2034	2043	2036	2055
Ningaloo Coast	2041	2049	2052	2074
Shark Bay, Western Australia	2038	2047	2045	2074
Belize Barrier Reef Reserve System	2028	2036	2036	2044
Brazilian Atlantic Islands	2028	2039	2035	2049
Malpelo Fauna and Flora Sanctuary	2038	2050	2056	2077
Cocos Island National Park	2019	2032	2028	2036
Area de Conservación Guanacaste	2030	2043	2040	2055
Galápagos Islands	2017	2036	2027	2042
Lagoons of New Caledonia	2031	2040	2039	2050
Komodo National Park	2017	2025	2021	2032
Ujung Kulon National Park	2032	2043	2042	2053
Ogasawara Islands	2030	2038	2041	2049
Phoenix Islands Protected Area	2020	2035	2028	2040
Gulf of California	2044	2052	-----	-----
Archipiélago de Revillagigedo	2031	2042	2043	2052
Sian Ka'an	2025	2033	2033	2041
Rock Islands Southern Lagoon	2028	2036	2032	2044
Coiba National Park	2030	2043	2040	2053
Tubbataha Reefs Natural Park	2030	2039	2037	2048
Aldabra Atoll	2028	2036	2034	2042
East Rennell	2025	2033	2030	2044
iSimangaliso Wetland Park	2031	2040	2036	2048
Sanganeb Marine National Park and Dungonab Bay – Mukkawar Island Marine National Park	2037	2046	2055	2069
Everglades National Park	2036	2044	2056	2071
Papahānaumokuākea	2029	2041	2044	2052
Ha Long Bay	2077	2086	-----	-----
Socotra Archipelago	2040	2048	2061	2077

Severe bleaching stress threshold defined as DHW of 8 °C-weeks.

2025 2040 2055 never

Source: Heron, et al., 2017

Projections of extreme temperature increases were also carried out in the Bappenas study which used percentile data analysis to calculate the probability of changes in extreme sea surface temperature that could occur in the future. This extreme analysis was performed looking at the 99 percentile difference relative to the median.

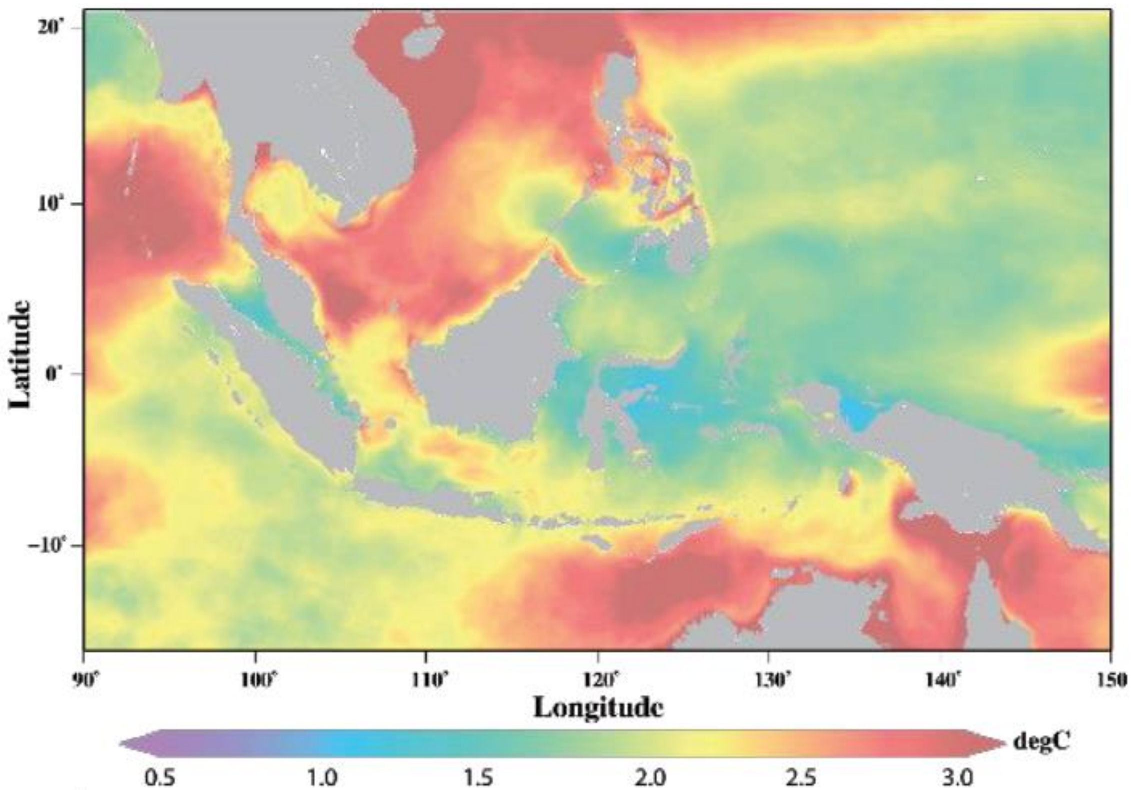


Figure 25 The value of extreme changes in sea surface temperature from the projection results of RCP4.5 2006-2040 (Bappenas, 2018).

Changes in sea surface temperature during extreme events vary from 1-3 °C (Figure 25). The highest changes can occur in the waters of the South China Sea, North West Kalimantan and south of the Savu Sea which can reach more than 3 °C. Meanwhile, in the interior of Indonesian seas such as the Java Sea, South Java Island and West Sumatra, Banda Sea and Sulawesi Sea the changes vary between 2-2.5 ° C. The smallest change occurred in the Makassar Strait and Tomini Bay at 1.3-1.5 ° C. The value of this change is quite high compared to the adaptability value of coral reefs of 1.5 ° C and if we consider extreme climatic factors such as ENSO and IOD, MJO which tends to increase in intensity, all coral reef ecosystems in Indonesian waters are expected to experience coral bleaching.

2.3.5 Overview and analysis of Anthropogenic Hazard

Destructive fishing is recognize as activities which has no boundaries and limitation, its activities it considered to be illegal by law in many countries, including Indonesia. However, due to a combination of socio economic condition and mis education, destructive fishing still become a permanent nuisance in fishing activity. This destructive fishing activity included in this study are blast fishing and poisonous fishing.

The effects of blast fishing can be devastating to both reefs and people. Prematurely exploding bombs have led to lost limbs and lives. Blast fishing also does not target the fish exclusively, but also destroyed the coral reefs. According to previous studies (Fox & Caldwell, 2006), in Komodo Island waters, the effect of blast fishing could obliterated reefs in the radius of 9 to 31 m^2, with various degree of destruction. For a blasts that occurred in water -5-10 m deep, using a kerosene-fertilizer mix in 300-mL glass soda bottles with homemade fuses, within a radius of approximately 0.5-1.5 m from the blast epicenter (hereafter, the "rubble zone"), the impact of the explosion shattered scleractinian corals into small rubble (1-10 cm). Surrounding the rubble zone, coral colonies had broken into larger pieces (10-50 cm) 1.5-4.0 m away from the epicenter ("the broken zone") (Fox & Caldwell, 2006).

Similar founding was reported by Burke et al which noted that, depending upon the distance from the substrate at the time of explosion, a typical 1-kg beer bottle bomb can leave a crater of rubble 1–2 m in diameter. The extent and severity of damage to reefs often depends on the amount and type of explosive, the depth of the water, and the distance to stands of corals. Regularly bombed reefs frequently exhibit 50–80 percent coral mortality (Burke, Selig, & Spalding, 2002).

Coral recovery from a single blast fishing could take up to 5-10 years, while with an extensive regional blast fishing recovery could take decades or centuries, even if the reef are then protected from further blasting (Fox & Caldwell, 2006).

Poisonous fishing does the same destructive effect to reefs, as found in Mandangin and Gili Raja island. Due to poisonous fishing, dead or bleached coral due to cyanide poisoning is found in these waters. Cyanide poisoning will destroyed algae which resided in the reefs polips, leaving only dead or bleached rocks (Hidayah & Nuzula, Pemetaan Sebaran Terumbu Karang Studi Kasus Selat Madura, Jawa Timur, 2014).

Marine accidents, purposely or unpurposely, also have high potentials to damage the reef, especially if the reef is in area of high shipping intensity activity. Busy port activity could give a high stress level to the near coral reefs group, opening a higher probability of accidents that could damage the reef or the community. One of its accidents are ship grounding. Unknown water chart or lack of navigation skills could lead to ship grounding. Coral reefs which located in a relatively shallow water becomes an “easy target” of this accident.

A literature review of ship grounding in Bangka Belitung Province analyze the effect of a ship (MV Lyric Poet) which run aground a group of coral reef in *Gosong Pesawat* area. The ship was a cargo ship (mother vessel) with length of 229 m and width of 32.25 m with Bahamas flag. It had grosstonage weight of 44,203 tonnes and deadweight of 81,276 tonnes, draught height of 11.2 m, and last recorded speed before grounding was of 11.6 knots. The event of the grounding of the MV Lyric Poet on the Bangka Waters, Bangka-Belitung Province, has caused damage to the coral reef ecosystem. There are four damage zones identified, i.e., trajectory, mound, propeller, and dispersion zone. It can be concluded that the hard coral coverage on the control location was 80.38% and on affected area was only 20%. Coral reef damage zones identified were trajectory zone, mound zone, propeller zone, and dispersion zone. Death of coral organisms and other biota reached 100%, leaving behind damaged, shattered, or dislodged coral structure. Corals are damaged with a total area of 13.540m2; equivalent to twice that of an international football field (Idris, Suharsono, & Fakhrurrozi, 2020).

Direct anthropogenic disaster (destructive fishing, ship grounding) as explain above is an irregular data collected from various sources which has no pre-existing database sources such as pre-existing natural hazard disaster databases as seen in Figure 7. This different source of anthropogenic data has different values compared to natural hazard disaster database, hence, not all information regarding its anthropogenic disaster impacts is available and ready to use for hazard indexing. To quantify and simplify its various value of impact and damages, direct anthropogenic hazard utilizes hazard events probability for development of anthropogenic hazard index for further risk assessments. This is incompliance with natural hazard index. From analysis, there were 123 valid anthropogenic disaster events (Table 15).

Table 15 Anthropogenic Disaster Events with probability of occurrence for seven study locations.

Type of Hazard	**Destructive Fishing**	**Ship Grounding**	**Oil Spill**	**Total**
Number of Events	47	74	3	123
Probability	0.38	0.60	0.02	1

Source: Analysis, 2021

Apart from collecting direct anthropogenic hazard events, this study also analyzes threats from human factors that can occur on coral reefs. The analysis is modified from a study conducted by WRI in 2011. In this study, there are 3 types of threats of human factor, namely: Coastal Development, Marine Based Pollution and Damage and Destructive Fishing.

Improper management of coastal development can threaten coral reefs through dredging, land reclamation, mining of sand and limestone, dumping of waste, and river runoff. Sewage discharge from human settlements increases nutrient and bacteria levels in coastal waters and can have an adverse impacts on reef health. In addition, undermanaged tourism can harm coral reefs, both through poorly planned and implemented construction and through careless recreation on reefs.

Coastal development analysis is based on the size of the physical and social factors of the coastal area which include coastal population size, type of port and airport, number of accommodations or tourism industry and the population growth rate and the presence or absence of reclamation in coastal areas. Marine based pollution analysis is based on shipping intensity, potential river run off and location of the closest oil infrastructure. Meanwhile, destructive fishing utilize the hazard index of anthropogenic disaster.

Table 16 Threat and damage potential model analyses for coral reefs based on WRI, 2011.

Subject / Stressor	Qualifier	High	Medium	Low
Ports: Threat distance scaled based on shipping volume (2003)	Very Large	0–30 km	30–60 km	Areas not classified as high or medium default to low.
	Large	0–20 km	20–40 km	
	Medium	0–10 km	10–20 km	
	Small	0–5 km	5–10 km	
	Very Small	0 km	0–5 km	
	Tiny	0 km	0–2 km	
Cruise Ports: Threat distance scaled based on expected annual ship visitation and passenger volume (2009–10)	Very Large	0–10 km	10–20 km	
	Large	0–6 km	6–12 km	
	Medium	0–4 km	4–8 km	
	Small	0–2 km	2–5 km	
	Very Small	0 km	0–3 km	
Shipping Intensity	Commercial and Research Vessels		Highest 5 percentile intensity	
Oil Infrastructure	Offshore oil rigs and associated infrastructure		0–4 km	

Source: Burke, Reytar, Spalding, & Perry, 2011

The analysis also considered past bleaching events as it may have resurface again in future climate change conditions and accelerated through destructive human activities. By combining anthropogenic hazard index and threats of human factor to coral reef, hence, the total risk of anthropogenic factor for coastal community as well to the coral ecosystem could be determined. A combination of high anthropogenic hazard index with a high threat of human factor could surely gives a higher risk probability for the coral reefs. While combination of low anthropogenic hazard index and high threat of human factor does not make it safer for coral reefs ecosystem nor the combination of high anthropogenic hazard index with low threat of human factor.

Previous study conducted by WRI 2011, stated coastal population sizes in threat is between 50,000 to over than 1 million inhabitants, with number population which are close and over 1 million is classified as a high threat eventhough is relative distances is over than 15 km. This study also uses coastal district population which is always located adjacent to the sea and classified into three types namely population between 0-250 thousand people as low threat, while 250-500 thousand people as a medium threat and above 500 thousand to over than 1 million people as a high threat.

This study also defines fishing port and shipping harbos as threat to coral reefs based on its number of port/harbor and its type. In Indonesia, fishing port is classified into 4 main classes namely Oceanic Fishing Ports (OFPs), Archipelagic Fishing Ports (AFPs), Coastal Fishing Ports (CFPs) and Fish Landing Centres (FLCs). OFPs are the largest ports and form the main gateways to the international export markets. Seven are currently operational. These ports have the capacity to shelter at least 100 fishing units over 60 GRT daily, mostly those operating in international or EEZ waters. The fish landing capacity is 200 t/day or 18,000-120,000 t/year. OFPs house general port facilities but also processing and cold storage facilities. In Muara Baru, one of the OFPs, for example, many processing facilities of Indonesia's large tuna exporters are located in or around the fishing port. Examples of OFPs are Nizam Zachman (DKI Jakarta), Bitung (North Sulawesi) and Belawan (Sumatra). AFPs are able to support 75 fishing vessels of 15-60 GT daily, that fish in archipelagic and EEZ waters. Daily fish landing capacity is around 40/50 t or 8,000-15,000 t on an annual basis. Currently, 16 of these ports exist which focus on local and export markets. CFPs can harbour 50 vessels ranging from 5-15 GT daily for vessels that operate in coastal waters and archipelagic waters. At the moment there are 43 CFPs, which have a fish landing capacity of 15-20 t/day or 3,000-4,000 t/year. Landings mainly serve the domestic market. CFPs provide general port facilities. FLCs are the smallest landing sites and are managed by the provincial government. FLCs can only provide support to small scale fishing units that operate in coastal waters. Daily landing capacity is 10 t, or 2,000 t/year which mainly supplies local markets.

Other than fisheries, coastal cities usually have container port and ferry port (major port or branch/feeder port) as means to transport person or good in or outside the city. Another type port/harbor which could potentially increase threat to coral reefs is port/harbor for oil and mining infrastructure. This type of port/harbors usually involves a large barge vessel or a tanker size vessel. This study examines the existence of all type of port/harbor in every study location, especially if its centralized in one area which significantly gives higher threat to the coastal ecosystem especially the coral reef.

Similar with port and harbor, airports type and its location also has potentially to be a threat to coral reefs, especially if it have high intensity flight activities and are located near the sea or coral reefs. Each study site which has airports and located near the coast is examined. High flight intensity means a high exchange of transport for people and goods, either for domestic importance or tourism importances. Its relative proximity with the sea or coast provided high accessibility which in further increases its threat to coastal ecosystem.

Table 17 Summary of Anthropogenic Hazard Risk Parameter (Adapted from WRI,2011).

Anthropogenic Hazard Risk Parameters (adapted from WRI, 2011)	Pandeglang	Klungkung	Makassar	Wakatobi	Berau	Raja Ampat	Rote Ndao
Number of Coastal District Population (2019)	1,233,581	215,542	1,470,303	217,803	114,510	94,074	148,506
Number of Ports/Harbor	1 CFP/6 FLC/45 Local Port	1 FP / 5 CFP	1 MP/1 OFP/ 2 CFP / at least 6 Local Port	1 FLC/ at least 9 Local Port	4 CFP/ More than 10 local port	4 CFP/ at least 90 local Port	1CFP/4 FLC/at least 3 local port
Number and distance of Airports from coast/reef	Tanjung Lesung Airfield, located at the coast. Non Operational airfield	NONE	Not In Range (Maros Airfield is around 8-10 km from coast)	At mainland Berau in riverside, accessible by riverboat and roads	At Wangi-Wangi Island and Tomia Island. All airport located at the coast	Marinda, Kabare and Gag Airfield. All airport located at the coast	At the center of the island, near coast
Tourism Center (Number of hotel)	168	207	207	289	21	99	26
shipping intensity	High Density in offshore, Low to Med nearshore	Med - High Density from mainland Bali, mainly tourism, High Density in the Strait	High Density Shipping and Ferries	High Density in Mining, Ferries and Med-High density in Tourism, local transport	Med to High Density activity from mainland to Wanci Island (capitol of Wakatobi), Underestimate of local interisland activity due to non existent of VMS/GPS	Med to High density of marine activity from interisland transport, fishing and tourism	High Density of Shipping in Baa Harbor and Ndao Nusa Harbor, low to med local transport
oil infrastrucure (rad 4 km)	Not in range (Exist at Cilegon)	Not In Range (Exist At Manggis TBBM)	YES	YES (in mainland Berau)	NONE	Not In Range (Exist at TBBM Sorong)	NONE
Summary	Medium	Medium	High	Medium	Low	High	Low

Source: Analysis, 2011

From analysis in seven study locations (Table 17) it is seen that Makassar coastal area has the highest anthropogenic factor threat among other city/regency. While low anthropogenic factor threat could be the same in Rote, Berau, Wakatobi and even Klungkung. Further analysis of the threat in each locations will be described in the following chapters.

2.4 Stakeholder Analysis and Mapping

Stakeholder analysis and mapping is carried out in three steps: 1) identification of a list of disaster management stakeholders and profiling based on the context of interest and influence based on sectors related to coastal disasters, 2) analysis of the relationship between disaster management agency, and 3) gap analysis of the capacity of disaster management stakeholders.

Table 18 Methodology for Stakeholder and Local Capacity Analysis.

Methodology for Scope of Work #5	Input Data
Identification, categorization of types of actors, and categorization according to the attributes of the level of interest and influence of stakeholders on coastal disaster management affairs (Pomeroy & Douvere, 2008; Bostick et al, 2016; Isa et al, 2019; Francis et al, 2019; Sapapthai et al., 2020) and Step 2 of BlueGuide for Coastal Resilience (TNC, 2021). This method produces a list of stakeholders for coastal disaster management in the seven locations at various levels, including government agencies (Central and Regional) and non-government organizations (including local research / education institutions, NGOs, and business actors in the study locations).	✓ Local Government Organization schemes and main functions ✓ Profile of related non-governmental organizations (online and offline)
Analysis of the relationship between stakeholders for disaster management (and emergency) using social network analysis). Figure in 2.2.2 illustrates the output of this analysis (Bisri, 2016; Bisri, 2017; Bisri et al., 2019, and other references here.	✓ Institutions' profile (online) ✓ Local organization duties and functions ✓ Indications of joint activities/programs between institutions
Gap analysis of the capacity of stakeholders in coastal disaster management affairs through qualitative analysis of policy documents, budgeting, and documentation of programs/activities (Artingsih et al, 2015; Pescaroli et al, 2020)	✓ Strategic Plan, Work Plan and Institutional Work Report of related government organizations ✓ Local budgeting ✓ Relevant NGO reports and profiles ✓ Types of related Local Agencies

2.4.1 Stakeholder Identification and Mapping

Referring to Table 18, at this stage the identification and categorization of the types of actors/stakeholders is divided into four special sectors/functions, namely disaster management, fisheries and maritime affairs, the environment, and coastal development in general (which includes cross-cutting affairs between spatial planning, public works, tourism, and other sector activities that have a locus in the coastal area). In addition, there is also a category of general stakeholders, if the actor in question does not specifically manage the sector/function in question but is found in a working/activity relationship with actors who carry out activities in the coastal area.

Table 19 Categorization of Stakeholders.

Sector	Sectoral stakeholder institutions (examples)	General stakeholder institutions (examples)
Disaster management	Regency LDMO Provincial LDMO	Assembly at regency level Regent Office Regency Secretariate
Marine and fisheries	Marine Agency	
Environment	Environmental Agency	
Coastal development (cross-cutting between spatial planning, public works, tourism, and other sector activities)	Planning Agency Transportation Agency Tourism Agency	

Types: National Government, Provincial Government, City/Regency Government, NGO, Business owner, Research/education institutions, Community Groups.

Furthermore, as shown in Table 18 above, the types of classified stakeholders include National Government actors, both Ministries/Agencies); Local Organization of the Provincial Government (Agencies, Offices, and so on); Local Organization of City/Regency Government (Agencies, Offices, etc.); Non-governmental organizations (NGOs), including non-government organizations that are often registered as foundations, for example the The Natural Conservacy; research/education institutions, including universities; as well as community groups, for example the Joint Business Group (*Kelompok Usaha Bersama/KUBE*) or Youth Organization (*Karang Taruna*).

Apart from the classification based on sector/function and type of institution, this study will also provide initial information on the level of importance/priority recommendation for further engagement. It is based on the BlueGuide stakeholder interest level matrix (TNC, 2021, p. 17). As shown in Figure 26, there are two axes for classification of stakeholders. The x-axis (horizontal) describes the positions and perspectives of stakeholders, which in this study are simplified into “positions and perspectives on disaster risk reduction and environmental protection in coastal areas”. Meanwhile, the y (vertical) axis describes the influence of stakeholders which is divided into three levels, namely:

1. Level 1 (Essential) stakeholder, stakeholders with the highest level of influence on a planning process and activities. Thus, it is highly recommended to have intense and routine contact and communication with this actor.
2. Stakeholders with level 2 (important), stakeholders with medium level of influence, so it is advisable to communicate regularly with this actor.

3. Stakeholders level 3 (Interesting), stakeholders with possible minor levels of influence, but who may still need to be involved/invited to key meetings of a program/activity formulation.

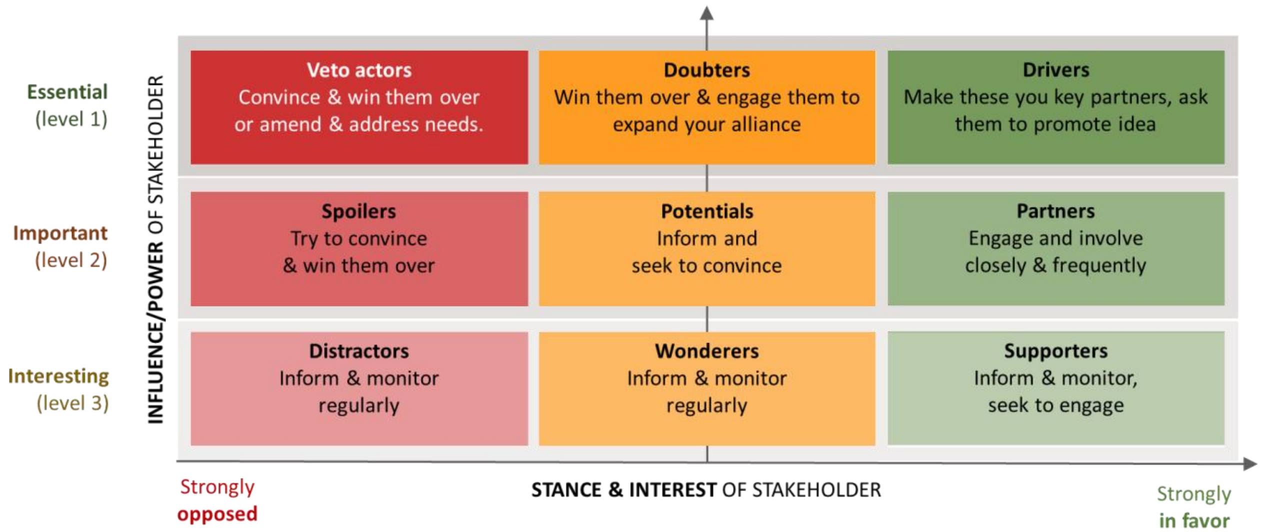


Figure 26 Classification of Influence and Stances of Stakeholder (TNC, 2021).

Based on the matrix in Figure 26, the identification and classification consist of 9 types of stakeholders with recommendation for engagement can be seen in the figure. In the program/activity planning cycle, after stakeholders can be identified and grouped into the matrix above, the program/activity initiator can relate to them according to the priority level and can determine which activities the actor will be involved in, for example in the initial analysis/study, planning, and implementation. Stakeholder relations strategies can minimize conflict. Stakeholder mapping is not a single analytical activity but must be updated according to the program/activity planning cycle.

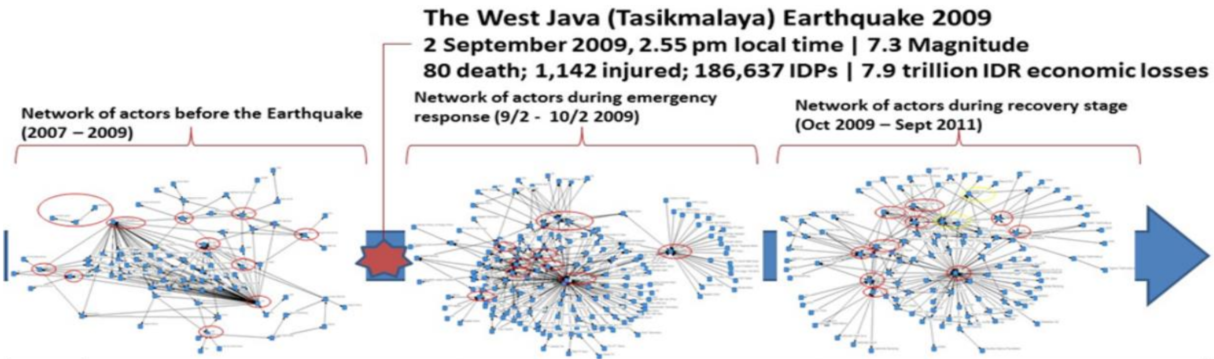
In this study, the process of identification and categorization of stakeholders according to affairs/sector, type of institution, and categorization according to Figure 26 is carried out based on secondary sources which include: 1) search results from research products compiled from the CARI! search engine based on "keywords" agreed with TNC (can be accessed here); 2) search results of policy documents, which can be accessed here; and 3) news search results from electronic media, with a combination of searches based on research "keywords", location, and coastal context using searches through GoogleNews. The determination of the stance of stakeholders and the relationship between stakeholders (will be explained further in 2.2.2) is still subjective from the study team based on the “sentiment” that can be identified from these secondary sources (positive - for example cooperation or collaboration, neutral - for example working relations. according to policy documents, or negative - for example indications of conflict found). Therefore, it is very important to carry out validation and verification for these initial findings, especially from YKAN staff at the study sites.

2.4.2 Social Network Analysis

Social Network Analysis (SNA) is an analytical tool to examine the structure and relationships in a network with various interacting actors (Prell, 2012) using visual exploration and various mathematical measurements (Varda, Forgette, Banks, & Contractor, 2009). The continued purpose of using SNA in general is to determine the impact of the network structure in an environment on an aspect under study. As shown in Figure 27 below, the network diagram and measurement analysis at the network and actor level are the main outputs of the analysis. In the case example in this illustration, the two outputs are used to determine the integration of cooperation between various actors in the 3 phases of disaster management.

The data used to perform network analysis using SNA can be primary (interviews, questionnaires, observations) or secondary data (documents, regulations, internet crawling data, etc.). From these various data sources, the actors involved in the network can be identified and the relationships between these actors can be extracted to form a network matrix. Creating a network matrix is a crucial process because it is necessary to produce network diagrams and perform network analysis and network actor analysis. Figure 27 illustrates the stages in SNA analysis using various types of data.

In the context of this study, a node or actor is an institution or organization (not an individual), while ties is the existence (presence/absence) of a joint program/activity and the existence of a working relationship regulated in regulations/policies for two or more actors in the sectors, namely: disaster management, environment, coastal management, and development in coastal areas. As an initial analysis to help identify key stakeholders, an estimate of the degree centrality and betweenness centrality values will be carried out based on existing network data. Degree centrality is an index that calculates the proportion of the number of relationships between an actor compared to the total number of existing relationships in a network (Prell, 2012). Meanwhile, betweenness centrality is a proxy for "potential coordinator" and is generated from calculating the frequency of how often an "actor" is between two or more other actors and compared to the total relationships that exist in a network (Prell, 2012).



Phase	Mean of Degree Centrality (by Type of Actor)								
	Edu	Foreign govt	Central Govt	Prov Govt	Mun. Govt	INGO	NGO	UN	Private
Pre	10,290	1,000	2,910	4,190	2,800	2,170	3,000	4,330	1,000
ER	2,217	1,500	5,000	10,118	2,825	3,417	2,595	6,875	1,222
Post	3,000	0,000	5,140	3,130	4,630	3,780	2,090	11,710	2,000
Phase	Mean of Betweenes Centrality (by Type of Actor)								
Pre	278,670	0,000	135,570	151,290	58,900	87,950	183,630	124,670	0,000
ER	55,748	0,000	232,847	1280,085	143,050	77,424	51,909	167,117	0,0304
Post	223,300	0,000	224,410	208,960	66,220	223,690	54,670	945,670	1,000

SNA Measurements	Pre Earthquake Phase	Emergency Response Phase	Post Earthquake Phase
Closeness	Farness (4692.842)	Farness (7503.864)	Farness (4908.533)
Density	0.0241	0.0184	0.0237
Cliques Identified	1 clique	14 cliques (minimum set size 4)	19 cliques (minimum set size 3)

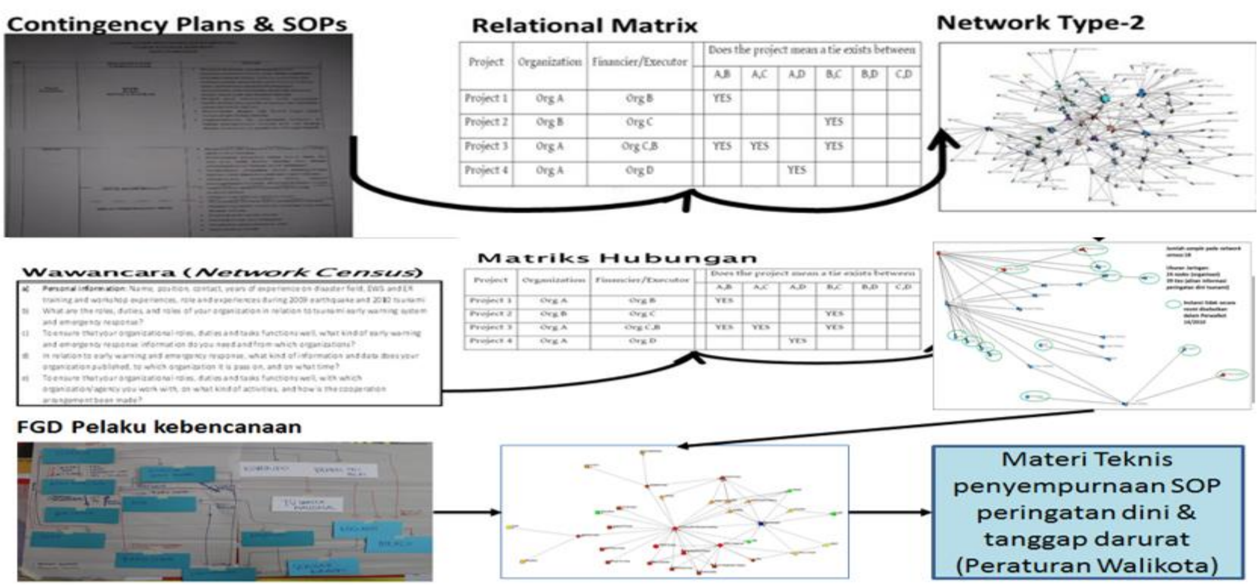


Figure 27 Output Illustration of Scope of Work #5 – Stakeholder network mapping in Disaster Risk Management (Bisri, 2017).

In creating program/project interventions, the SNA can be used to identify networks of influential actors within a community. Understanding influential actors and their networks can be useful for knowing the roles and positions of actors so that they can take effective steps. (Berdej & Armitage, 2016) examined the role of bridging organizations in the management of marine conservation in Indonesia, particularly in the Nusa Penida and Buleleng areas. The research found that there was one bridging organization in the network for the Nusa Penida area and three bridging organizations that worked together in the network for the Buleleng area. The existence of various bridging organizations in these conservation areas indicates a more adaptive and collaborative governance. This has led to interaction between stakeholders, exchange of information and resources, and a platform for collaboration, capacity building, and learning so that the output of the conservation activities carried out has a more real impact. On the other hand, governance that is not well organized can cause various problems in collaboration so that the desired goals will be more difficult to achieve.

In this baseline assessment, stakeholder identification and analysis of the relationship between stakeholders are carried out to compare the level of adaptive capacity in 7 city and regencies in coastal disaster management and environmental conservation, particularly in water areas. The actors described in the outcome of this inter-stakeholder relationship analysis describe various agencies and institutions at the national, provincial, city/regency level, as well as non-governmental organizations, community groups and business entities that play a role in disaster management and environmental conservation in the city and regency studied. The presence of a line connecting the two actors in the stakeholder relationship analysis output, also called ties, illustrates the collaboration between the two actors identified in activities related to disaster management and environmental conservation. In addition, various measurements at the network and actor level can be used as indicators of good collaboration between agencies in the city/regency being studied, as well as identifying (several) strategic actors who have the potential to be invited to collaborate so that intervention objectives can be achieved more effectively.

In reference Table 18 analysis of relationships between stakeholders and analysis of relationships between stakeholders will be made using input data in the form of secondary data, which includes regulatory documents regarding the organizational structure and work procedures of city/regency as well as related Provinces and Nationalities, institutional profiles as available agency websites, various records of activities and programs obtained through official documents or websites as well as internet crawling.

2.5 Local Capacity Analysis

To support disaster risk assessment in selected coastal areas in Indonesia, analysis is needed to understand the level of stakeholder capacity. The analysis process is carried out qualitatively with the steps below, combined with quantitative assessment expressions by the Study Team based on the indicators of the Disaster Safe Area Service Standard (SPDAB) (BNPB, 2020) which is a combination of indicators formulated using factor analysis on various standards referring to national, regional, and international resilience index. The justification for the use of the SPDAB indicators is given at the end of this section.

The steps for analyzing the gap in the capacity of stakeholders are as follows:

1. Initial capacity, presence/absence and class (Type A or B) for LDMO, environmental agency, marine/fishery agency, development planning agency, spatial planning agency; as well as the number of personnel for each organization and the total compared to the total population.
2. Existence of vertical agency offices (Ministry/Agencies), particularly: SAR office, Meteorological Office, Marine unit class (Kodim/Korem), Indonesian Police unit class; as well as the number of personnel for each agency and the total compared to the total population.
3. Existence of Disaster Risk Assessment and Disaster Management Plan documents, as well as tracing of Disaster Management Plan documents regarding the existence, number, and intensity of special programs/activities for DRR in coastal areas.
4. The amount of the budget for LDMO, environmental agency, marine/fisheries agency, development planning agency, spatial planning agency compared to Local Budget; then compared with the total budget expenditure plan. This step will analyze data for the last 5 years, if available
5. Existence (presence/absence) of DRR forums and environmental preservation forums (or similar), across governmental agencies and with non-government stakeholders
6. Number and type of financial institutions
7. Number and type of health facilities, as well as number of health personnel (total); and the ratio to the total population
8. Existence (presence/absence) and number of non-government actors for disaster management, environmental protection/conservation, especially in coastal areas.
9. Triangulation with the DFI Value and comparison of the DFI value with the hazard and vulnerability component values on the IRBI value for each location
10. Triangulation with *SPM Permendagri 101/2018* value/performance (if any)
11. Triangulation with the calculated Value ScoreCard/USAID-APIK/KARINA (if any)
12. Estimation of the value of the SPDAB indicators by the study team. Note: this is incomplete because it is not done in a 360 way according to the SPDAB Academic Paper, but it is sufficient for initial information.
13. Comparison of the final SPDAB scores of the seven locations, and class division of the numerator factors in a later risk assessment.

The proxy for the value of regional capacity and resilience at the seven study locations will be approached by evaluation using SPDAB indicators (BNPB, 2020). The SPDAB document is not yet regional capacity assessment tool that is yet legally established by BNPB, but it has been prepared as a basis for updating the Regional Resilience Index (IKD, along with its 71 indicators) calculation tool that had been used by BNPB since 2017. The SPDAB concept was also developed by the CARI! Team and in consultation with various stakeholders to ensure that the SPDAB indicators are comprehensive in assessing the resilience of a region and at the same time can be carried out massively. The SPDAB concept is also developed through factor analysis of substance and indicator index/reference standards related to national and international regional resilience, namely: Disaster Resilience Score Card (UNDRR, 2020); Regional Resilience Index (BNPB, 2017); Guidelines for Assessment of Disaster Resilient Districts/Cities (USAID-APIK, 2017); Permendagri 101/2018, SPM for disaster management; Policy Brief "Developing a Disaster Resilient District / City and Climate Change" (KARINA, 2019); and ISO 37123: 2019 Indicators for Resilient city (ISO, 2019). The SPDAB concept and indicators have also been tested by BNPB to calculate the resilience value of West Manggarai Regency, East Nusa Tenggara, in 2020.

The SPDAB compound indicators can be said to be the essence of the six reference standards/indexes mentioned above and are made with due observance of implementation principles and are easy to implement. The structure and indicators compiling the SPDAB consist of four standard pillars: 1) Governance standards, policies and disaster management planning; 2) Standard services for preparedness and socio-economic strengthening; 3) Critical infrastructure protection and recovery readiness standards; and 4) Disaster emergency service standards. In total, there are 26 SPDAB indicators, with each indicator having three achievement classes (minimum, medium, and maximum). Assessment of SPDAB indicators, ideally it should be carried out by representatives of three levels of government (Central, Provincial and City/Regency) as well as representatives of independent institutions; however, for the Coastal Disaster Risk Assessment, only the fourth assessment will be carried out due to constraints on time, scope of work, and mobility due to COVID-19. There is a calculator to generate the SPDAB aggregate score, with 5 regional achievement classes. For the record, SPDAB pillars and indicators are arranged in such a way that the measurement method and period are not dependent on and affected by the presence or absence of a disaster and are made to be measured during normal times. Thus, the context of disaster recovery is measured in terms of "readiness to undertake recovery". The image below shows an illustration of the concept of calculating regional resilience with SPDAB.

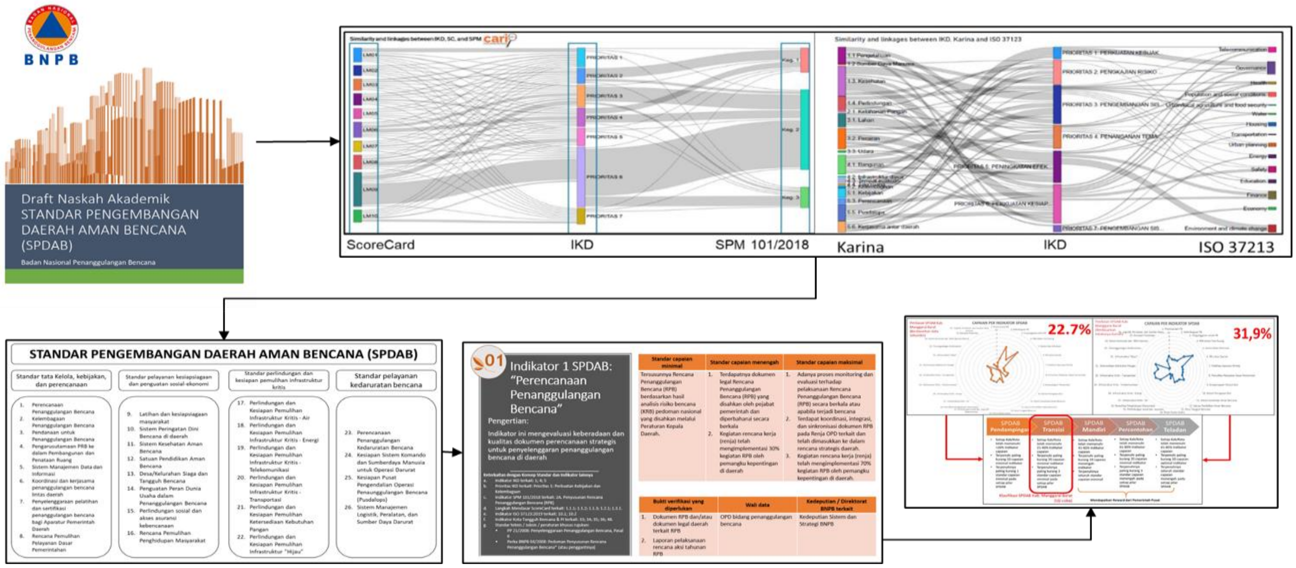


Figure 28 Concept Illustration of Calculating Regional Resilience with SPDAB (BNPB, 2020).

3. Risk and Disaster Management Profile of Pandeglang

3.1 Overview of Pandeglang

Pandeglang Regency is an administrative area of Banten Province which is located at the westernmost point of Java Island. This district is directly opposite the Indian Ocean in the western and southern parts. Administratively, it is divided into 35 districts consisting of 326 villages and 13 sub-districts. Out of all districts, 10 districts are in coastal areas or have coastlines, namely Sumur, Cimanggu, Cibitung, Cikeusik, Cigeulis, Panimbang, Pagelaran, Sukaresmi, Labuan, and Carita.

Table 20 Area size, number of islands and the number of Villages / Sub-districts in the Coastal Delineation of Pandeglang Regency.

No	District	Area (km^2)	Percentage of Regency Area	Amount of Island	Amount of Sub-district
1	Sumur	648.91	23.17	29	7
2	Cimanggu	159.70	5.70	0	12
3	Cibitung	121.88	4.35	0	10
4	Cikeusik	208.29	7.43	2	14
5	Cigeulis	176.75	6.31	0	9
6	Panimbang	101.20	3.61	1	6
7	Pagelaran	42.66	1.52	0	13
8	Sukaresmi	50.62	1.80	0	10
9	Labuan	16.38	0.58	1	9
10	Carita	70.82	2.52	0	10
TOTAL		**1597.20**	**56.99**	**33**	**100**

Source: Pandeglang Regency in Figures 2020, BPS, 2020,

Table 21 Demographic Conditions in the Coastal Delineation of Pandeglang Regency.

No	District	Amount of Population	Rate of Population Growth	Percentage of Population	Population Density per km^2	Sex Ratio
1	Sumur	24,270	0.16	1.97	0.37	103.40
2	Cimanggu	36,880	0.28	2.99	2.31	103.42
3	Cibitung	20,417	0.16	1.66	1.68	105.73
4	Cikeusik	49,775	0.16	4.04	2.39	104.87
5	Cigeulis	33,739	0.22	2.74	1.91	107.61
6	Panimbang	50,101	0.13	4.06	4.95	104.30
7	Pagelaran	36,847	0.28	2.99	8.64	102.88
8	Sukaresmi	35,924	0.25	2.91	7.10	104.37
9	Labuan	53,882	0.07	4.37	32.90	106.10
10	Carita	33,260	0.3	2.70	4.70	103.15
TOTAL		**375,095**	**0.20**	**3.04**	**6.70**	**104.58**

Source: Pandeglang Regency in Figures 2020, BPS, 2020, Labuan District is the district with the largest population in Pandeglang Regency, reaching 53,882 people in 2019 with the smallest area of 15.66 km2. Thus, it is become the most densely populated district with a population density of 32.9 people / km2.

Based on the direction of the National Spatial Plan (RTRW) , Pandeglang is designated as a Regional Activity Center (PKW) which functions to encourage the development of production center cities. PKW is an urban area purposedly to serve provincial scale activities or several regencies/cities. In the Banten Province RTRW , Pandeglang is included in the Development Working Area (WKP) III, together with Lebak Regency which is directed to the development of forestry, agriculture, mining, tourism, marine, and fishery activities. Derived in the RTRW of Pandeglang Regency , PKW Pandeglang has the main function as a center for government activities, trade and service areas, industry, tourism, regional economies, education, health, worship, transportation nodes, and community service centers. Furthermore, the marine waters around Banten are a National Strategic Area in the form of a State Border Area on the open seas which functions as rehabilitation and development of a national strategic area with a defense and security point of interest.

There is a conservation area in Pandeglang Regency in the form of a national park, a forest park, a natural tourism park, and a mangrove forested coastal area called Ujung Kulon National Park. The Ujung Kulon National Park has an area of approximately 78,619 hectares (9.09%) of the Banten Province total area which includes Sumur District and Cimanggu District. Sumur District is a buffer zone for the Ujung Kulon National Park. The Ujung Kulon National Park area includes Mount Honje, Panaitan Island, Peucang Island, and Handeuleum Island Area.

In the economic aspect, the sectors driving the regional economy can be seen from the contribution of these sectors to the Gross Regional Domestic Product (GRDP). GRDP is the amount of added value generated by all business units in a certain area or is the sum of the value of final goods and services produced by all economic units in an area. Based on data from Pandeglang Regency in Figures 2020, the value of GRDP in Pandeglang Regency reached IDR 28.32 trillion in 2019, with the most contributing sectors are Agriculture, Forestry, and Fisheries. However, seen from the PDRB growth rate of each sub-sector in the Agriculture, Forestry, and Fisheries sectors, the fisheries sub-sector is not a high growth rate, which is only 5.2% in 2018. While looking at the GRDP growth in recent years based on constant prices, there is a PDRB growth in Pandeglang Regency of 5.04% in 2019, with the sector with the highest growth rate, namely the sector 1) Real Estate; 2) Construction; and 3) Providing Accommodation and Food and Drink.

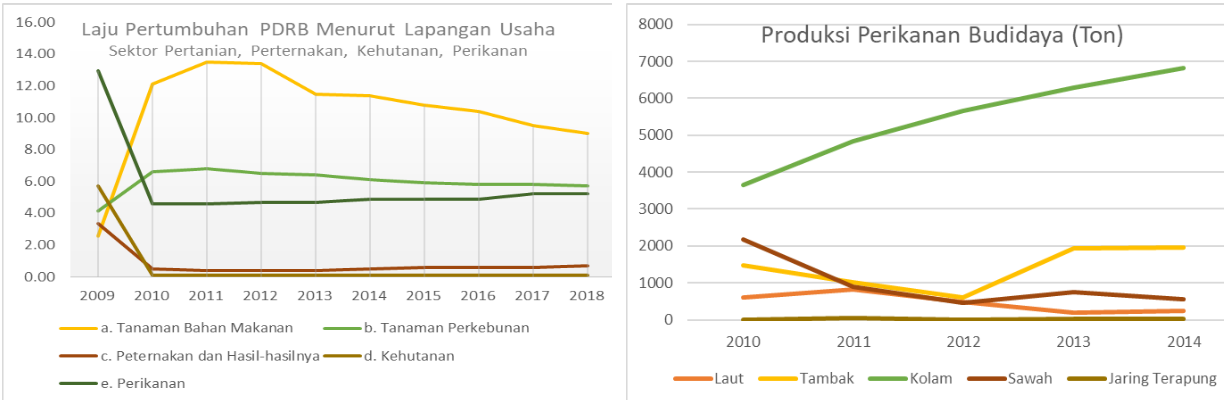


Figure 29 Overview of the Economic Sector of Pandeglang Regency, especially the fisheries sector (Analysis, 2021).

The economy in terms of capture fisheries in Pandeglang Regency shows, the production of fish catch reached 13,050 tons with a value of Rp. 355,012,257,000, - in 2019. Catching units commonly used are lifting nets (1,712), gill nets (1,661), motorboats (1,047), and trawl nets (727). The highest aquaculture production is pond aquaculture with a total production of 6,812 tonnes in 2014 or 71.08% of total aquaculture production. Meanwhile, marine aquaculture only contributed 236 tons or 2.46%.

3.2 Summary of Past Disaster Events in Pandeglang

3.2.1 Past disaster events due to natural hazards and sudden onset in nature

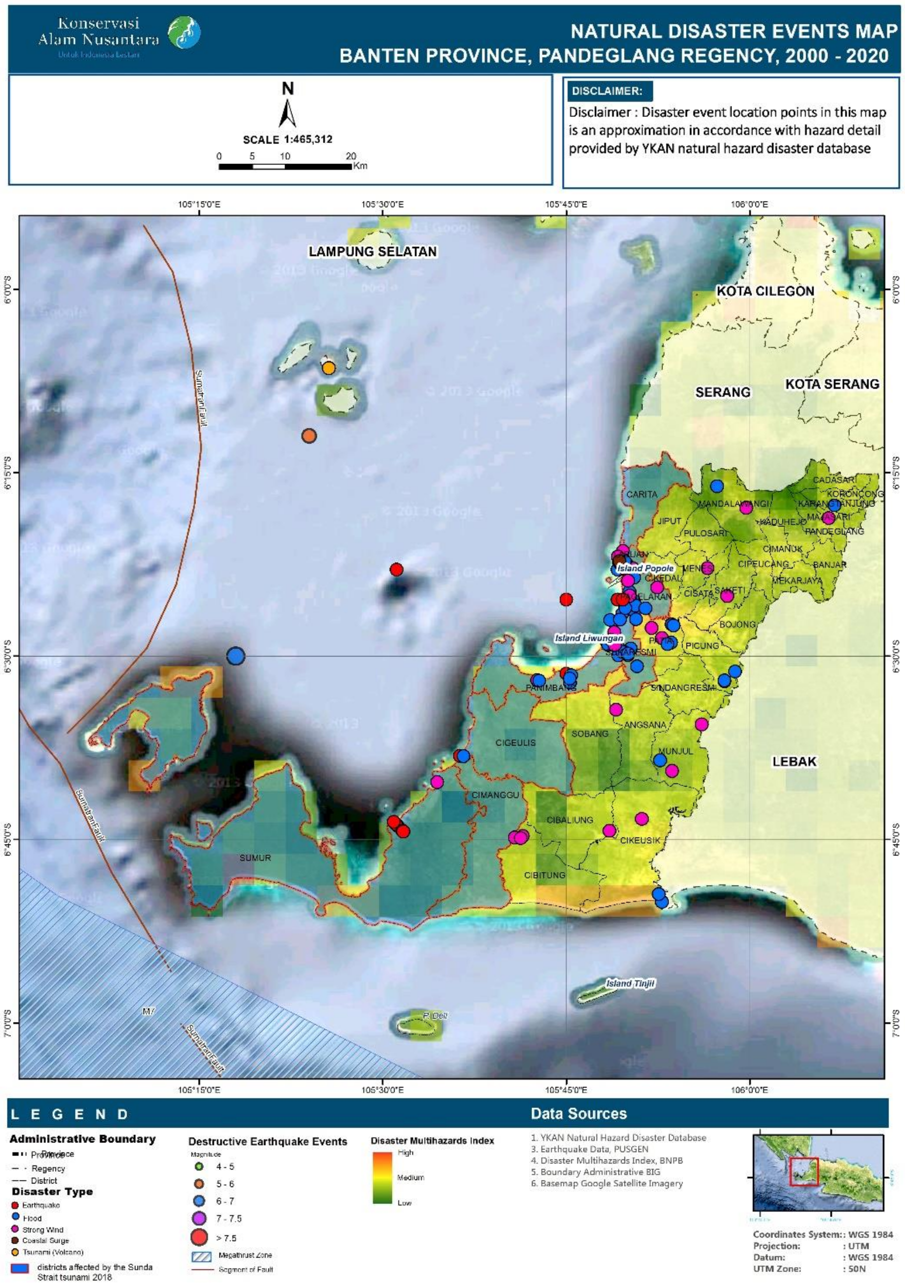


Figure 30 Map of Natural Disaster Events in Pandeglang Regency 2000-2020 (Analysis, 2021).

Pandeglang is a regency on the west side of Banten Province which is adjacent to the Indian Ocean and has a topography that extends from the coast to the mountains. Pandeglang Regency is threatened by several natural disasters such as earthquakes, tsunamis, floods, landslides, extreme waves/abrasions, and volcanic eruptions.

Pandeglang is also located close to Mount Krakatau which lies in the Sunda Strait. The volcanic and tsunami disasters in 2018 proved that the threat from volcanoes and tsunamis to the Pandeglang area and Banten Province is something that needs to be taken into account for disaster mitigation. However, the southern region of Pandeglang which borders the Indian Ocean also makes it close to the threat of tropical cyclones, such as the one that occurred in 2007, where there was the Jacob tropical cyclone phenomenon that crossed the southern region of Java. The cyclone that hit the southern coast of Java caused disruption on fisheries or transportation activity, making it difficult for fishermen to go to sea.

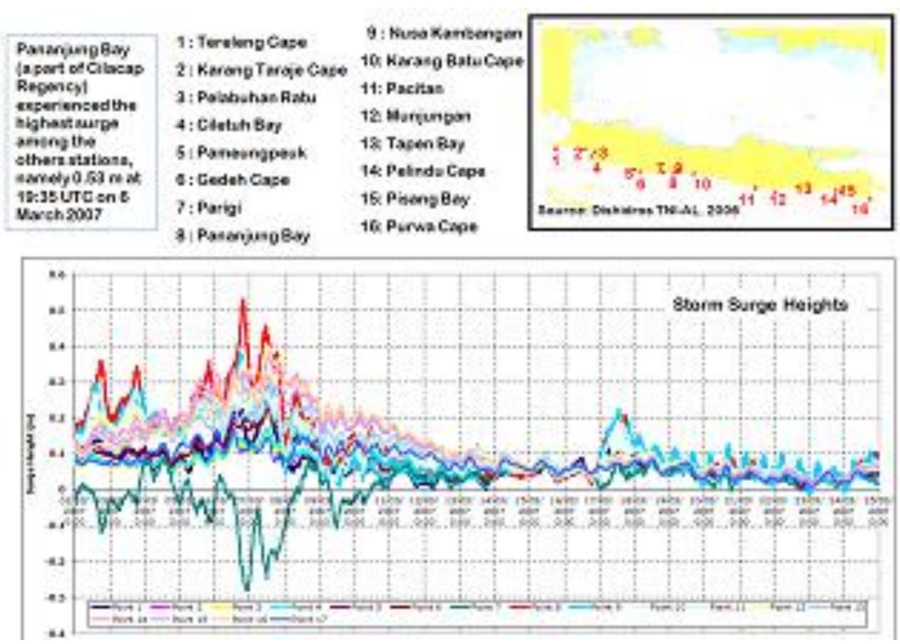


Figure 31 Distribution of extreme wave height as a result of model simulation on the southern coast of Java Island (Ningsih N. S., 2010).

Through modeling and analysis of the storm phenomenon, Ningsih (2010) shows an average sea level rise (SLR) of about 50 cm relative to normal MSL, during the Jacob Tropical Cyclone as shown in the image below (Ningsih, 2010). This study (Ningsih N. S., 2010) also states that there are indications of the emergence of extreme waves (swell) from storms in the Cape of Good Hope, South Africa and Kelvin Waves in the Indian Ocean which spread and cause quite destructive tidal waves or storm surges in the southern areas of Java, Bali to NTB in May 2007.

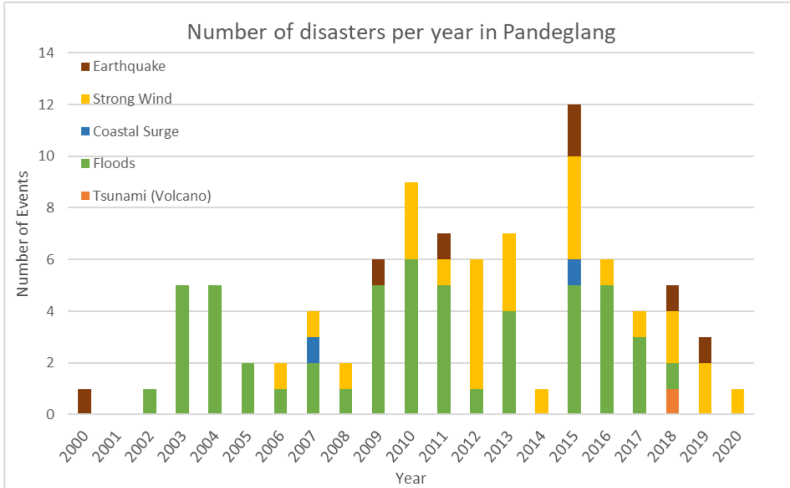


Figure 32 Number of Disasters due to natural hazards in Pandeglang Regency 2000-2020 (Analysis, 2021)

With such geographical position, the number of natural disasters in Pandeglang for 20 years is the highest natural events among other study location with 107 events. The highest disaster intensity was during 2010-2020 period (Figure 32). Of all the disasters, 50% of the disasters were floods, with 52 incidents, with a fairly stable frequency in the 2000-2010 period (28 events) and the 2010-2020 period (24 events). Monsoon storms accompanied by strong winds in the rainy season that often occur together with high intensity of rainfall can also cause floods to the low plain of coastal area of Pandeglang districts.

Table 22 Summary of Impacts of Disaster Due to Natural Hazards in Pandeglang Regency

District Name	Frequency Index	Severity Index	Hazard Index
Sumur	0.60	0.80	0.69
Cimanggu	0.40	0.60	0.49
Cibaliung	0.20	0.20	0.20
Cibitung	0.20	0.40	0.28
Cikeusik	0.40	1.00	0.63
Cigeulis	0.40	0.80	0.57
Panimbang	0.80	1.00	0.89
Sobang	0.20	1.00	0.45
Munjul	0.60	1.00	0.77
Angsana	0.40	1.00	0.63
Sindangresmi	0.20	1.00	0.45

District Name	Frequency Index	Severity Index	Hazard Index
Picung	0.40	1.00	0.63
Bojong	0.00	0.00	0.00
Saketi	0.20	0.80	0.40
Cisata	0.00	0.00	0.00
Pagelaran	1.00	1.00	1.00
Patia	1.00	1.00	1.00
Sukaresmi	1.00	1.00	1.00
Labuan	1.00	1.00	1.00
Carita	0.60	1.00	0.77
Jiput	0.00	0.00	0.00
Cikedal	0.00	0.00	0.00
Menes	0.20	0.40	0.28
Pulosari	0.00	0.00	0.00
Mandalawangi	0.20	0.60	0.35
Cimanuk	0.00	0.00	0.00
Cipeucang	0.20	0.60	0.35
Banjar	0.20	0.20	0.20
Kaduhejo	0.00	0.00	0.00
Mekarjaya	0.00	0.00	0.00
Pandeglang	0.00	0.00	0.00
Majasari	0.00	0.00	0.00
Cadasari	0.00	0.00	0.00
Karangtanjung	0.00	0.00	0.00
Koroncong	0.00	0.00	0.00

Source: Analysis, 2021

From the database of collected natural hazard events, the compiled impact matrix describes the losses and casualties incurred by each disaster in the 2000-2020 period and transfom it into a hazard index as seen in Table 20 above. From the above graphic and table it is seen that the flood disaster events which sometimes occurred twice in a year is one of the biggest causes of severity perceived by Pandeglang coastal community especially in Pagelaran, Patia, Sukaresmi and Labuan districts.

With a fairly frequent frequency, flood disasters event could cause the number of affected communities up to 40 thousand people and more than 28 thousand people have been displaced in the past 20 years (a more complete hazard index table could be seen in annexes). The impact of natural disasters caused by this flood also causes huge economic losses which in turn has a large potential to disturb the

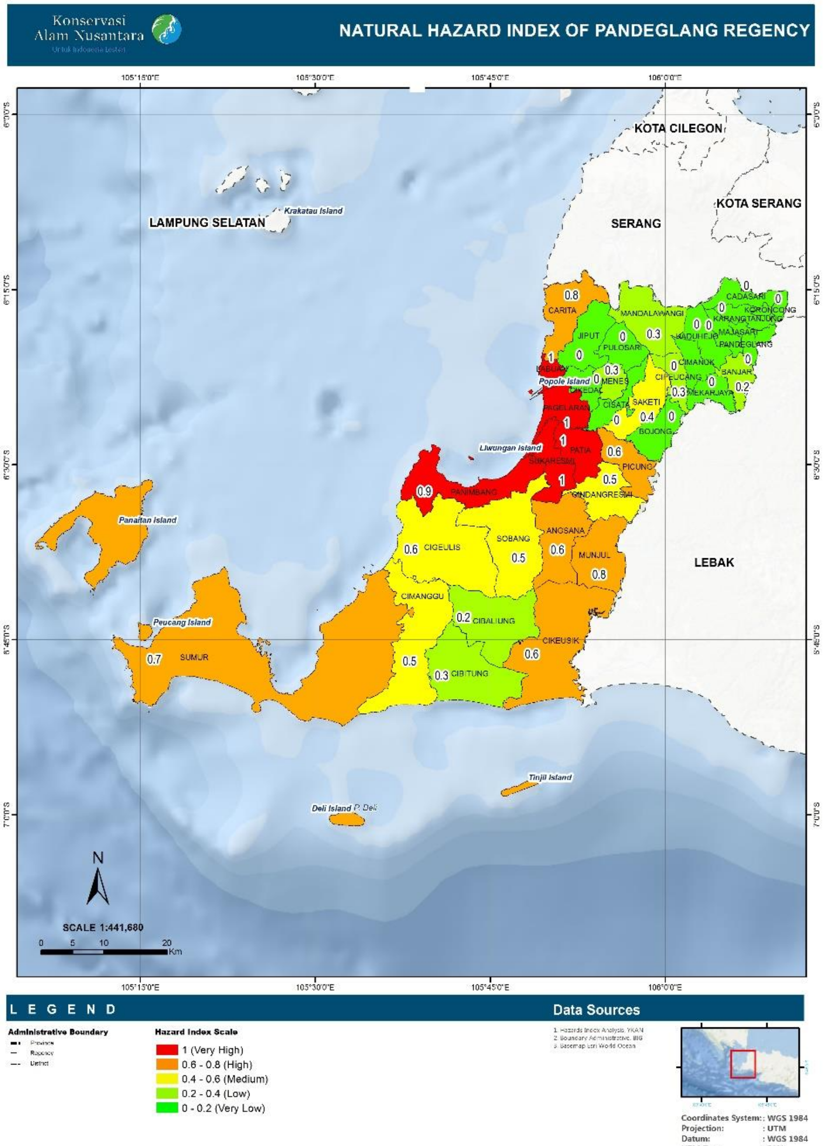


Figure 33 Natural Hazard Index Map of Pandeglang Regency (Analysis, 2021)

In the DIBI database along with other disaster database (EMDAT, ADInet etc), the Sunda Strait Krakatau Tsunami in December 2018 caused in 453 fatalities, 47,778 suffering, 28,139 displaced persons and more than 80 trillion IDR of losses in various sectors. Even though it has a smaller return period, when an earthquake and tsunami occur, the loss is significantly large. This is different from the frequency of floods which can occur almost every year and cause repeated damage. The value of losses per year can be smaller but the value of accumulated losses per decade will be the same or greater than other disasters. This accumulated loss value will greatly disrupt the livelihoods of the coastal community of Pandeglang.

From the results of the analysis obtained, natural disasters that occur which can cause environmental degradation or disturb coral reefs are found in volcanic and tsunami disasters. Prawira, (2020) shows that the coral community after the tsunami showed a significant increase in density and there was an increase or decrease in coral recruitment. This results shows a rather positive impact rather than the Wu et al, 2018 study that suggest Vulcanic materials which penetrated the sea could contaminate the water (sub chapter 2.3.4 .C)

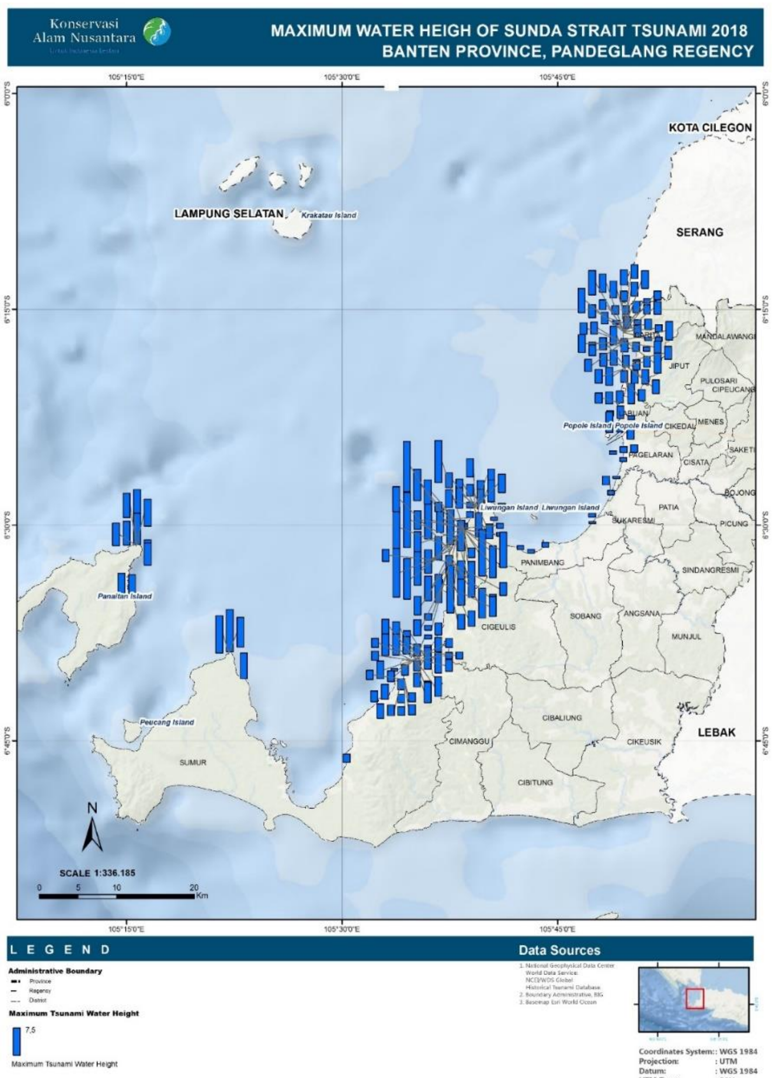


Figure 34 Tsunami Run Up during 2018 Sunda Strait Tsunami (Analysis, 2021).

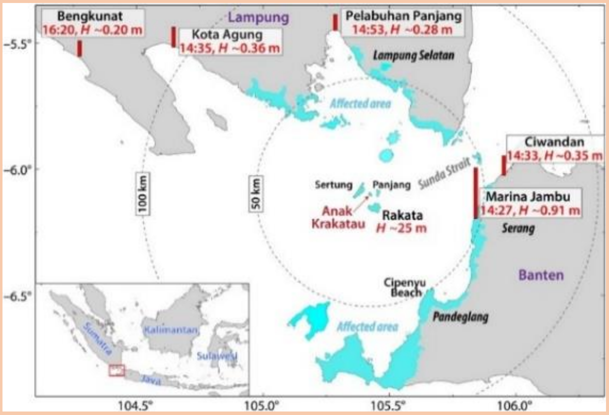
The damages and losses estimation from past hazards/stressors was calculated using the Blue Guide Calculator (The Nature Conservation, 2020) and the results were showed in Figure 35 below. In brief, the most frequent and damaging natural hazards in Pandeglang Regency are flood, followed by tsunami and earthquake. Over ten years, floods give damages and losses estimation of approximately IDR 36.74 trillion in total with the annualised value reaches IDR 91.85 trillion, while tsunami was estimated to possess damages and losses of approximately IDR 102.37 billion in total with annualised value of about IDR 10.24 billion.

Collect and add data on damages and losses from past hazards/stressors over the past ten years.					
HAZARD/STRESSOR 1 (Most damaging)		**HAZARD/STRESSOR 2**		**HAZARD/STRESSOR 3**	
List the most damaging hazard/stressor	Flood	List the second-most damaging hazard/stressor	Tsunami	List the third-most damaging hazard/stressor	Earthquake
How many times has this occurred over the past ten years?	25.0	How many times has this occurred over the past ten years?	1.0	How many times has this occurred over the past ten years?	12.0
The annual probability rate (APR) for this hazard is:	2.5	The annual probability rate (APR) for this hazard is:	0.1	The annual probability rate (APR) for this hazard is:	1.2
What currency will you use for monetary figures?	IDR	What currency will you use for monetary figures?	IDR	What currency will you use for monetary figures?	IDR
Damages (monetary values)		**Damages (monetary values)**		**Damages (monetary values)**	
Damages to homes	639,420,000,000	Damages to homes	0	Damages to homes	126,600,000,000
Damages to business assets	35,970,038,461,539	Damages to business assets	0	Damages to business assets	2,500,000,000
Damages to public infrastructure	700,000,000	Damages to public infrastructure	0	Damages to public infrastructure	5,750,000,000
Other damages (e.g. loss of land from erosion)	0	Other damages (e.g. loss of land from erosion)	0	Other damages (e.g. loss of land from erosion)	0
Total damages	36,610,158,461,539	Total damages	16,425,350,000	Total damages	134,850,000,000
Direct losses (monetary values)		**Direct losses (monetary values)**		**Direct losses (monetary values)**	
Losses in produce		Losses in produce	0	Losses in produce	0
Losses in income		Losses in income	0	Losses in income	0
Other direct losses		Other direct losses	0	Other direct losses	0
Total direct losses	0	Total direct losses	63,669,600,000	Total direct losses	0
Indirect losses (monetary values)		**Indirect losses (monetary values)**		**Indirect losses (monetary values)**	
Prolonged losses from produce sales	0	Prolonged losses from produce sales	0	Prolonged losses from produce sales	0
Prolonged income losses	0	Prolonged income losses	0	Prolonged income losses	0
Other indirect losses	131,392,500,000	Other indirect losses	22,275,000,000	Other indirect losses	0
Total indirect losses	131,392,500,000	Total indirect losses	22,275,000,000	Total indirect losses	0
Hazard 1: Total damages and losses	36,741,550,961,539	Hazard 2: Total damages and losses	102,369,950,000	Hazard 3: Total damages and losses	134,850,000,000
Hazard 1: Annualised damages and losses	91,853,877,403,848	Hazard 2: Annualised damages and losses	10,236,995,000	Hazard 3: Annualised damages and losses	161,820,000,000
The combined damages and losses from all four hazards/stressors over ten years have been:			36,978,770,911,539		
On an annual basis, the combined damages and losses over ten years have been:			92,025,934,398,848		

Figure 35 Past Damages and Loss Estimation Pandeglang Regency (Analysis, 2021).

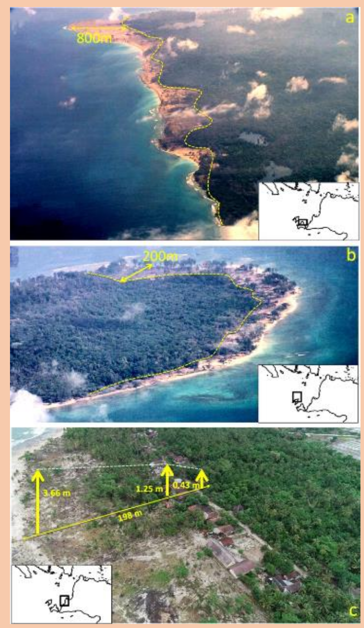
The damages and losses estimation from past hazards/stressors was done using the Blue Guide Calculator (The Nature Conservation, 2020) and the results were showed in Figure 35. In brief, the most frequent and damaging natural hazards in Pandeglang Regency are flood, followed by tsunami and earthquake. Over ten years, floods give damages and losses estimation of approximately IDR 36.74 trillion in total with the annualised value reaches IDR 91.85 trillion, while tsunami was estimated to possess damages and losses of approximately IDR 102.37 billion in total with annualised value of about IDR 10.24 billion. Earthquakes were found to produce higher monetary values than tsunami in terms of damages and losses, reaching IDR 134 billion in total and IDR 161.82 billion annualised. Further, the combined damages and losses monetary value from all the hazards/stressors over ten years was calculated to be around IDR 36.98 trillion with IDR 92.02 trillion calculated in an annual basis.

BOX 1: Pandeglang / Anak Krakatau Tsunami 2018



Months of increased activity from Anak Krakatau volcano has mount up into a dramatic increases in December 22, 2018. Hundreds of eruption occurred from 12 to 18 pm, a warning was issued by local authorities to noc conduct any activity within 2 km from the volcano. Around 21 pm a large eruption and continous tremors are detected. The eruption had caused the collapse the southwest portion of the volcano, which triggered a tsunami. Around thirty minutes later, 21:27 pm BMKG detected a tsunami which hit beaches in Lampung and Banten (*Cyan* zones indicate areas affected by the tsunami, adapted from the map of Tsunami Selat Sunda created by Badan Nasional Penanggulangan Bencana dated 14 January 2019. Zero-to-peak wave heights (*H*) and arrival times (hh:mm UTC on 22 December 2018) are from Joint Research Centre emergency reporting released by 24 December 2018 (Ye et al, 2018)). *In Pandeglang, the tsunami has also hit Tanjung Lesung area which as a popular tourist destination especially at that time people has arrived in the location for Christmas and New Year Holiday.*

The collapse of Anak Krakatau mountain, trigger a sub marine landside which produces tsunami with strong forces. Post-tsunami surveys conducted by Muhari et al, 2019 revealed moderate tsunami height along the coast of Sumatra and Java with maximum surveyed runup of 13.5 m and maximum inundation distance of 330 m which destroys vegetation and lift coral boulder to the land. At small islands located close to the volcano, extreme tsunami impacts were observed, indicating not only a huge tsunami was generated by large amounts of collapse material which caused notable changes of seafloor bathymetry, but also indicates the role of those small islands in reducing tsunami height that propagated to the mainland of Indonesia.



L. Ye, H. Kanamori, L. Rivera, T. Lay, Y. Zhou, D. Sianipar, K. Satake, The 22 December 2018 tsunami from flank collapse of Anak Krakatau volcano during eruption. Sci. Adv. 6, eaaz1377 (2020).

Muhari, A., Heidarzadeh, M., Susmoro, H. et al. The December 2018 Anak Krakatau Volcano Tsunami as Inferred from Post-Tsunami Field Surveys and Spectral Analysis. Pure Appl. Geophys. 176, 5219–5233 (2019)

3.2.2 Past disaster events due to anthropogenic hazards

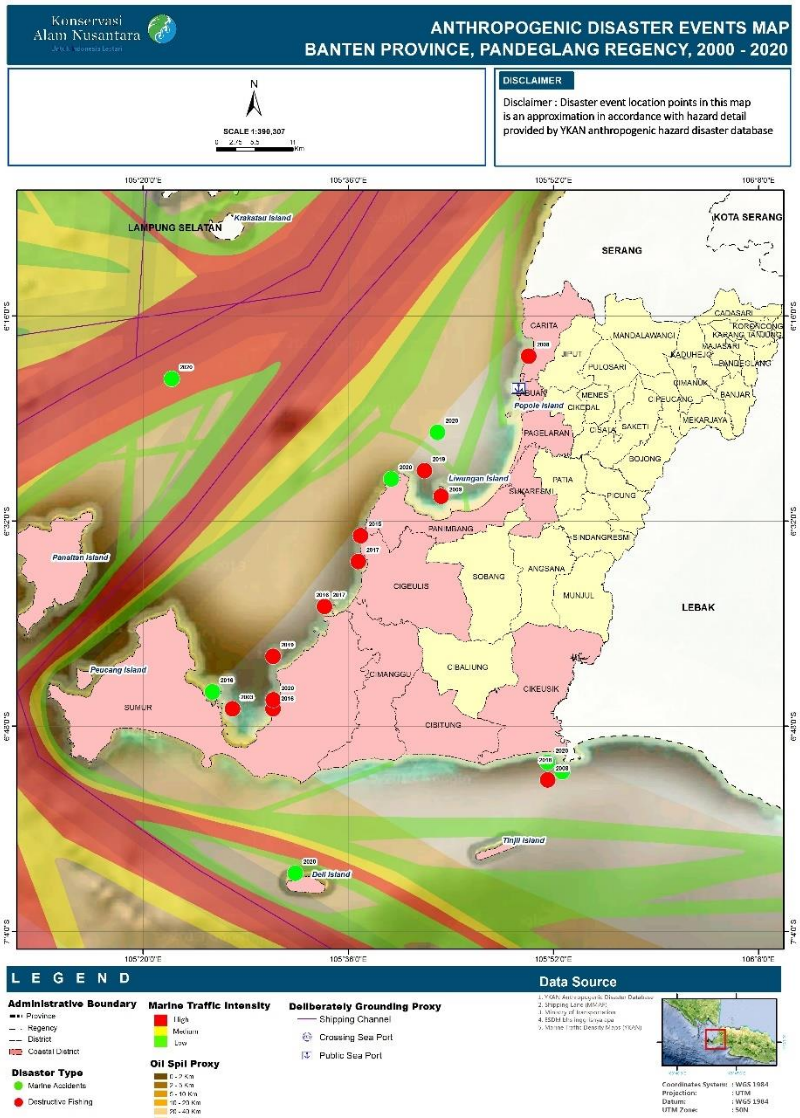


Figure 36 Map of Anthropogenic Disaster Events in Pandeglang Regency 2000-2020 (Analysis, 2021).

In general, the occurrence of disasters due to anthropogenic hazards that occurred in Pandeglang Regency, Banten Province was dominated by events related to destructive fishing. Data collected over the last 20 years shows, the number of destructive fishing incidents was 68% or 15 incidents consisting of 13 cases of using fish bombs and 2 cases of selling fish bomb. Then, the number of ship accidents was 32% or 7 incidents consisting of 2 cases of shipwreck, 3 cases of ship accidents, and 2 cases of capsized ship.

When compared with the previous decade, there were 6 incidents of disasters due to anthropogenic hazards recorded in Pandeglang from 2000 - 2010, and it increased to 16 events in the period 2011-2020.

The pattern of the number of disasters due to anthropogenic hazards that occurred in Pandeglang is shown in Figure below.

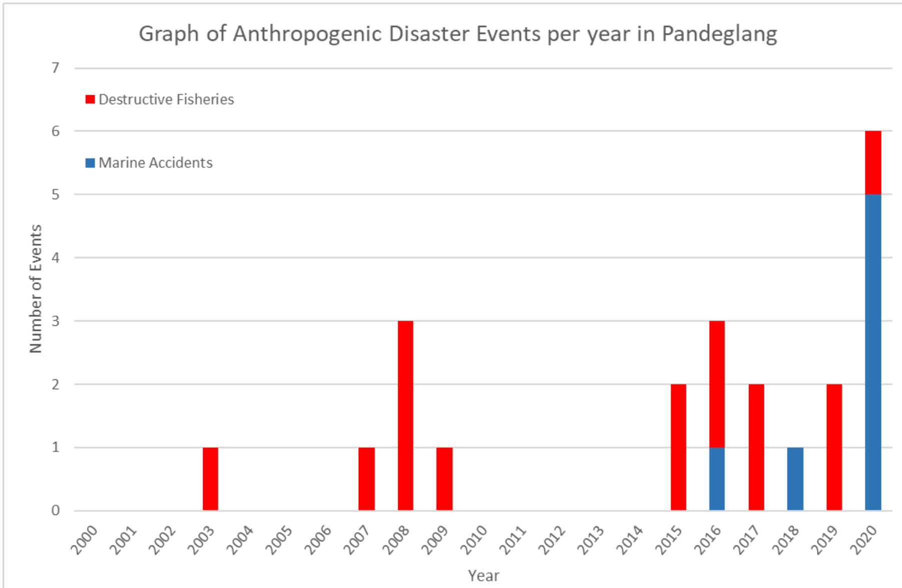


Figure 37 Number of Disaster Antrhropogenic in Coastal Pandeglang Regency period Last 20 Years (Analysis, 2021).

Among the 22 disasters, some of which had a direct effect on coastal communities, which resulted in death, loss, drowning and injuries, loss of ships, sinking (drowning) or damage and loss of potential fish catch income. Apart from directly affecting life and livelihoods, disasters due to anthropological hazards also have the potential to impact the health of the surrounding environment. Based on records, it was found that during the last 20 years, destructive fishing activities that occurred in Pandeglang Regency have the potential to cause losses in the economic sector, seeing from the rampant illegal fishing that has occurred there.

Table 23 Anthropogthropogenic Hazard Index of Pandeglang Regency

District	Destructive Fishing	Marine Accident	Oil Spill	Anthropogenic Hazard Index
Sumur	8	2	0	1.00
Cimanggu	0	0	0	0.00
Cibaliung	0	0	0	0.00
Cibitung	0	0	0	0.00
Cikeusik	1	2	0	0.37
Cigeulis	0	0	0	0.00
Panimbang	4	0	0	0.36

District	Destructive Fishing	Marine Accident	Oil Spill	Anthropogenic Hazard Index
Sobang	0	0	0	0.00
Munjul	0	0	0	0.00
Angsana	0	0	0	0.00
Sindangresmi	0	0	0	0.00
Picung	0	0	0	0.00
Bojong	0	0	0	0.00
Saketi	0	0	0	0.00
Cisata	0	0	0	0.00
Pagelaran	0	0	0	0.00
Patia	0	0	0	0.00
Sukaresmi	0	0	0	0.00
Labuan	0	0	0	0.00
Carita	1	0	0	0.09
Jiput	0	0	0	0.00
Cikedal	0	0	0	0.00
Menes	0	0	0	0.00
Pulosari	0	0	0	0.00
Mandalawangi	0	0	0	0.00
Cimanuk	0	0	0	0.00
Cipeucang	0	0	0	0.00
Banjar	0	0	0	0.00
Kaduhejo	0	0	0	0.00
Mekarjaya	0	0	0	0.00
Pandeglang	0	0	0	0.00
Majasari	0	0	0	0.00
Cadasari	0	0	0	0.00
Karangtanjung	0	0	0	0.00
Koroncong	0	0	0	0.00

Source: Analysis, 2021.

In addition, several destructive fishing businesses using fish bombs were also found (13 cases were found) which were supported by the distribution of materials for making fish bombs. This is evidenced by the arrest of the suspect selling bombs to fishermen in Sumur, Ujung Kulon, Pandeglang along with 100 kg of potassium on October 27, 2017. The same thing happened in 2007 which proved that the distribution chain for incomplete bomb materials for fisheries was found.

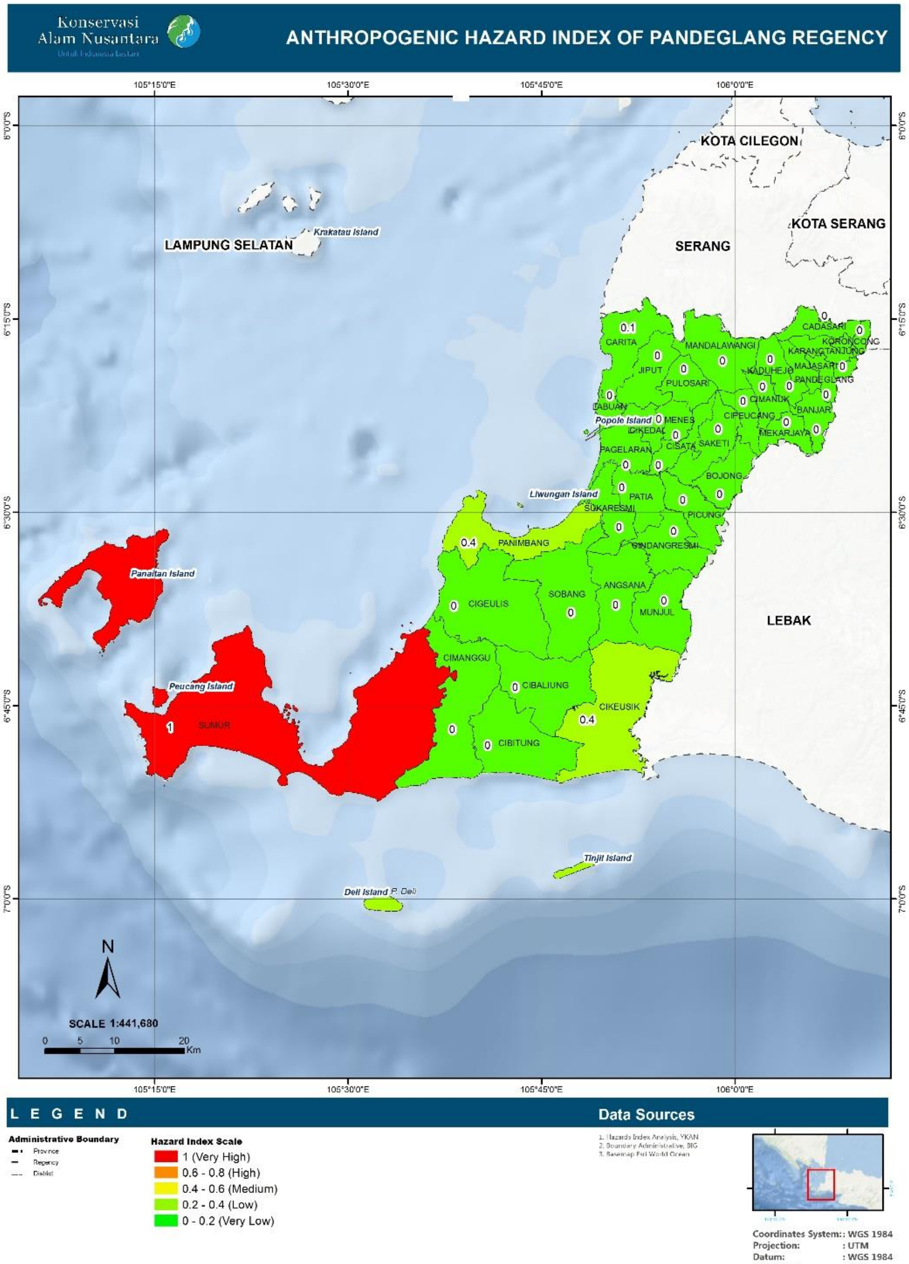


Figure 38 Anthropogenic Hazard Index Map of Pandeglang Regency

Apart from destructive fishing activities, there were also several boat accidents that caused five people missing and one drowning. From an economic perspective, the marine accident that occurred has at least caused the loss of important livelihood assets for coastal communities, namely the sinking of two ships, two capsized ships, and three ship accidents. Although in terms of quantity it is still relatively small when compared to the impact of destructive fishing, the impact caused by boat accidents has resulted in direct impacts on humans (lost and drowned), hence, it needs more attention and efforts to reduce these both impacts by avoiding threats and by reducing or transferring disaster risk, one of which is by using insurance.

3.2.3 Past disaster events due to natural and anthropogenic hazards and slow onset in nature

Coral reefs in the Pandeglang area, are corals formed in groups of corals. There are differences in the condition of coral reefs in coral groups which are closely related to the environmental conditions of each region. The western part of Indonesia is directly influenced by the waters of the Indian Ocean and Java Sea. From the analysis of the increase in sea surface temperature (Figure 24), the waters of Pandeglang, Banten have an increase in sea surface temperature of 0.2-0.3°C per year. This increase in temperature can affect the health of coral reefs to become increasingly vulnerable and deteriorate. The results of coral reef health observations as shown in the 2019 report on the status of Indonesia's coral reefs stated that of the 16 observation points in Ujung Kulon, 9 observation locations were in poor coral condition. Although there is no complete description of the exact location of the coral reef points, the increase in temperature could worsen the health condition of Pandeglang's coral reefs in the future.

Table 24 Status of Coral Reef in Pandeglang Regency.

Location	Number of Station	Very Good	Good	Enough	Bad
Ujung Kulon Selat Sunda (Banten)	16	0	1	6	9
Banten Bay (Banten)	4	0	4	0	0

Source: Hadi, et al., 2019.

The health of coral reefs is strongly influenced by the development and good management of coastal areas. By preserving the environment, the health of coral reefs can be maintained, and their health can be monitored. Destruction of environmental conditions and improper development of areas can exacerbate the condition of coral reefs in the future.

From anthropogenic factor analysis as seen in Table 17 in Chapter 2.3.5. Threats from anthropogenic factor which could potentially risk coastal ecosystem especially coral reefs are mainly generated from coastal population. Pandeglang has high coastal population among other regencies in this study around 1.23 million people. This massive population requires a large carrying capacity in other to survive and to further develop.

Pandeglang Regency has ports and harbors (6 PPI, 1 PPP and around 40 local port) intended for fisheries or local transportation. Although Pandeglang mainly dependent on agriculture sector, for communities which resided in adjacents with the sea, fisheries and tourism sector is their main livelihood. The existenxce of considerable fishing port and local port suggest this Pandeglang coastal area is active in fishing activities.

Pelabuhan Merak or Merak Sea Port, around 40-50 Km in the north from pandeglang regency, are a massive and busy harbor intended for ferrying and container is located in the Cilegon City. Merak Sea port is a crucial link in the connection between Java and Sumatera island, along with it the transpotation for good and people from and to the location has also become compact. This flow of transportation activity is seen in shipping intensity maps (figure AH disaster event) where red line (high intensity) indicated in the north of Pandeglang.

This shipping acitivites includes crossing the territorial sea near Pandeglang, as seen in the map above (Figure 37), the shipping activities lie in imminent with Ujung Kulon National Park especially in the strait between Panaitan Island and Ujung Kulon National Park. This could be a major threat if the passing ships could not maintain its navigation and ran aground to the nearby reefs or if the passing ships polluted the area with trash or polluted ballast water.

Although there are no massive seaport in Pandeglang, an apparent low intensity shipping is seen in Panimbang, Labuan and Carita PPI fishing port. This domestic fishing port provide fish supplies for the adjacent cities and probably to support tourism activity which lies in the Carita or Anyer region. In total, for Pandeglang, from BPS data there are 168 hotels to support its tourism activity. Although there are limited data to classify according to coastal districts, it is seen that high tourism activity in Pandeglang is mainly focused in Ujung Kulon National Park, Carita and Anyer beach.

Carita Beach is a tourist area that has grown rapidly in Pandeglang Regency. The development of the management of tourism activities that are not environmentally sound will increase the health vulnerability of coral reefs. Illegal beach reclamation for tourism purposes can also cause environmental degradation and must be monitored by various parties. Unregulated reclamation of beaches, such as those carried out in the beach area of Asri Carita Hotel, Sukarame Village, Carita District, needs to be identified as a risk factor for disasters and environmental degradation in Carita.

In addition to the Carita tourism area, Pandeglang Regency also has the Tanjung Lesung Tourism Special Economic Zone (KEK) located in the Panimbang District, so that good regulation and supervision for tourism purposes also needs to be done for this KEK. With the appointment of Tanjung Lesung as a SEZ, this area is projected to attract national and international tourists. The Tanjung Lesung SEZ is delineated with an area of 1,500 hectares with various tourism potentials, including the natural beauty of the coast, the diversity of flora and fauna as well as exotic cultural wealth. In addition, Tanjung Lesung is also design with its own airport to maintain its proximity with tourism area, although its airport is still unactive commercialy the existence of this airport is a high threat for the coral reefs in the future. The Tanjung Lesung SEZ is also close to other Banten tourist attractions such as the Banten Old Area, Bedouin and Debus Culture, Ujung Kulon National Park, Mount Krakatau and archipelago tourism.

Figure 39 Tourism Special Economic Zone Masterplan of Tanjung Lesung
(https://kek.go.id/kawasan/Tanjung-Lesung).

3.3 Stakeholder Mapping and Local Institutional Capacity of Pandeglang

The intersection between programs/activities for disaster management affairs, marine fisheries, environment protection, and development of coastal areas largely determines the list of stakeholders identified in Pandeglang Regency. To date, a total of 40 actors have been identified as can be seen in related annex. In total, there are 7 national government actors, 1 provincial government actor, 8 district government actors, 14 NGOs, 6 business actors, and 4 community groups. In terms of affairs/sectors, there are 20 disaster management actors, 5 fishery/marine actors, 4 coastal development actors, and 9 general/cross-sector actors.

In the context of the fisheries and marine sector, the environment, and tourism, this is an implication of the classification of Pandeglang Regency, as part of the Development Working Area (*Wilayah Kerja Pengembangan/WKP*) III in the Spatial Plan of Banten Province, which is mandated for developing forestry, agricultural, mining, tourism activities. marine and fisheries. Furthermore, the Spatial Plan of Pandeglang Regency mandated main functions of Regional Activity Center in Pandeglang for government activities, trade and service areas, industry, and tourism. In Pandeglang Regency, there are locations for local scale fisheries and tourism activities, for example Carita Beach. Furthermore, there are several decisive policies from the Central Government, including the determination of the Ujung Kulon National Park and the Tanjung Lesung Tourism Special Economic Zone (SEZ).

The types of stakeholders in the disaster management sector/affairs are strongly influenced by the variety of actors in the emergency response and recovery after the tsunami disaster on December 22nd, 2018 due to the activities of Mount Anak Krakatau. According to BNPB records, this disaster resulted in 426 people dying, 7,202 people being injured, 40,386 people homeless, 1,300 houses damaged. Furthermore, the Post-Disaster Needs Assessment Report estimates the total damage and losses to be more than 80 trillion rupiah (BNPB, 2019, in Shalih et al, 2019). The majority of programs and activities for emergency response and recovery after the 2018 tsunami disaster were dominated by local and national organizations because the Indonesian Government did not request and receive international assistance due to this disaster. However, there are many records of funding flows from international organizations to local/national organizations that carry out emergency response, recovery programs/activities, as well as some that have transformed into disaster risk reduction programs/activities in Pandeglang District. This becomes a further analysis of the stakeholder categorization and the relationship between them.

Figure 40 below shows that in general the identified stakeholders in Pandeglang Regency are quite neutral and support a variety of programs / activities for disaster risk reduction, conservation / protection of coastal areas and the environment, and development of coastal areas. Secondary source tracing shows that there are coral reef conservation programs / activities that are already running involving support from the Ministry of Marine Affairs and Fisheries (KKP through the Serang Coastal and Marine Resources Management Workshop (LPSPL), Banten Province Marine Fisheries Service, Pandeglang Regency Marine Fisheries Service, and community groups. In the coral reef conservation program/activity in Pandeglang Regency, it was also found that there were several collaborations with the business sector. Furthermore, it is necessary to analyze the volume of this program/activity to find out whether it is still ceremonial or has become a strategic program/activity in Pandeglang Regency. However, the actors identified have the potential to become driving actors or partners for YKAN in planning future programs.

Furthermore, in this classification, stakeholder analysis positions disaster management actors who contributed to the 2018 tsunami emergency response and recovery activities as potential actors who can be further advocated or invited to enrich their programs/activities so that they have ecosystem protection value. coastal areas, including for coral reef conservation. Donors from these actors can also be identified as potential donors for coastal ecosystem protection activities.

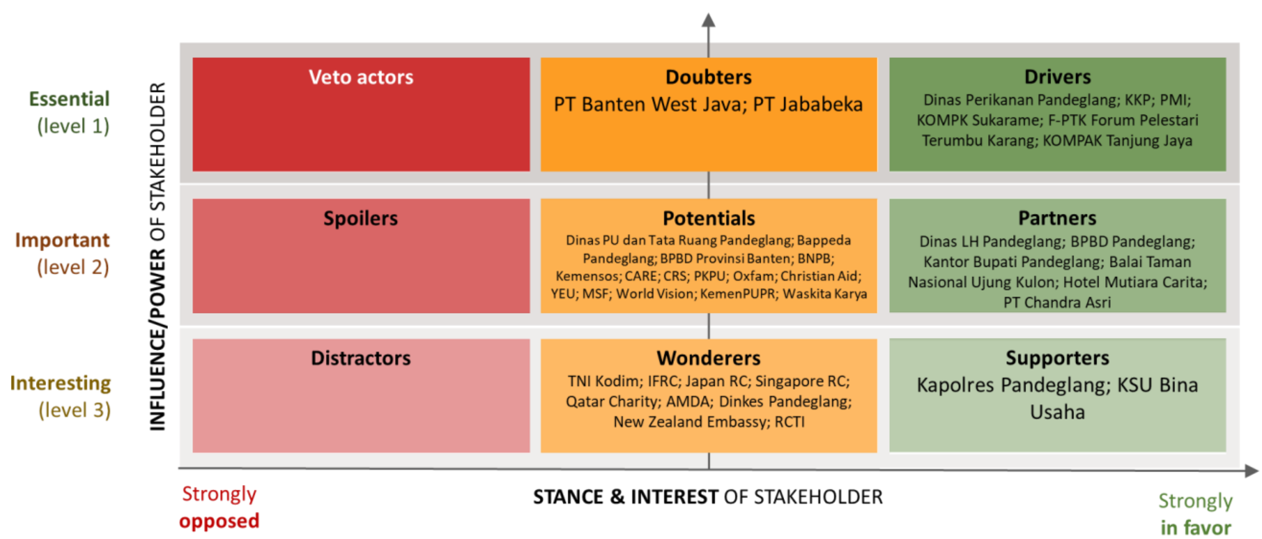


Figure 40 Pandeglang Regency Stakeholder Map (Analysis, 2021).

Based on information that can be gathered from official documents as well as news available online, the relationships between identified stakeholders in Pandeglang District are as mapped in the social network graphic below.

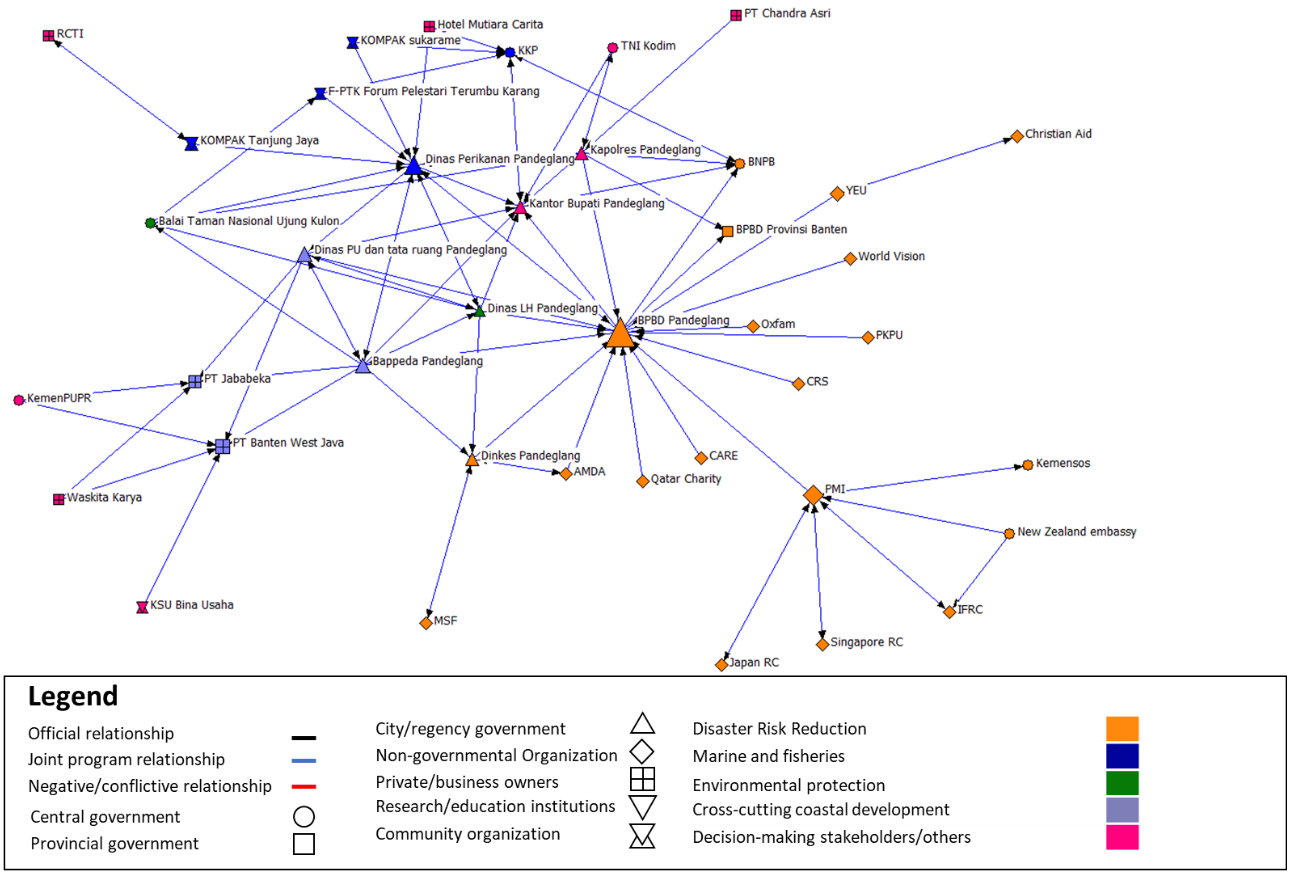


Figure 41 Social Network Analysis Diagraph between stakeholders in Pandeglang Regency (Analysis, 2021)

The network graphic above depicts 3 types of relationships, namely (1) relationships stipulated in official regulations, (2) cooperative relationships from indications of carrying out joint programs in disaster management and nature conservation, (3) negative relationships due to conflicts in terms of disaster management and nature conservation. In this network, 40 actors (nodes) were identified and 91 total ties (ties). Among them are 90 program/activity cooperation relationships and only 1 negative relationship.

As can be seen in Figure 41, the momentum of disaster risk reduction and recovery programs/activities in Pandeglang Regency has several potential actors, as shown on the right of the figure. In particular, the Indonesian Red Cross (PMI) and its relationship with BPBD Pandeglang can be prepared for further engagement. Learning and experience in managing post-Tsunami 2018 programs/activities need to be considered as capital for these actors in dealing with external actors (for example YKAN) for planning programs/activities in Pandeglang Regency.

Meanwhile, the left side of Figure 41 is a combination of working relationships identified from various actors in various coral reef conservation activities and development of coastal areas (particularly in the Tanjung Lesung SEZ location). At first glance, the attention of Ministry of Marine and Fisheries, Banten DKP, and DKP Pandeglang Regency, is the initial capital that government actors in the locations have enough initiative and program planning direction that is in line with TNC. This section also identifies local actors who have the potential to become movers or partners, for example the Coral Reef Conservation Forum (*Forum Pelestarian Terumbu Karang/F-PTK*), KOMPAK Sukarame, and KOMPAK Tanjung Jaya. This does not preclude the possibility of looking for other fishing community groups (KOMPAK) outside the two villages.

In terms of development progress in the Tanjung Lesung SEZ, no information has been found on a major conflict between development and disturbance to coral reefs. To date, only one conflict has been found between PT Banten West Java (as the manager of the Tanjung Lesung SEZ) and the Multipurpose Coop (*Koperasi Serba Usaha/KSU*) regarding the delineation of areas and land ownership matters. This issue has received special attention and the Office of the Regent of Pandeglang (particularly the Regional Assistant for Government Affairs) plays the role of mediator. This indicates that the element of regional leaders is quite sensitive, and it is necessary to consider having special communication with these actors in the planning of the TNC program. In addition, by becoming “victims” of the 2018 Tsunami, PT Banten West Java and PT Jababeka seem sensitive enough to carry out disaster risk reduction-based recovery and can be leveraged for things that are ecosystem protection. This can be seen from the contents of the SEZ reconstruction plan carried out by PT Waskita Karya with supervision from the Ministry of Public Works and Housing.

Furthermore, the table below shows the agencies with the largest temporary degree and centrality values in Pandeglang Regency, as an initial proxy for the identification of key actors at the location. The value of Degree centrality shows the number of relationships; Meanwhile, the Betweeness centrality value shows the frequency of one actor between two or more other actors, thus indicating the proxy role as coordinator. However, due to the limited data input at secondary sources, this finding needs further validation.

Table 25 Degree and betweenness centrality values of stakeholders in Pandeglang Regency.

Stakeholder	Degree	Stakeholder	Betweenness
BPBD Pandeglang	15	BPBD Pandeglang	303.33
Dinas Perikanan Pandeglang	9	Bappeda Pandeglang	187.83
Dinas LH Pandeglang	7	Dinas Perikanan Pandeglang	110.50
Bappeda Pandeglang	4	PMI	105.00
Dinas PU & Tata Ruang Pandeglang	4	Balai Taman Nasional Ujung Kulon	83.00

Source: Analysis, 2021.

Based on the measurement against indicators and performance standard in the SPDAB, Pandeglang Regency scored 27.4% out of total 100%. Hence, measured in SPDAB's resilient city class, Pandeglang Regency would fall in the second class (out of maximum five), which means the regency has several initiatives of disaster management activities across pillar, but has not yet make any significant structural changes. In Pillar 1 (disaster governance) and Pillar 4 (emergency management services), the average value of Pandeglang Regency is 2.25. It is slightly higher in Pillar 3 (protection and recovery preparedness of critical infrastructure), at 2.50, and Pillar 3 (social and economy preparedness), at 2.75. The average value of Pillar 3 performed a bit better, due to the achimevement of health system in Pandeglang Regency, measured by the Public Health Index (IPKM) of Ministry of Health.

As one of the areas with the highest risk index in Indonesia, Pandeglang Regency has received various technical assistance from national ministries as well as international organizations. For instance, the Disaster Risk Assessment document (KRB) of Pandeglang Regency has been developed in 2013 and effective until 2018. As well as the enchancement of preparedness impetus by the assignment of the regency as one of the priority locations for the 2016 IOWave. Nevertheless, there were no significant DRR successes in terms of making an equitable DRR investment across the vast areas and sub-districts in Pandeglang Regency. This is also one of the reasons why BPBD Pandeglang Regency is still rated B. Another factor that made disaster governance rather weak in Pandeglang, despite past DRR investment, was the fact that DRR Forum (a forum that usually constitutes of various stakeholder) also non-existent in the area.

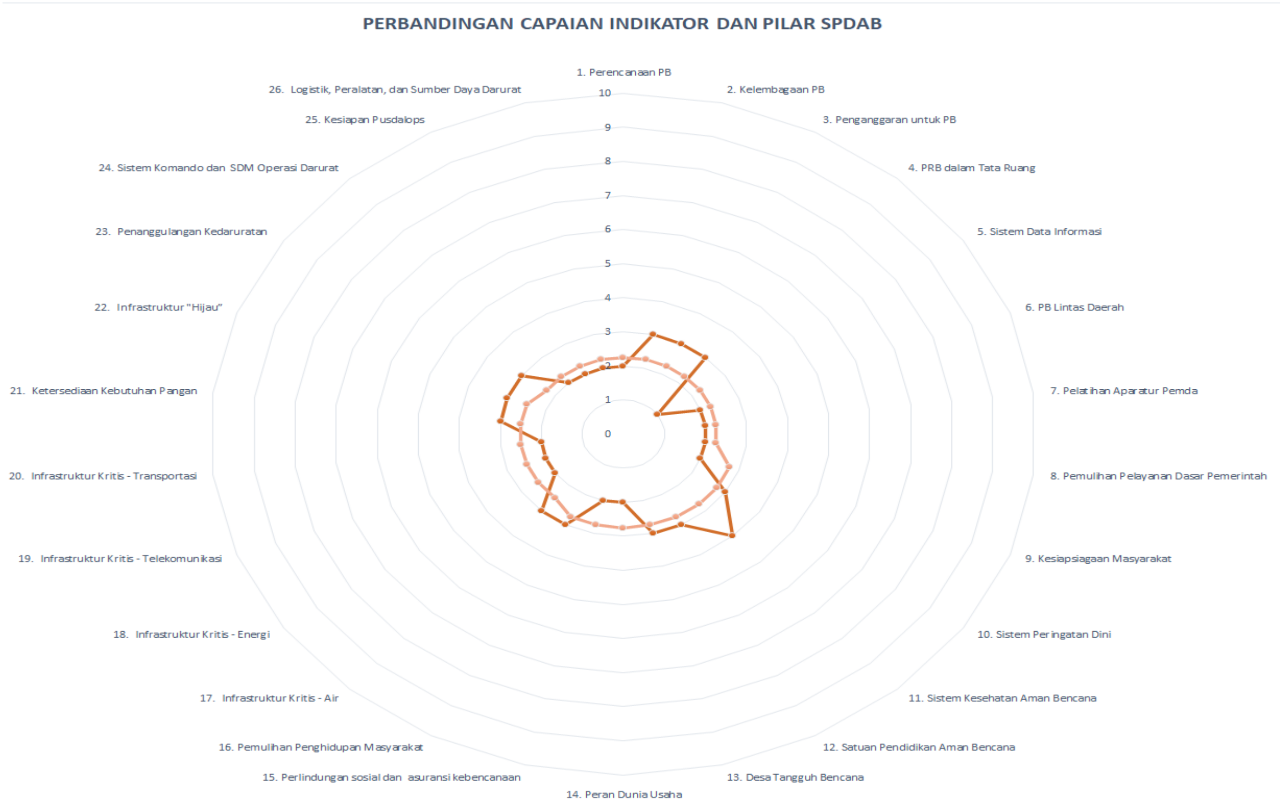


Figure 42 CARI! SPDAB Tool Output Spiderweb Capacity Diagram for Pandeglang Regency (Analysis, 2021).

Table 26 SPDAB Pillar Average Indicator and Final Score in Pandeglang Regency.

SPDAB Pillar	**Average Indicator Score**
PILLAR 1: Governance, Policy, and Planning Standard	2.25
PILLAR 2: Preparedness and Socio-Economic Strengthening Service Standard	2.75
PILLAR 3: Critical Infrastructure Protection and Recovery Preparedness Standard	2.50
PILLAR 4: Disaster Emergency Service Standard	2.50
	Final SPDAB Score = **0.274**

Source: Analysis, 2021.

3.4 Risk Profile, Valuation, and Scenario of Pandeglang

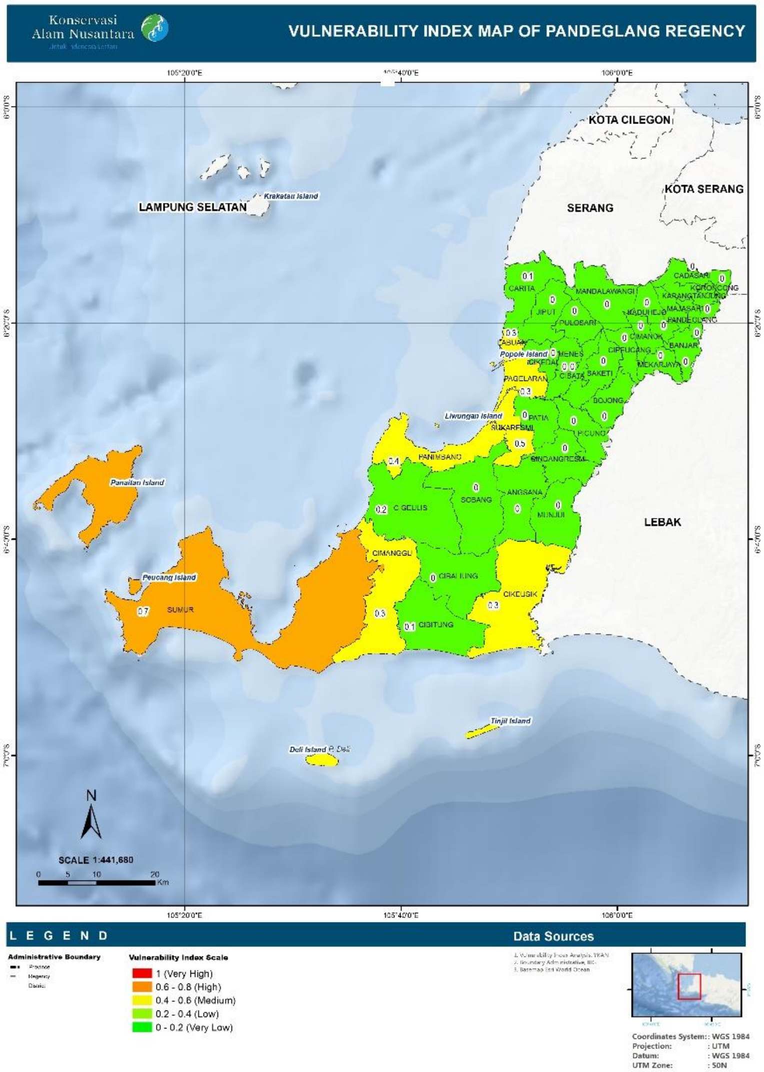


Figure 43 Vulnerability Index Map of Pandeglang Regency (Analysis, 2021)

This section provides an analysis into the development of risk Profiles in Pandeglang which gives a comprehensive view of hazard, vulnerability and risk and uncertainties for each of its district. Based on the BNPB report (BNPB, 2018), the score of the Pandeglang District Disaster Risk Index (IRBI) for multi-hazard in 2018 was 215.2 which are classified as High risk. This scores marked Pandeglang Regency ranked 5th highest among other cities/regencies for disaster risk in Indonesia.

From further analysis, In Pandeglang, the district with the highest risk is in Sukaresmi and Sumur districts. The coastal district Sumur is located alongside the Ujung Kulon National Park, while Sukaresmi district is located facing the Banten bay. Risk index for those two districts is nearly identical 7.3 and 7.4. For

Sukaresmi district, along with other district such as pagelaran, and labuan has the highest hazard index, which means there is minimum of one disaster events occurred per year for the last two decades.

Another district which has potentially high-risk profile is the Panimbang, Labuan and Pagelaran. The most frequent hazard in these districts are inland flooding, which are mainly caused by the monsoon and changes in hydrometeorological condition. For instances, on the December 7th of 2020, Sukaresmi district is once again suffered damages from flood due to the overflow of Ciliman river. This end of year flood does not happen once but frequently happened and has impacted many lives and livelihood in the area. With an area populated more than 50,000 people, the area of Sukaresmi districts and its surrounding, including Sumur District, has a higher threat from reoccurring disaster such as flood.

Table 27 Risk Profile of Pandeglang Regency.

District	Index Hazard	Index Exposure	Index Sensitivity	Adaptive Capacity Index	Index Vulnerability	Risk Index
Sumur	0.69	0.60	0.35	0.27	0.77	**0.73**
Cimanggu	0.49	0.40	0.26	0.27	0.38	**0.43**
Cibitung	0.28	0.20	0.17	0.27	0.12	**0.19**
Cikeusik	0.63	0.40	0.26	0.27	0.38	**0.49**
Cigeulis	0.57	0.20	0.27	0.27	0.20	**0.34**
Panimbang	0.89	0.40	0.33	0.27	0.48	**0.65**
Pagelaran	1.00	0.40	0.24	0.27	0.36	**0.6**
Sukaresmi	1.00	0.60	0.25	0.27	0.54	**0.74**
Labuan	1.00	0.20	0.54	0.27	0.40	**0.63**
Carita	0.77	0.20	0.20	0.27	0.14	**0.33**

Source: Analysis, 2021.

With low laying area, most of the district in pandeglang are vulnerable from inundation from any type of hydrometeorological hazard. Changes in hydrometeorological condition such as monsoon, ENSO and even tropical cyclone, makes the area to be more prone from disaster. Tropical cyclone Jacob and effect of swell from southern Africa are the examples of how hydrometeorological changes in the ocean threaten more coastal community at risk (sub chapter 2.34). By analyzing the tropical cyclone event in the southern Indian Ocean, which lies in the south with Pandeglang Regency, there is a higher probability that other cyclone would have impacted to the Pandeglang area.

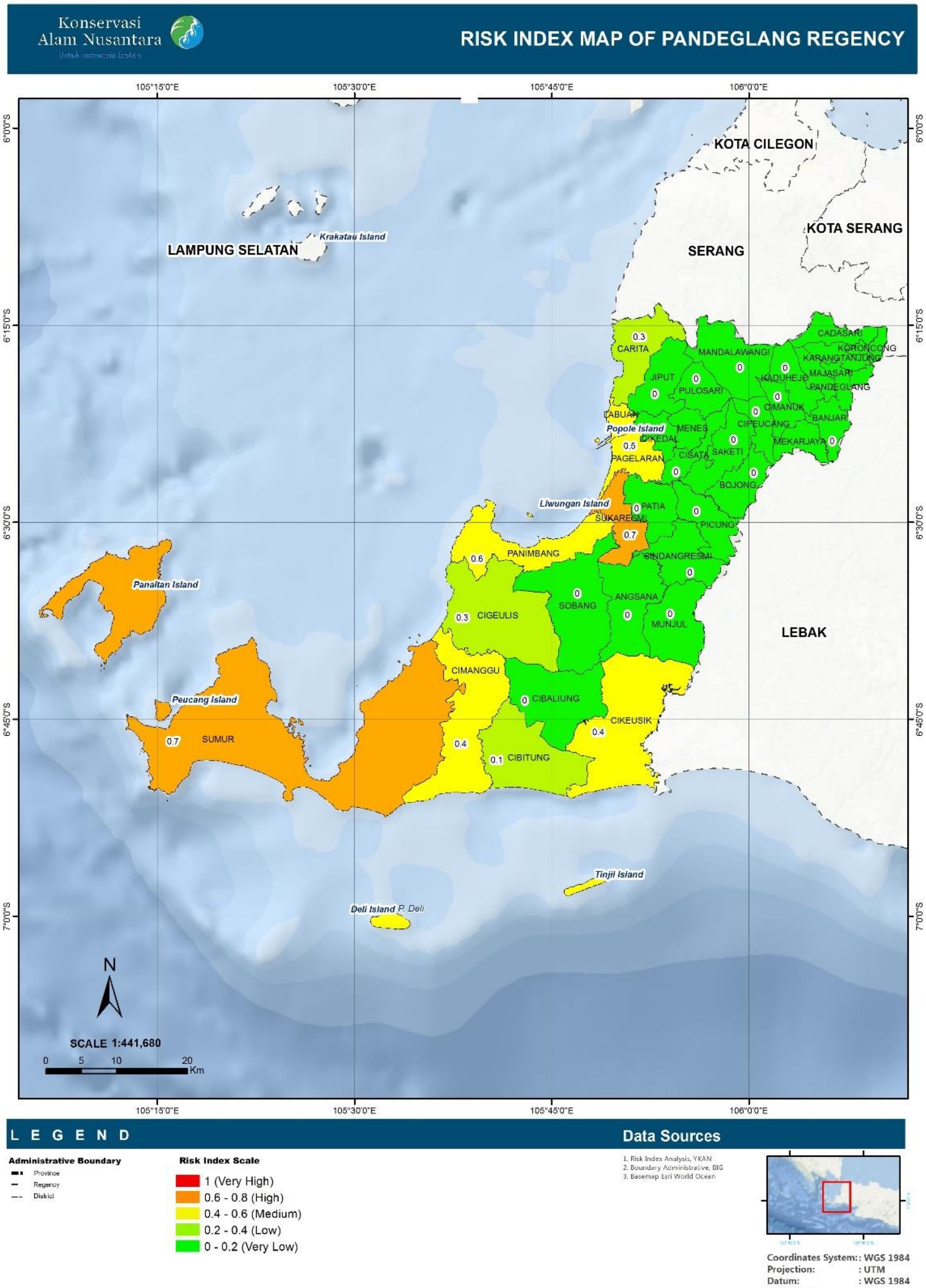


Figure 44 Risk Map of Pandeglang Regency (Analyss, 2021).

During Anak Krakatau tsunami event in 2018, a large tsunami height was observed with a maximum runup of 13.5 m, maximum flow depth of 5.4 m and inundation distance of up to 159 m. Most of the beach areas were completely swept away and coastal forest was heavily damaged. This tsunami also uprooted coral boulders which were drifted up to 100 m to inland with sizes of up to as big as a medium truck indicating the extreme powers of the tsunami flows. As well as damages and losses in coastal communities and coastal ecosystems, the tsunami also gives a high losses economically.

Accordingly, the risk scenario of Pandeglang Regency in monetary terms is presented in the following figure. The calculations were done using the Blue Guide with inputs from the recorded disaster events and risk profiles of the regency. The approaching scenario forecasts the total damages and losses for the next 20 years with 5% discount rate to reveal a summary figure based on present currency value.

SCENARIOS

Basic approach (simplified)	
Timeframe (years into the future)	20
Discount rate	5%

In the basic approach, the three scenarios are automatically generated based on the data you entered above. Scenario A assumes that the level of damages and losses will remain the same as it was over the past 10 years. Scenario B assumes an increase by 10% (progressive increase by 2.5% every 5 years). Scenario C assumes an increase by 20% (progressive increase by 5.0% every five years). The discount rate of 5% is applied across all three scenarios to reveal a summary figure based on **present currency values**.

SCENARIO A		SCENARIO B		SCENARIO C	
Assumption for this scenario		Assumption for this scenario		Assumption for this scenario	
The level of damages and losses will not change, compared to the past ten years	0%	The level of damages and losses will progressively increase by*:	10%	The level of damages and losses will progressively increase by*:	20%
Year 1	92,025,934,398,848	Year 1	94,326,582,758,819	Year 1	96,627,231,118,790
Year 2	87,424,637,678,905	Year 2	89,610,253,620,878	Year 2	91,795,869,562,850
Year 3	83,053,405,794,960	Year 3	85,129,740,939,834	Year 3	87,206,076,084,708
Year 4	78,900,735,505,212	Year 4	80,873,253,892,842	Year 4	82,845,772,280,473
Year 5	74,955,698,729,951	Year 5	76,829,591,198,200	Year 5	78,703,483,666,449
Year 6	71,207,913,793,454	Year 6	74,768,309,483,126	Year 6	78,328,705,172,799
Year 7	67,647,518,103,781	Year 7	71,029,894,008,970	Year 7	74,412,269,914,159
Year 8	64,265,142,198,592	Year 8	67,478,399,308,522	Year 8	70,691,656,418,451
Year 9	61,051,885,088,662	Year 9	64,104,479,343,096	Year 9	67,157,073,597,529
Year 10	57,999,290,834,229	Year 10	60,899,255,375,941	Year 10	63,799,219,917,652
Year 11	55,099,326,292,518	Year 11	59,231,775,764,457	Year 11	63,364,225,236,395
Year 12	52,344,359,977,892	Year 12	56,270,186,976,234	Year 12	60,196,013,974,576
Year 13	49,727,141,978,997	Year 13	53,456,677,627,422	Year 13	57,186,213,275,847
Year 14	47,240,784,880,047	Year 14	50,783,843,746,051	Year 14	54,326,902,612,055
Year 15	44,878,745,636,045	Year 15	48,244,651,558,748	Year 15	51,610,557,481,452
Year 16	42,634,808,354,243	Year 16	46,898,289,189,667	Year 16	51,161,770,025,091
Year 17	40,503,067,936,531	Year 17	44,553,374,730,184	Year 17	48,603,681,523,837
Year 18	38,477,914,539,704	Year 18	42,325,705,993,675	Year 18	46,173,497,447,645
Year 19	36,554,018,812,719	Year 19	40,209,420,693,991	Year 19	43,864,822,575,263
Year 20	34,726,317,872,083	Year 20	38,198,949,659,291	Year 20	41,671,581,446,500
Total damages and losses over 20 years	1,180,718,648,407,370	Total damages and losses over 20 years	1,245,222,635,869,950	Total damages and losses over 20 years	1,309,726,623,332,520
Annualised average	59,035,932,420,369	Annualised average	62,261,131,793,497	Annualised average	65,486,331,166,626
		*In 2.5% increments every 5 years		*In 5.0% increments every 5 years	

Figure 45Figure 45 Monetary Risk Scenarios of Pandeglang Regency (Analysis, 2021).

The summary in Figure 45 shows the damages and losses forecast in three scenarios A, B, and C. Following the recent monetary values calculation for the past ten years (Section 3.2.1), the forecasted monetary values for the next 20 years counts as IDR 1.18 quadrillion with an annual average of IDR 59.03 trillion (Scenario A). Scenario B takes into account the increasing level of damages and losses by 10% and by that, the total value elevates to IDR 1.24 quadrillion. The forecasted annual average for Scenario B is IDR 62.26 trillion, which takes into account a 2.5% of increments every 5 years. The most extreme scenario, Scenario C, have a 20% increase of damages and losses from Scenario A, which leads to a higher value of IDR 1.31 quadrillion in total and an annual average of IDR 65.49 trillion, with a 5% increments every 5 years.

4. Risk and Disaster Management Profile of Makassar City

4.1 Overview of Makassar city

Makassar City, which functions as the capital city of South Sulawesi Province, is located at the southernmost point of Sulawesi Island with a coastal area and islands in its vicinity. In 2018 the number of districts in Makassar City was 15 districts and 153 sub-districts. Compared by 2015, the number of districts has increased by one district, namely Sangkarang District, which was a division of Ujung Tanah District. From the total of all districts, there are 9 districts that are in coastal areas or have coastlines, namely Mariso, Tamalate, Ujung Pandang, Wajo, Ujung Tanah, Kep. Sangkarrang, Tallo, Biring Kanaya and Tamalanrea.

Table 28 Area, number of islands and the number of Villages / Sub-districts in the Coastal Delineation of Makassar City

No	District	Area (Km^2)	Percentage of Regency Area	Amount of Island
1	Mariso	2.76	1.60	9
2	Tamalate	23.40	13.52	13
3	Ujung Pandang	2.89	1.67	10
4	Wajo	2.07	1.19	8
5	Ujung Tanah	1.47	0.85	9
6	Sangkarrang Islands	1.54	0.89	3
7	Tallo	9.73	5.62	15
8	Biring Kanaya	36.08	20.85	11
9	Tamalanrea	38.76	22.40	8
TOTAL		**118.69**	**68.59**	**86**

Source: Makassar City in Figures 2020, BPS, 2020.

The Biringkanaya District is the district with the largest population in Makassar City, reaching 211,495 people in 2019. Meanwhile, the district with the smallest area is Sangkarrang Island with a land area of 1.54 km^2. However, the most densely populated district is the Ujung Tanah district with a population density of 25,943.34 people / km^2.

Table 29 Demographic Conditions in the Coastal Delineation of Makassar City

No	District	Amount of Population (thousand)	Rate of Population Growth	Percentage of Population	Population Density per km^2	Sex Ratio
1	Mariso	60,242	0.61	4.10	21,807.85	99.77
2	Tamalate	188,835	1.8	12.84	8,069.66	100.64
3	Ujung Pandang	25,866	0.59	1.76	8,960.72	94.48
4	Wajo	31,599	0.5	2.15	15,280.72	100.58
5	Ujung Tanah	38,007	0.51	2.58	25,943.34	100.94

No	District	Amount of Population (thousand)	Rate of Population Growth	Percentage of Population	Population Density per km^2	Sex Ratio
6	Sangkarrang Islands	14,531	0.5	0.99	9,436.00	99.27
7	Tallo	152,287	0.22	10.36	15,651.12	101.93
8	Biring Kanaya	211,495	2.81	14.38	5,861.90	100.34
9	Tamalanrea	104,441	1.02	7.10	2,694.61	100.27
TOTAL		**827,303**	**0.95**	**6.25**	**12,633.99**	**99.80**

Source: Makassar City in Figures 2020, BPS, 2020.

Based on the direction of the National Spatial Plan (RTRW)[15], Makassar is incorporated in the Makassar - Sungguminasa - Takalar - Maros (Maminasata) Urban Area which is designated as the National Activity Center (PKN) which functions as the Revitalization and Acceleration of the Development of National Growth Centers. PKN is an urban area that has a function to serve international, national, or several province activities. In addition, Makassar is also a National Strategic Area (KSN) from the point of view of economic growth, that is the Mamminasata Metropolitan Area along with urban areas in Maros, Gowa, and Takalar Regencies. The Mamminasata area is a national mainstay area with leading sectors of tourism, industry, agriculture, agro-industry, and fisheries. And there are other national mainstay areas, that is the Makassar Strait Sea Mainstay Area with the leading sectors of fisheries, tourism, oil, and natural gas.

Based on the direction of the RTRW for Makassar City 2015-2034[16], there are coastal and small island conservation areas which include: areas with unique characteristics protected to establish sustainable management of coastal areas and small islands. Coastal and small islands conservation area are defined in:

a. Small island conservation areas include: Barang Lompo Island, Kodingareng Lompo Island, Barang Caddi Island, Lae-Lae Island, Bone Balang Island, and Samalona Island in the Sangkarrang Islands District;
b. Marine conservation areas in the waters of the Spermonde Area;
c. Conservation and protection of coastal ecosystems in the form of mangrove coastal forest areas in parts of Biringkanaya District, parts of Tallo District, and parts of Tamalanrea District, as well as

[15] Government Regulation Number 26 of 2008 concerning National Spatial Planning
[16] Makassar City Regional Regulation Number 4 of 2015 concerning Makassar City Spatial Planning 2015 - 2034

mangrove coastal forest areas in parts of Biringkanaya District and parts of Tamalanrea District; and

d. A maritime conservation area in the form of a fishing settlement in the Untia Area, Biringkanaya District, Makassar City.

In the division of the National Fisheries Management Area, Makassar City waters located in the Makassar Strait are included in the WPPNRI 713. In the direction of the WPPNRI 713[17], the province has the authority and responsibility to manage fish resources while in the field of empowering small fishermen, managing and the operation of the Fish Auction Place (TPI) is under the authority of the city government.

In the economic aspect, the sectors that drive the regional economy can be seen from the contribution of these sectors to the Gross Regional Domestic Product (GRDP). Based on data from the City of Makassar in Figures 2020 (BPS, 2020), the value of the GRDP of Makassar City reached 178,430,057 billion rupiah in 2019, with the most contributing sectors being wholesale and retail trade. As for the contribution of the agricultural, forestry and fisheries sectors, amounting to 854,968 billion rupiah, or with a contribution of 0.48% of the total GRDP. Meanwhile, looking at the GRDP growth in the last few years based on constant prices, the most densely populated GRDP growth of Makassar City was 8.79% in 2019, with the sectors with the highest growth rates, namely 1) Corporate Services; 2) Wholesale and retail trade; 3) Other Services.

[17] Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 80 / KEPMEN-KP / 2016 concerning the Fishery Management Plan for the State Fisheries Management Area of the Republic of Indonesia 713

4.2 Summary of Past Disaster Events in Makassar city

4.2.1 Past disaster events due to natural hazards and sudden onset in nature

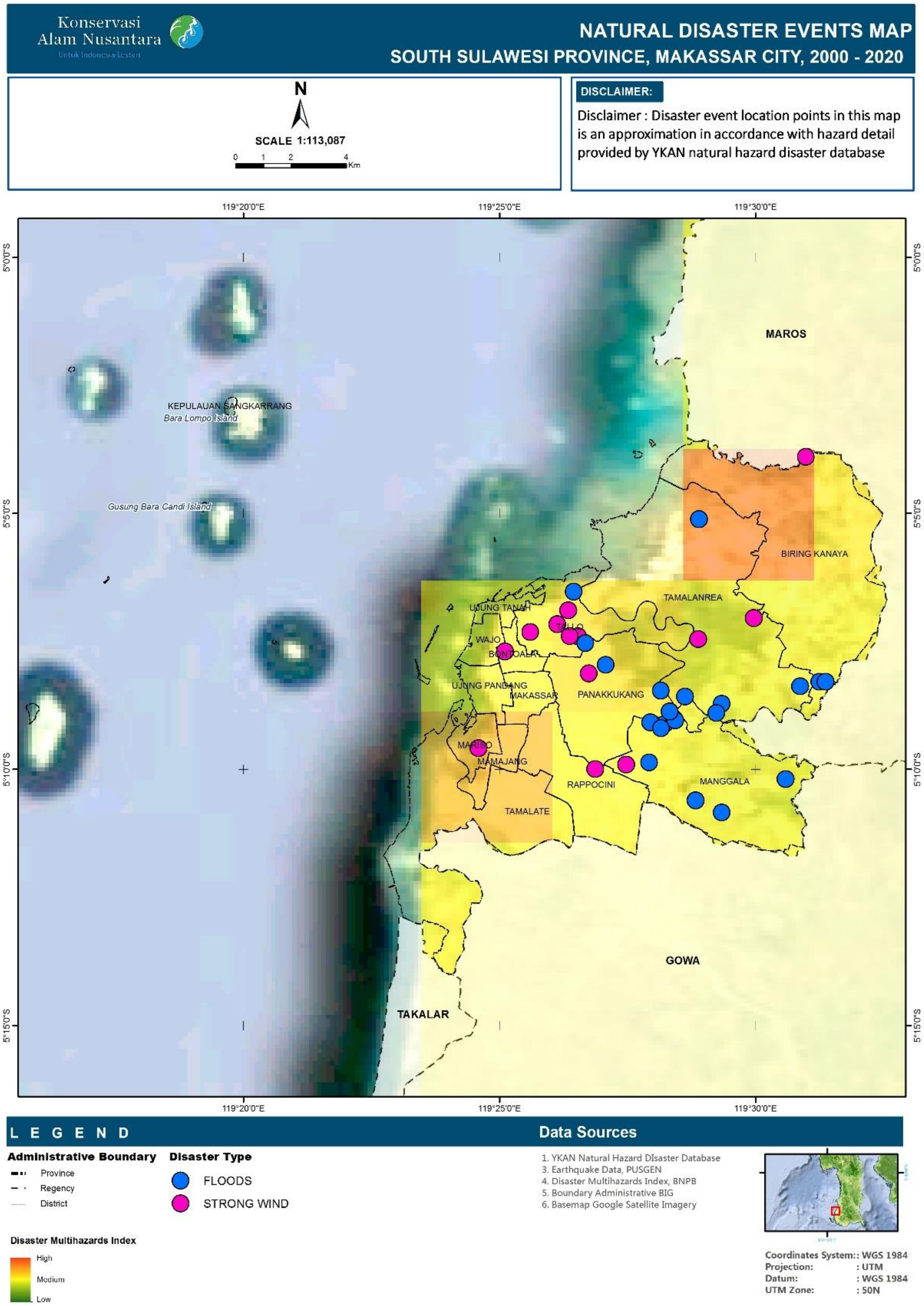


Figure 46 Map of Disaster Events Due to Natural Hazards in Makassar City 2000-2020 (Analysis, 2021).

Makassar City is the center of national activities that connects western and eastern Indonesia. Makassar City, which is located on the edge of the sea and borders the Makassar Strait, is a metropolis filled with human activities on the coast. With its fairly sloping landscape conditions, flowed by large rivers, the city of Makassar is vulnerable to hydrometeorological natural disasters such as floods and rainstorms.

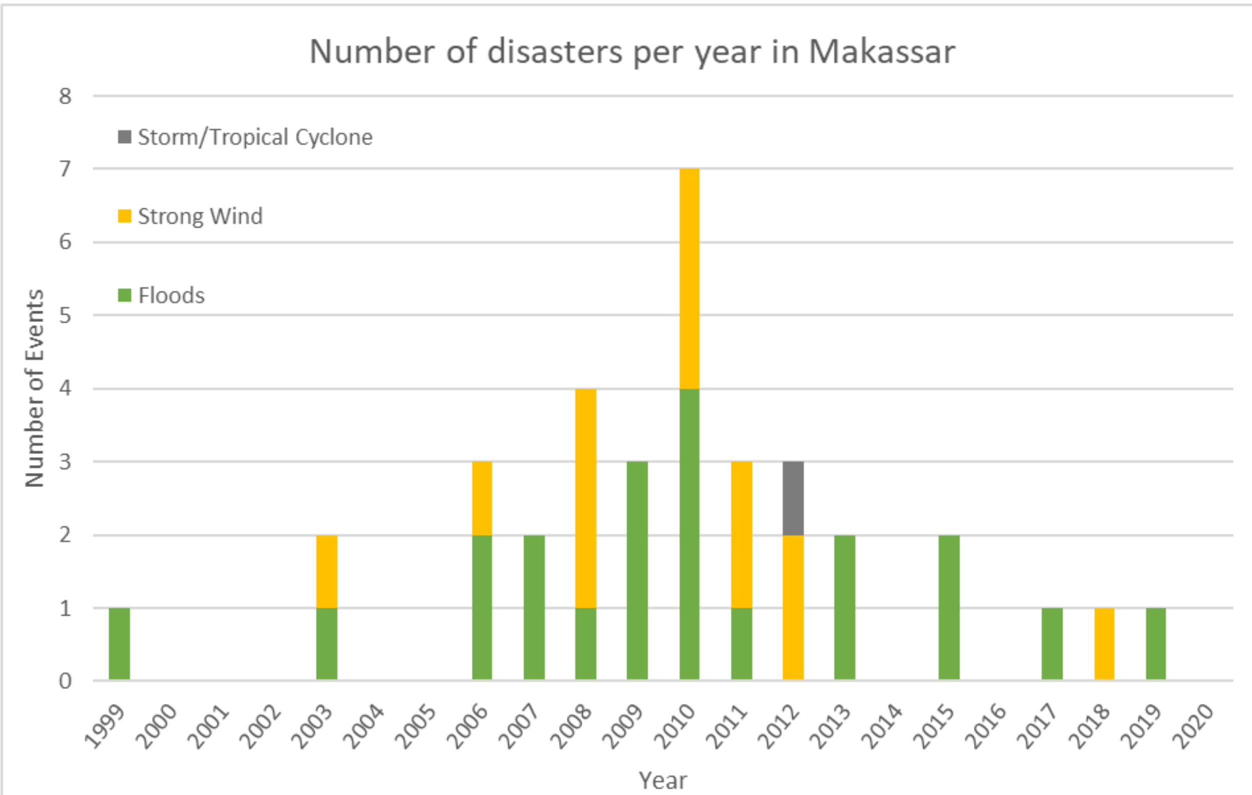


Figure 47 Number of Disasters due to natural hazards in Makassar City 2000-2020 (Analysis, 2021).

The analysis shows that there were 34 natural disasters in Makassar from 2000-2020. During the study period, most of disasters occurred throughout 2006-2014 period. Of these 34 disasters, 21 of them were floods (including coastal flood and flash floods) that occurred in the districts of Makassar City and its surroundings.

Table 30 Summary of Impacts of Disaster Due to Natural Hazards s in Makasar City.

District Name	Frequency Index	Severity Index	Hazard Index
Biringkanaya	0.40	0.60	0.49
Bontoala	0.20	0.40	0.28
Kepulauan Sangkarrang	0.00	0.00	0.00
Makassar	0.00	0.00	0.00
Mamajang	0.00	0.00	0.00
Manggala	0.60	0.80	0.69
Mariso	0.20	0.20	0.20
Panakkukang	0.40	0.60	0.49
Rappocini	0.20	0.20	0.20
Tallo	0.40	0.60	0.49
Tamalanrea	0.40	1.00	0.63
Tamalate	0.00	0.00	0.00
Ujung Pandang	0.00	0.00	0.00
Ujung Tanah	0.00	0.00	0.00
Wajo	0.00	0.00	0.00

Source: Analysis, 2021

Risk of floods coming from coastal surge could also disturb coastal communities due to the low laying topography area such as Tallo and Tamalanrea districts, although there is no strong evidence of coastal surge found in the disaster databases. Meanwhile, the second most common disaster is strong wind which generally occurs during the monsoon season and in an extreme atmospheric condition. During rainy season, heavy rainstorms is sometimes accompanied by strong winds and the excess water could cause flooding. In the last 20 year, 13 cases of strongwind disaster occurred and damage houses. Compared to the flood, the impact of strongwind is quite small. In one single event, flood could take up more than 9000 people affected and more than a thousand to be displaced. Whereas, a single event of strongwind only damage houses. However, impact and damages is not something to be taken just by the statistic numbers, a measured mitigation assessment and action need to be conducted to further reduce loss from the community. Table 28 above gives a description of the severity of natural hazard disaster in Makassar City which are mainly caused by flood and strongwind for the last 20 years.

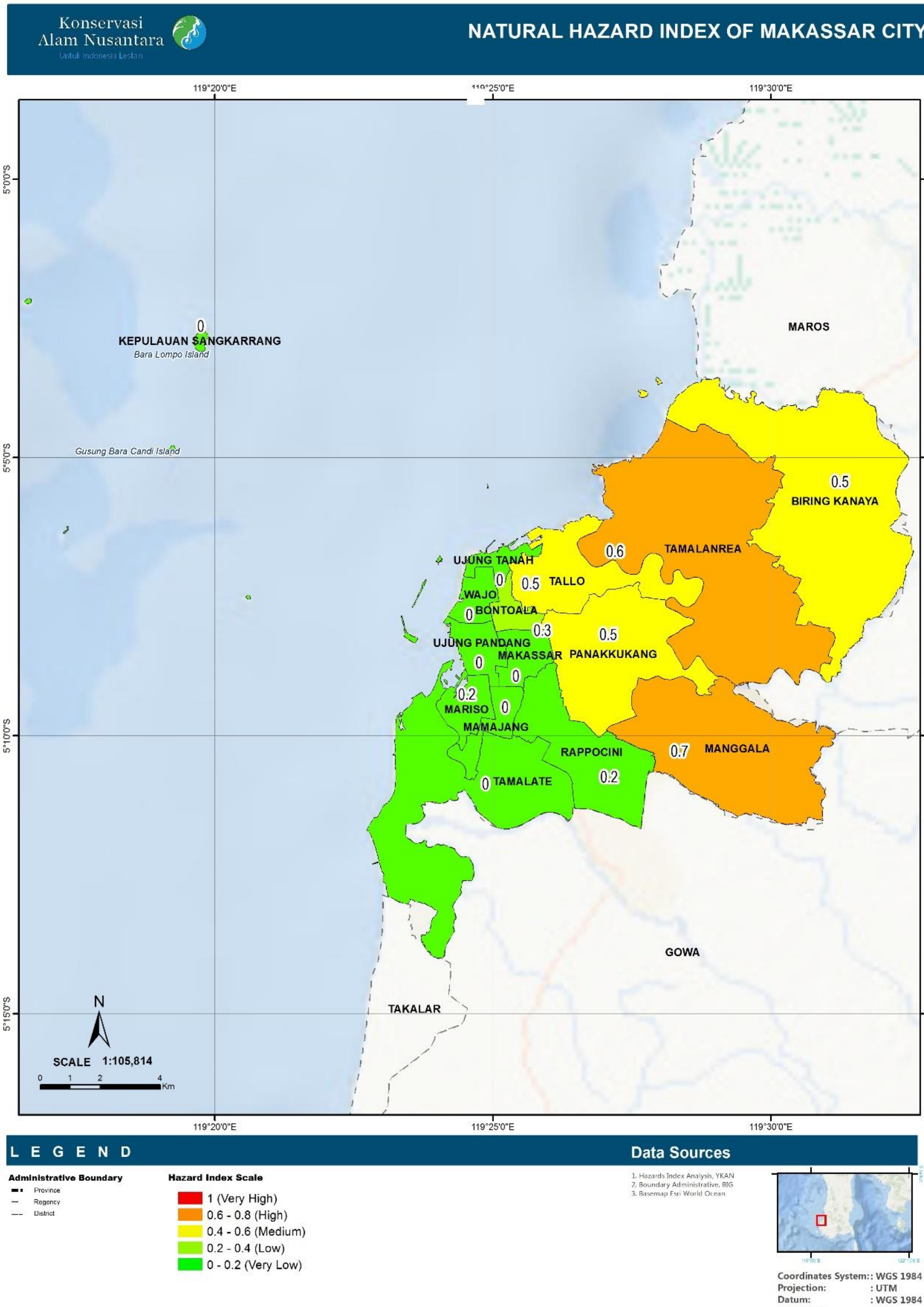


Figure 48 Hazard Index Map of Makasar City (Analysis, 2021)

With the frequency of flood disasters that can occur almost every year and cause repeated damage, the annual loss incurred can be considered smaller but if it is taken accumulatively, per decade, the loss value will be greater than other disasters. The value of this loss will greatly disrupt the livelihoods of the coastal communities in the Makassar region. An example is the Makassar Flood in 2019 where a few days of heavy rain accompanied by strong winds made Makassar City and 6 neigboring districts in South Sulawesi hit by floods. A bridge and a number of settlements were swept away by a swift current from the Jeneberang River, Tuesday (22/1/2019).

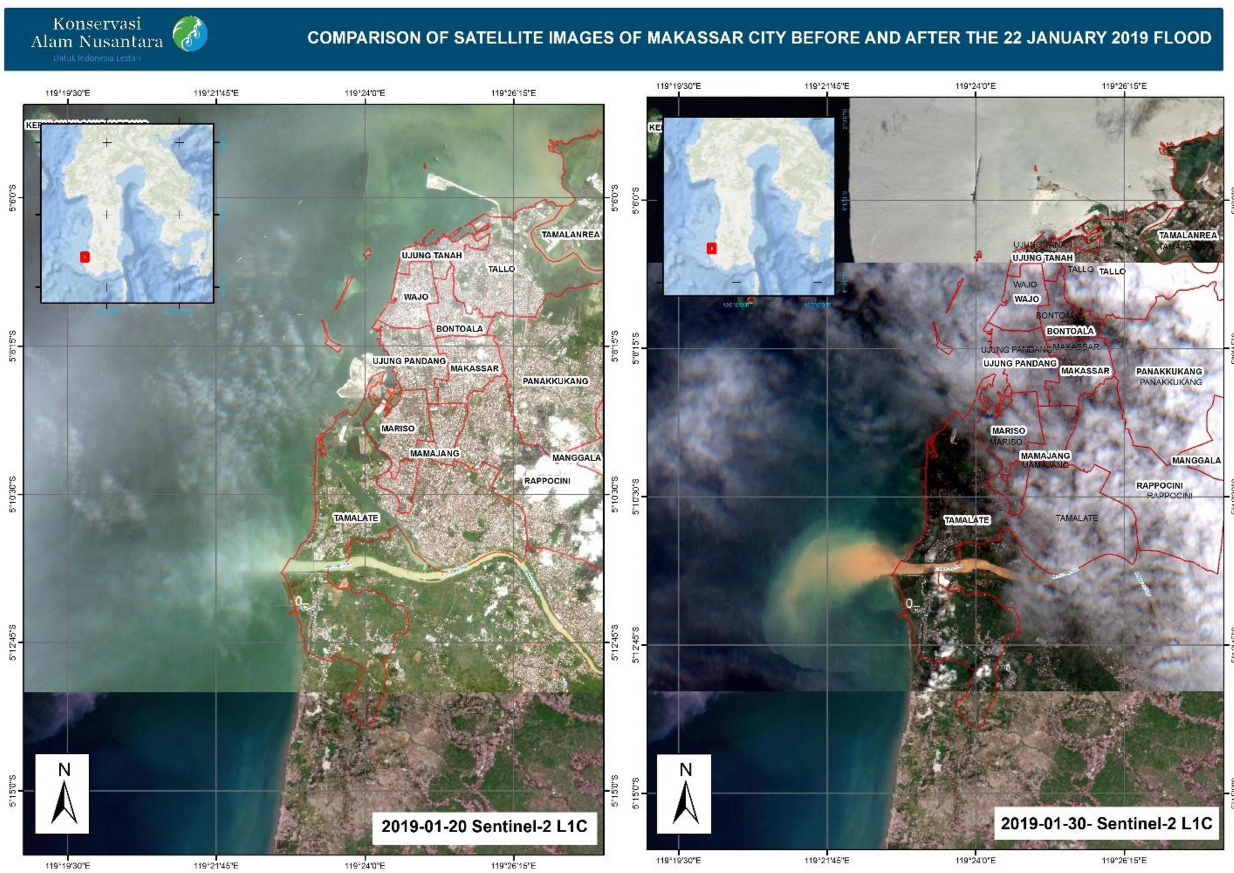


Figure 49 Map of Before and after Makasar flood 2019 (Analysis, 2021).

From literature reviews and analysis, hydrometeorological disasters such as floods and strong wind in the Makassar area do not provide an indication/explanation of direct impact to the coral reef ecosystem. The occurrence of floods and storms caused more losses to coastal communities in the Makassar area. However, it is to be noted for further investigation regarding the effect of floods sediment to the circulation of water on the seas in front of Makassar. Subsequent from extent flooding events at the beginning of 2019 (22/1/2019), through satellite image, it can be seen that the sediment outflow from Jeneberang River to the sea is quite considerable (Figure 50).

Collect and add data on damages and losses from past hazards/stressors over the past ten years.			
HAZARD/STRESSOR 1 (Most damaging)		**HAZARD/STRESSOR 2**	
List the most damaging hazard/stressor	Flood	List the second-most damaging hazard/stressor	Strong Wind
How many times has this occurred over the past ten years?	21.0	How many times has this occurred over the past ten years?	13.0
The annual probability rate (APR) for this hazard is:	2.1	The annual probability rate (APR) for this hazard is:	1.3
What currency will you use for monetary figures?	IDR	What currency will you use for monetary figures?	IDR
Damages (monetary values)		**Damages (monetary values)**	
Damages to homes	97,455,000,000	Damages to homes	3,810,000,000
Damages to business assets	48,300,000,000	Damages to business assets	100,000,000
Damages to public infrastructure	150,000,000	Damages to public infrastructure	75,000,000
Other damages (e.g. loss of land from erosion)	0	Other damages (e.g. loss of land from erosion)	0
Total damages	145,905,000,000	Total damages	3,985,000,000
Direct losses (monetary values)		**Direct losses (monetary values)**	
Losses in produce	0	Losses in produce	0
Losses in income	0	Losses in income	0
Other direct losses	0	Other direct losses	0
Total direct losses	0	Total direct losses	0
Indirect losses (monetary values)		**Indirect losses (monetary values)**	
Prolonged losses from produce sales	0	Prolonged losses from produce sales	0
Prolonged income losses	0	Prolonged income losses	0
Other indirect losses	35,295,000,000	Other indirect losses	0
Total indirect losses	35,295,000,000	Total indirect losses	0
Hazard 1: Total damages and losses	181,200,000,000	Hazard 2: Total damages and losses	3,985,000,000
Hazard 1: Annualised damages and losses	380,520,000,000	Hazard 2: Annualised damages and losses	5,180,500,000
The combined damages and losses from all four hazards/stressors over ten years have been:			185,185,000,000
On an annual basis, the combined damages and losses over ten years have been:			385,700,500,000

Figure 50 Past Damages and Loss Estimation of Makasar City (Analysis, 2021).

The damages and losses estimation from past hazards/stressors was done using the Blue Guide Calculator (The Nature Conservation, 2020) and the results were showed in Figure 50. In brief, the most frequent and damaging natural hazards in Makassar City are flood, followed by the strong wind. Over ten years, floods give damages and losses estimation of approximately IDR 181.2 billion in total with the annualised value reaches IDR 380.52 billion, while strong winds were estimated to possess damages and losses of approximately IDR 3.98 billion in total with annualised value of about IDR 5.18 billion. Further, the combined damages and losses monetary value from all the hazards/stressors over ten years was calculated to be around IDR 185.18 billion with IDR 385.7 billion calculated in an annual basis.

Box 2: The 2019 Makasar Floods

According to the National Agency for Disaster Management (BNPB) official report[18] on 25 January, the flood has affected 106 villages within 13 districts (Jenepoto, Maros, Gowa, Makassar-city, Soppeng, Wajo, Barru, Pangkep, Sidra, Bantaeng, Takalar, Selayar and Sinjai district).

Furthermore, according to the report:

- 59 people reported dead, 25 people are missing, 47 people injured, 3,481 people evacuated and a total of 6,596 people affected by the flood;
- 79 unit of houses are damaged (32 unit washed away by the flood, 26 heavily-damaged, 2 medium-damaged, 14 lightly-damaged and 5 buried by landslides);
- 4,857 houses inundated by flood;
- 11,876 hectare of farm field are destroyed by flood;
- 10 bridges damaged; the floods covered 16.2 km of road in the area, 2 markets, 12 praying houses, 6 government facilities and 22 schools.

[18] See https://reliefweb.int/report/indonesia/indonesia-flash-floods-and-landslides-south-sulawesi-province-information-bulletin

4.2.2 Past disaster events due to anthropogenic hazards

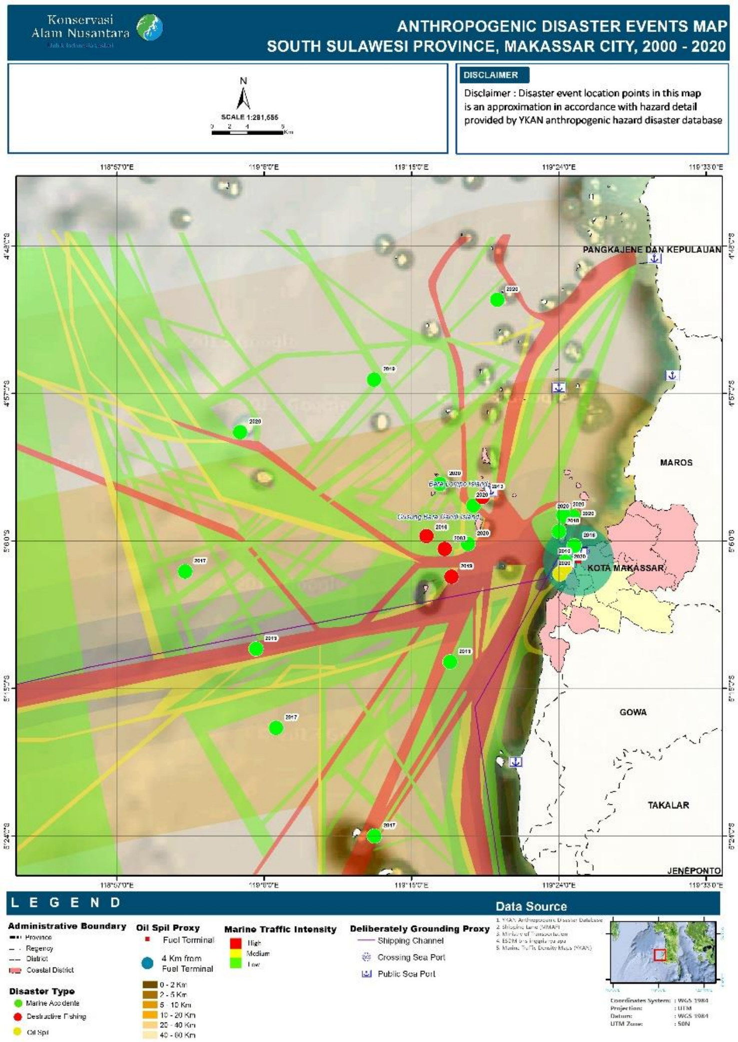


Figure 51 Map of Anthropogenic Disaster Events in in Makassar City 2000-2020(Analysis, 2021)

In general, disaster incidents due to anthropogenic hazards that occur in Makassar, South Sulawesi Province are dominated by events related to marine accidents. From the data collected in the last 20 years, the number of disasters due to anthropogenic hazards in Makassar City, is 27 incidents consisting of 7% oil spills, 19 % destructive fisheries and 74 % marine accidents. 13 of these activities takes place in the area of Makassar City districts, while the rest of events (14) take place in the vicinity of Makassar Strait waters, but still in the area of South Sulawesi Provinces. From this classification, 10 events takes place in the Sangkarrang District, which are the only Makassar City District with a range of islands. While the rest of events (3) takes place in nearshore of the proximate district (Wajo and Ujung Pandang).

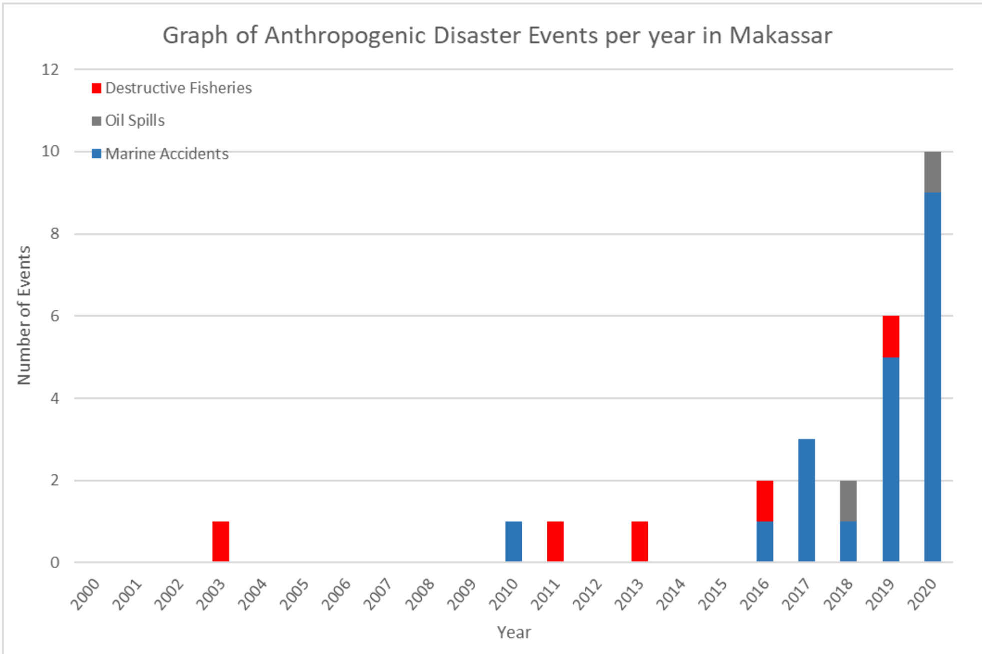


Figure 52 Number of Anthropogenic Disasters in the coastal area of Makassar City, South Sulawesi Province during the Last 20 Years (Analysis, 2021).

When compared to former decade, the incidence of disasters due to anthropogenic hazards recorded in Makassar tended to increase significantly from 2001-2010, which only recorded 2 events, while in later decade of 2011-2020 period, increased to 25 incidents. The pattern of the number of disasters due to anthropogenic hazards that occurred in Makassar is shown by Figure 52 above.

Apart from directly affecting life and livelihoods, anthropological disaster also have the potential to affect the health of surrounding environment. Based on records, destructive fishing activities that occurred in Makassar City waters has the potential to cause losses in the environment. During the last 20 years there have been at least 5 known cases from 2003 to 2019. This activity causes fisheries businesses in the area to be increasingly prone to violations of compliance with aspects of the health of the marine ecosystem and the use of fishing gears that have the potential to destroy.

Table 31 Anthropogenic Hazard Index of Makasar City.

Districts	Destructive Fishing	Marine Accidents	Oil Spills	AHI
Biringkanaya	0	0	0	0.00
Bontoala	0	0	0	0.00
Kepulauan Sangkarrang	3	7	0	1.00
Makassar	0	0	0	0.00

Districts	Destructive Fishing	Marine Accidents	Oil Spills	AHI
Mamajang	0	0	0	**0.00**
Manggala	0	0	0	**0.00**
Mariso	0	0	0	**0.00**
Panakkukang	0	0	0	**0.00**
Rappocini	0	0	0	**0.00**
Tallo	0	0	0	**0.00**
Tamalanrea	0	0	0	**0.00**
Tamalate	0	0	0	**0.00**
Ujung Pandang	0	0	1	**0.01**
Ujung Tanah	0	0	0	**0.00**
Wajo	0	1	1	**0.12**

Source: Analysis, 2021)

In addition, several fishing activity were also found damaging to more than 100 hectares of coral reefs by the use of trawling gear which was reported on May 10, 2011. Damage to coral reefs is suspected to continues until today and the following years based on the evidence of the arresting the perpetrator of blast fishing bomb suppliers in November 2019.

Destruction marine ecosystem in Makassar is also threatened by oil pollution, both caused by boat leaks (1 case) and pipe leaks (2 case). Two cases of pipe leakage occurred on March 31, 2018 originating from the Pertamina refinery Unit V Baikpapan pipeline, which leaks oil and have potential to spread to Makassar City waters. Six hours after the oil spill was first identified, a fire occurred at sea level. At around 11.25 WITA, fire struck the stern of the Panama-flagged MV EVER JUDGER, GT 44,060, which was anchored at anchor. As a result of this incident, five people died (Pitoko & Jatmiko, 2018).

The second leak occurred on May 20, 2020, originating from the bunker pipeline in Makassar City waters. The leaks are estimated only around 11 liters, but due to the oil type is low sulfur fuel oil (LSFO), the diversion becomes wider (Herlina, 2020). This pollution can damage and kill the surrounding biota.The potential for this incident is still very large considering the high activity of shipping and marine transportation in Makassar waters. Another consideration is the presence of oil storage facilities in Makassar city which will certainly have potential for increased damag if not properly managed with good monitoring and maintenance.

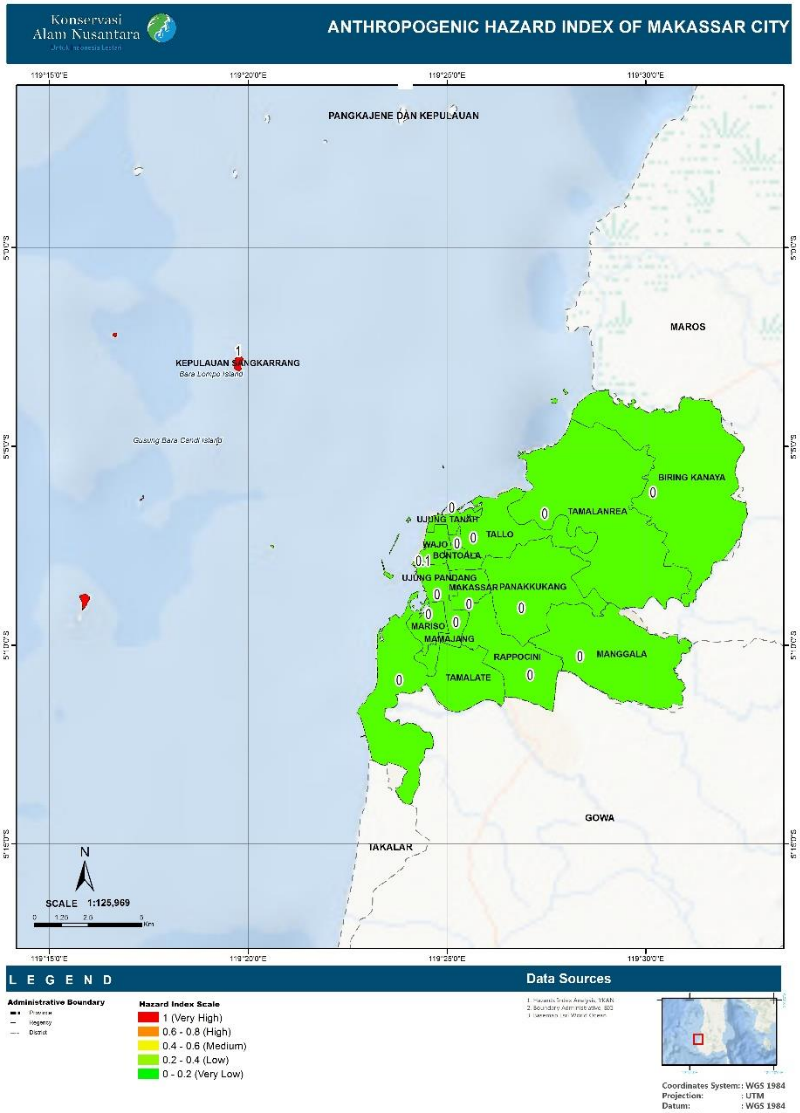


Figure 53 Anthropogenic Hazard Index of Makasar City (Analysis, 2021)

Apart from destructive fishing activities and oil spills, several marine accidents occurred which rendered a lot of people to be missing or injured. From an economic aspect, the marine accident that occurred has at least caused the loss of important livelihood assets for coastal communities, which are the sinking of ships. Although in terms of quantity it is still relatively small when compared to the impact of destructive fishing, impacts generated by marine accidents have caused direct impacts on humans (lost and drowned) so that it needs more attention and efforts to reduce these impacts, either avoiding threats, reducing, or transferring disaster risk, one of which is by using insurance. From the collected impacts and its probability, it is shown that the Sangkarrang District has the biggest magnitude of Anthropogenic Hazards, mainly due to its geographical factor, which are composed in group of island district.

4.2.3 Past disaster events due to natural and anthropogenic hazards and slow onset in nature

Coral reefs in South Sulawesi, including in the Makassar region, are a group of coral reefs that can develop well and can reach the peak of biodiversity. In some areas that still have high diversity, corals can develop horizontally and vertically to a depth of more than 30 meters. These good conditions are caused by natural factors which are very supportive, especially because the water is clear and warm. Another contributing factor is the constant supply of water flows from the Pacific Ocean through the Makassar Strait known as ITF (Indonesian Throughflow). However, this equilibrium can be disturbed by climate change which causes an increase in sea surface temperature, whereas in the waters of Makassar, the sea level rise per decade is in the range of 0.2-0.3 ˚C which can cause coral bleaching, as occurred in the Spermonde Island area in 2010 (Donner, Rickbeil & Heron, 2017).

BMKG analysis of warming sea temperatures provided information that the warm sea surface temperature (> 27˚ C) indicates very high evaporation which causes the potential for the formation of very large convective clouds. Weather conditions tend to be cloudy to rain in Makassar City and South Sulawesi MJO (Madden Julian Oscilation) on January 22 was in quadrant 5 (Maritime Continent).

Table 32 Status of Coral Reefs in Makasar City.

Location	Num of Station	Very Good	Good	Fair	Bad
Makassar (South Sulawesi)*	13	0	1	6	6

Source: Hadi, et al., 2019.

The condition of coral reefs in Makassar City waters in general are in moderate condition, where 6 of the 13 observation points are in bad condition (Hadi, et al., 2019). Although there is no complete information regarding the exact location of the coral reef observation points, the increase in temperature can worsen the health condition of coral reefs in Makassar waters in the future (see chap 2.3.4.D)

According to Hadi, et al., 2019, the locations of reefs with bad category in South and Southeast Sulawesi, North Maluku, and Papua are generally the result of anthropogenic factors, especially blast fishing. Not all of these locations are included in marine conservation areas, therefore destructive fishing is still ongoing. In addition, destructive fishing generally occurs far from settlements and mostly occurs in remote areas.

As this study examined threat from anthropogenic factor as seen in Table 17 in chapter 2.3.5. Threats from anthropogenic factor which could potentially risk coastal ecosystem especially coral reefs are mainly generated from coastal population. Makassar has high coastal population among other regencies in this study around 1.5 million people. This massive population requires a large carrying capacity in other to survive and to further develop. Makassar city is supported by a the biggest container terminal in the eastern Indonesia called Pelabuhan Soekarno Hatta, along with it there are 8 port/harbor (2 PPI and 6 Domestic port) intended for fisheries or transporting. Pelabuhan Soekarno Hatta container terminal and ferry port is also the busiest port in eastern Indonesia regions. The large transport ferry accommodate transportation for people to go to all part of Indonesia. In order to maintain this high level and massive activities an oil storage facilities (TBBM Makassar) is also build in Makassar city to supply fuel for the surrounding region. Busy port and harbor activitis coud also potentially polluted the sea directly from their ship and from the people activities in the mainland. Makassar also has two big river namely Jeneberang and Tallo river, which could bring sediment and pollutant material from land to sea which eventually could disrupted the nearby reefs.

Other than its busy activities, Makassar also relies on coral reefs as tourism destination in its islands. Samalona and Spermonde islands is well known for its tourism spot, with around 207 hotel in its area Makassar city also relies on tourism to attract people to come. Coastal and island tourism activity is commonly known in Makassar island which could also potentially increases its risk in the future for coral reefs.

As the center of national activities, Makassar City does not only develop its inland region, but systematically includes reclamation programs/activities. Reclamation is an activity carried out by everyone to increase the benefits of land resources from an environmental and socio-economic point of view by means of land filling, draining or drainage. The reclamation in WP-3-K is intended to: a) protect the coastal lowlands; b) overcome land subsidence; c) development of public areas and others; d) dealing with sea level rise; and e) reclaim / fill the lost land. The location of the reclamation of the City of Makassar shall be stipulated in WP3-K, except in: a. core zone conservation area; and b. sea lanes. However, further analysis is still needed to determine with certainty the impact on the coral reef ecosystem around the reclamation site in Makassar City. Figure 54 below shows the comparison of shoreline changes before / after reclamation.

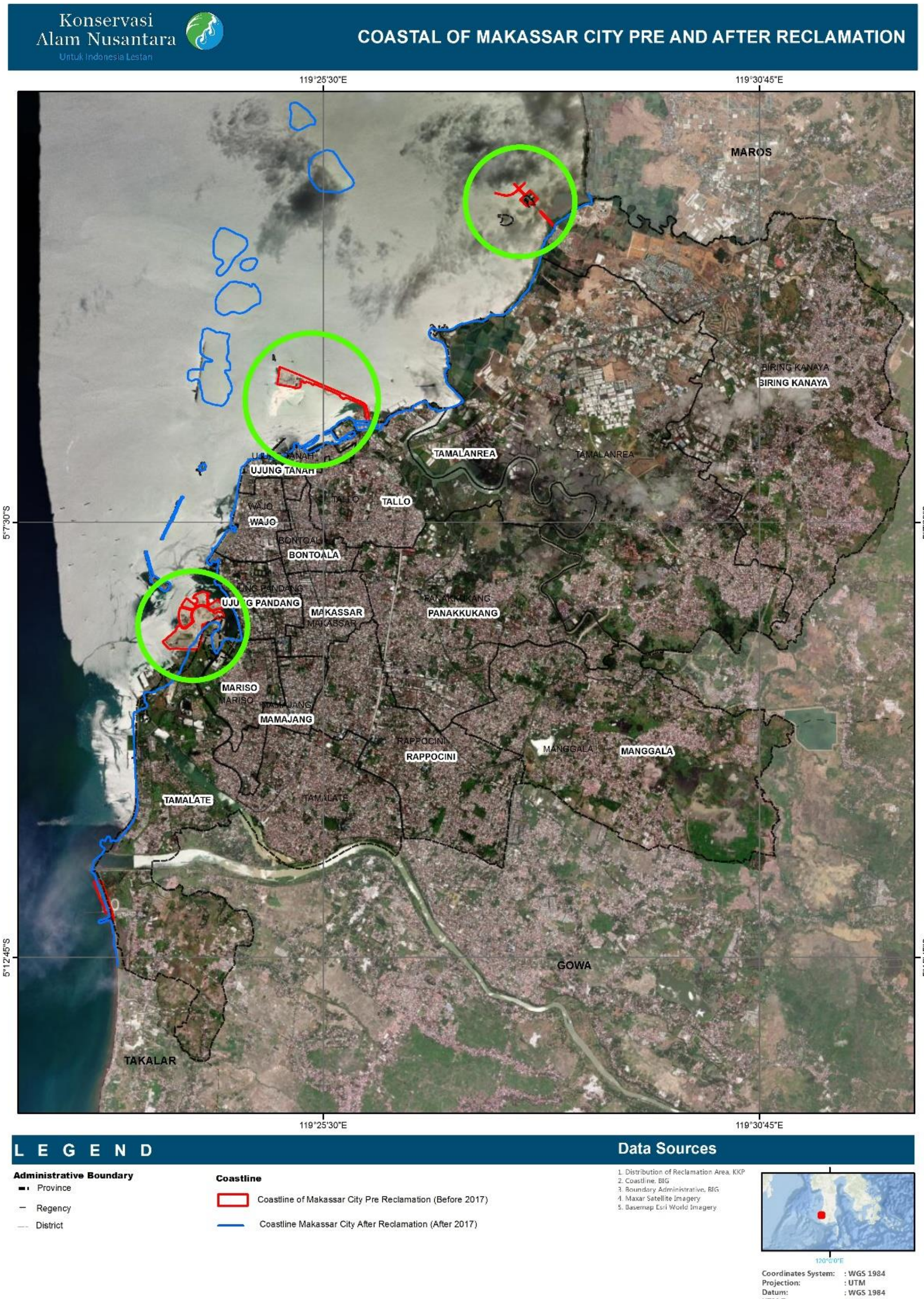


Figure 54 Map of Comparison of changes in the coastline of Makassar City before / after reclamation (Analysis, 2021).

4.3 Stakeholder Mapping and Local Institutional Capacity of Makassar city

The intersection between programs / activities of disaster management affairs / sector, marine fisheries, environment, and coastal area development largely determines the list of stakeholders in Makassar City which have been identified. To date, there are 55 actors / stakeholders identified as can be seen in the annex. In total, there are 3 national government actors, 5 Provincial Government actors, 6 City Government actors, 21 NGOs, 17 business actors, as well as 1 community group. Based on their sectors, there are 9 disaster management actors, 3 fishery / marine actors, 3 environmental actors, 29 coastal development actors, and 12 general / cross-sector actors.

Based on the results of data collection to date, actors in fisheries and marine affairs are not particularly prominent, especially fisheries and coral reef conservation businesses. Although this does not mean that in Makassar City there are absolutely no related programs / activities, only the number is very minimal documented and can be found in internet search engines. Another factor that might causes this is that after the filtering process on the search engine, it is known that most of the findings of conservation programs / activities that mention the “Makassar Strait” mostly come from surrounding districts / cities, for example Pangkajene, Maros, Goawa, or Takalar Districts; so they must be excluded from the dataset. This is also in line with the description in sub-chapter 4.1 that the intensity of fisheries sector activities is far below that of other sectors in the coastal area of Makassar City, for example trade-services, transportation, and construction.

Thus, the list of stakeholders in the appendix is dominated by actors related to development activities at two reclamation locations in Makassar City as well as actors identified and playing a role in the emergency response and recovery process after the January 2019 South Sulawesi Flood disaster. Moreover, reclamation on a large scale in Makassar City has been mandated in the 2015-2034 Makassar City Spatial Plan, covering the Center Point of Indonesia (CPI) Area in the south and the Makassar New Port Area. In general, until the beginning of 2021, all reclamation of Center Point of Indonesia has been built, while the Makassar New Port is only 20% of the total development plan.

Figure 55 illustrates the initial indication of the stakeholder interest level matrix which is generally influenced by the grouping of stakeholders based on working relationships according to the Makassar City development policy document in the related sector, as well as the real relationship of joint programs / activities between several actors, especially actors involved in reclamation activities in the two location, actors who opposed the reclamation activities, as well as actors involved in emergency response and recovery programs / activities after the January 2019 South Sulawesi Flood disaster.

The companies involved in reclamation activities in the southern part of Makassar City, around Center Point Indonesia are PT. Bosowa Property, a consortium of Center Point of Indonesia (PT. Yasmin Bumi Asri and Ciputra Indoland), PT. Mariso Indoland, PT. Puncak Bumi Gemilang, PT. Megasurya Nusa Lestari, PT. Central Cipta Bersama, PT. Tunas Karya Bersama, PT. Kibar Makassar Bisnisland, and Gowa Makassar Tourism Development (GMTDC). Furthermore, the companies reclaiming the northern part of Makassar city, Makassar New Port, were PT. Laburino, PT. Vacra Artha Monica, PT. Implementing Jaya Mulia, PT. Sinar Amali Pratama, and PT. Asindo.

Reclamation activities in Makassar City have received negative reactions from community groups and NGOs that are members of two network-like actors, namely the Save the Coast Alliance (*Aliansi Selamatkan Pesisir/ASP*) and the Community Against Reclamation (*Masyarakat Tolak Reklamasi/MTR*). ASP membership includes NGOs, student elements, and community groups including: South Sulawesi Forum for the Environment (Walhi), Sulawesi Anti-Corruption Committee (ACC), LBH Makassar, Information and Communication Forum (FIK), South Sulawesi NGOs, Anging Mammiri Women's Salodaritas, Kontras Sulawesi, LAPAR Sulawesi, YKL, Aman Sulsel, KN Katalassang, Celebes Journal, FMN Makassar, Srikandi, FND-SGMK, and Makassar Parking Attendants Union (SPJM).

Based on the compilation of secondary data to date, basically the categorization is done around the grouping above. Business actors involved in temporary reclamation activities are classified as “disturbing actors” because there is no clear evidence of their activities which also protect coastal areas and ecosystems, even though legally their businesses are already part of programs / activities in the 2015 Makassar City RTRW- 2034 and RPZWK Makassar City. In general, the OPDs of Makassar City and South Sulawesi Province are classified as "skeptical actors" who are still neutral and need further advocacy to be more serious about protecting coastal areas. However, the existence of policy products that have been issued by the Makassar City Spatial Planning Agency for reclamation activities and the absence of any attempts to review the existing spatial planning products have resulted in this OPD being classified as a "disruptive actor". From the elements of NGOs, research / education institutions, and community groups that oppose reclamation and do have expertise in coastal area management and the environment, they are classified as driving actors and partners. They include Walhi, the Alliance to Save the Coasts of

Makassar, Hassanudin University, KIARA, the Marine Conservation Foundation. Meanwhile, organizations that are members of the ASP and Community Reject Reclamation, but do not have expertise related to coastal area management, are classified as "supporting actors". Figure 55 also classifies actors playing a role in the disaster management sector as “potential actors”

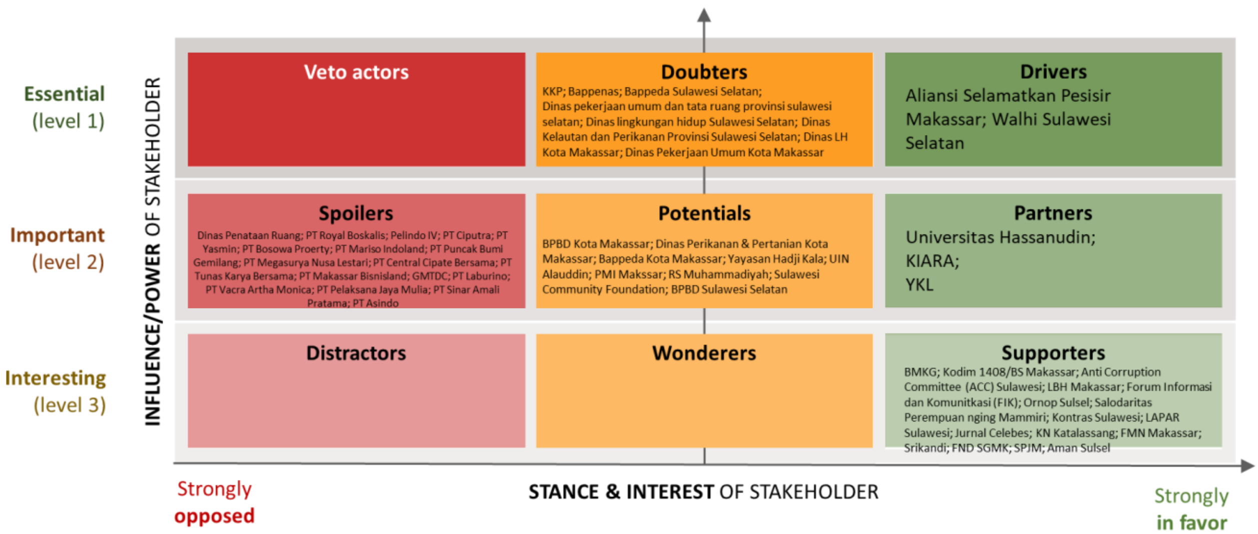


Figure 55 Makassar City Stakeholder Map (Analysis, 2021).

Based on the information that can be gathered from official documents as well as news available online, the relationship between identified stakeholders in Makassar City is mapped in the social network graphic below.

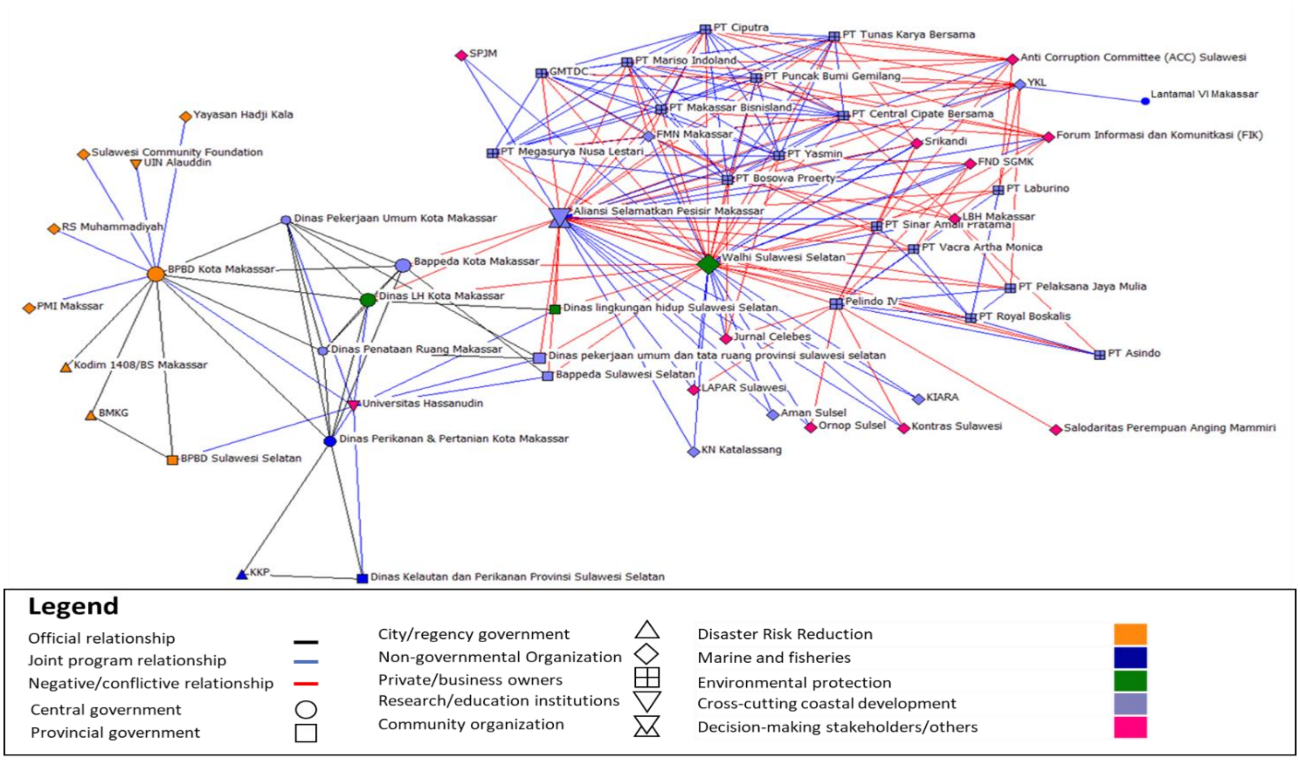


Figure 56 Social Network Analysis Diagraph between stakeholders in Makassar City (Analysis, 2021).

The network graphic above depicts 3 types of relationships, namely (1) relationships stipulated in official regulations, (2) cooperative relationships from indications of carrying out joint programs in disaster management and nature conservation, (3) negative relationships due to conflicts in terms of disaster management and nature conservation. In this network, 56 actors (nodes) were identified and 290 total ties (ties). Among them are 165 cooperative program / activity relationships and 145 negative relationships.

As can be seen in the figure, the left side gives an indication of the relationship between programs / activities with actors involved in disaster management after the 2019 South Sulawesi Flood. However, it should be noted that the compilation of data shows that these actors have not specifically carried out activities disaster risk reduction programs, except for Indonesian Red Cross. Figure 56 also captures several programs / activities for environmental and coastal conservation, including between Ministry of Maritime Affairs and Fisheries (MMAF), Makassar City DKP, and South Sulawesi DKP as well as between MMAF, YKL, and Lantamal VI Makassar on Kodingareng Island.

The right side of the picture depicts a constellation of conflicts between business actors directly related to NGOs and community groups that are members of the ASP and MTR, and indirectly with the Makassar City Government and the South Sulawesi Provincial Government. The ASP and MTR networks basically question whether the reclamation plan is in accordance with the regulations regarding coastal zoning and permits based on the Guidelines for Spatial Planning for Coastal Reclamation Areas, Ministerial Regulation of the Ministry of Maritime Affairs and Fisheries 40 / PRT / M / 2007 which states that coastal reclamation permits are issued by the ministry. This then became the basis for ASP to question the validity of the RZWP3K South Sulawesi. In RZWP3K, the Government of South Sulawesi is currently planning to reclaim 625.35 hectares of land in the core part of the CPI and 840.75 hectares for the CPI buffer zone. ASP and MTR also claimed that the Makassar New Port project was detrimental to fishermen.

NGO actors and community groups also based their arguments on the consideration that the regime of Law 32/2009 on the environment also illustrates the potential for conflict and inconsistencies with laws and regulations from reclamation activities in Makassar City. Several parties also stated that the documents of Environmental Impact Analysis (AMDAL) and Strategic Environmental Assessment (KLHS) were never accessible to the public and that there was a gap between AMDAL and KLHS preparation activities in 2010 and the start of reclamation implementation in 2013, indicating the need for a second re-evaluation. environmental documents.

Furthermore, the table below shows the agencies with the highest degree of centrality and betweenness centrality in Makassar City, as an initial proxy for the identification of key actors at the location. The degree centrality value shows the number of relationships; Meanwhile, the value of betweeness centrality indicates the frequency with which one actor is between two or more other actors, thus indicating a proxy role as a coordinator. However, due to the limited data input at secondary sources, this finding needs further validation.

Table 33 Degree and betweenness centrality values of stakeholders in Makassar City.

Stakeholder	Degree
Aliansi Selamatkan pesisir	66
Walhi Sulsel	66
Yayasan Konservasi Laut	28
BPBD Kota Makassar	20
Universitas Hassanudin	18

Stakeholder	Betweenness
Aliansi Selamatkan pesisir	179.923
Walhi Sulsel	179.923
BPBD Kota Makassar	175.400
Dinas LH Kota Makassar	90.733
Bappeda Kota Makassar	90.333

Source: Analysis, 2021.

Based on the measurement against indicators and performance standard in the SPDAB, Makassar City scored 32.5% out of total 100%. Hence, measured in SPDAB's resilient city class, Makasar City would fall in the second class (out of maximum five), which means the regency has several initiatives of disaster management activities across pillar, but has not yet make any significant structural changes. Makassar City performed best at indicators in Pillar 1 (disaster governance), at 3.50, and Pillar 2 (socio-economic preparedness), at 3.00. In Pillar 1, the value was increased due to the archival findings that the city has managed to complete the Disaster Risk Assessment (KRB) and Disaster Management Strategy (RPB) documents. Both sectoral disaster management policies were also adopted in the City Spatial Plan (RTRW) and other policy documents (Strategic Plan/RPJM and Annual Plan/RKP). In addition, BPBD Makassar is classified as Type A (the highest) by BNPB and in the past has an initiative to establish a DRR Forum in the city. With regards to Pillar 2, the value was higher due to the achimevement of health system in Pandeglang Regency, measured by the Public Health Index (IPKM) of Ministry of Health.

Makassar City performed weaker in Pillar 3 (protection and recovery preparedness of critical infrastructure), average performance at 2.50, and Pillar 4 (emergency management services), with average performance 1t 2.25. From secondary data availability, the factor affecting this evaluation was ratio of emergency service personnel in the city against the city population, inferior Emergency Operations Center (Pusdalops) classification, lack of performance during series of recent floods, both in terms of emergency response and recovery. However, in Pillar 3, one of the indicator that performed better than the pillar's average was indicator on food security, which was rated good by Ministry of Agriculture.

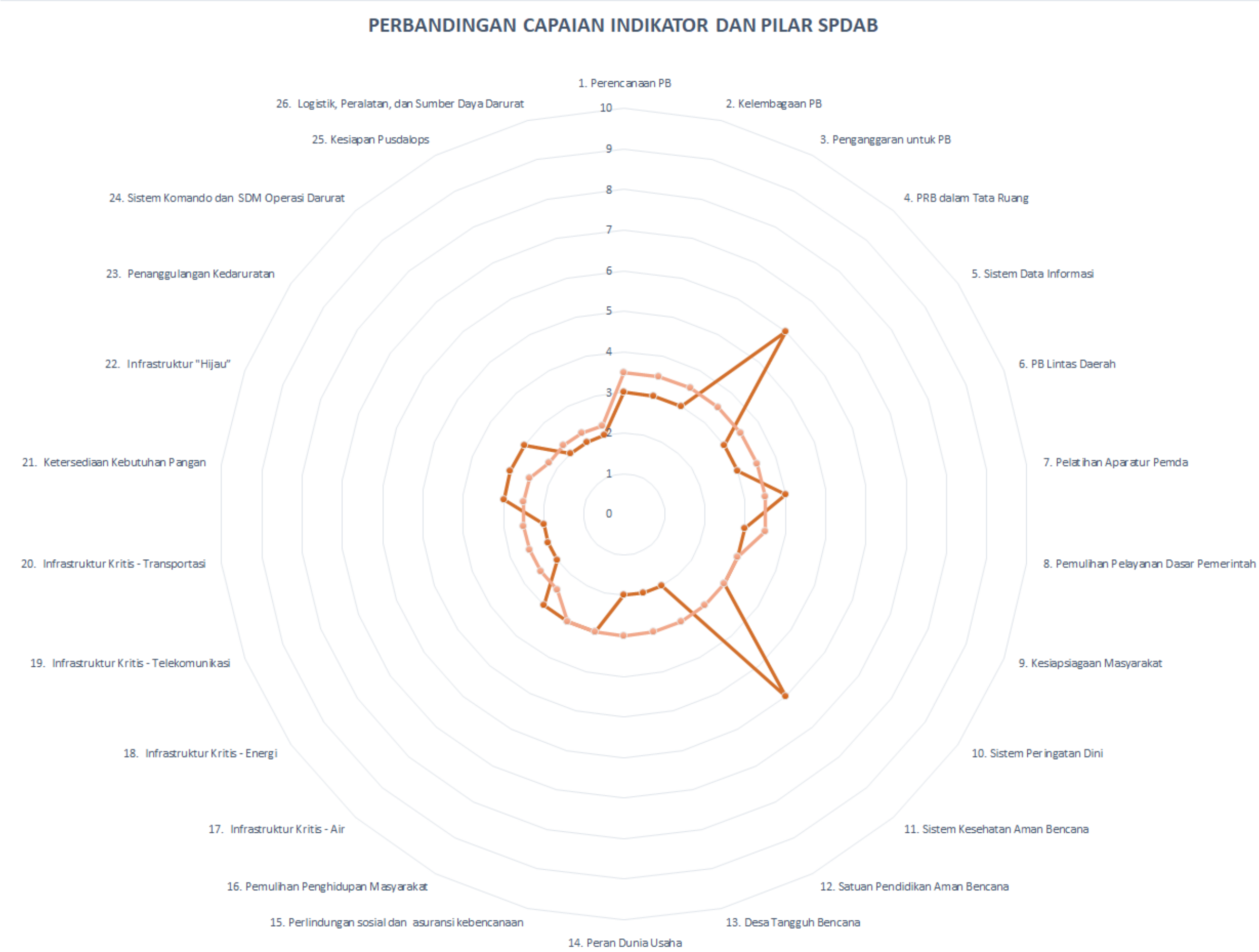


Figure 57 CARI! SPDAB Tool Output Spiderweb Capacity Diagram for Makassar City (Analysis, 2021).

Table 34 SPDAB Pillar Average Indicator and Final Score in Makassar City.

SPDAB Pillar	**Average Indicator Score**
PILLAR 1: Governance, Policy, and Planning Standard	3.50
PILLAR 2: Preparedness and Socio-Economic Strengthening Service Standard	3.00
PILLAR 3: Critical Infrastructure Protection and Recovery Preparedness Standard	2.50
PILLAR 4: Disaster Emergency Service Standard	2.25
	Final SPDAB Score = **0.325**

Source: Analysis, 2021.

4.4 Risk Profile, Valuation, and Scenario of Makassar city

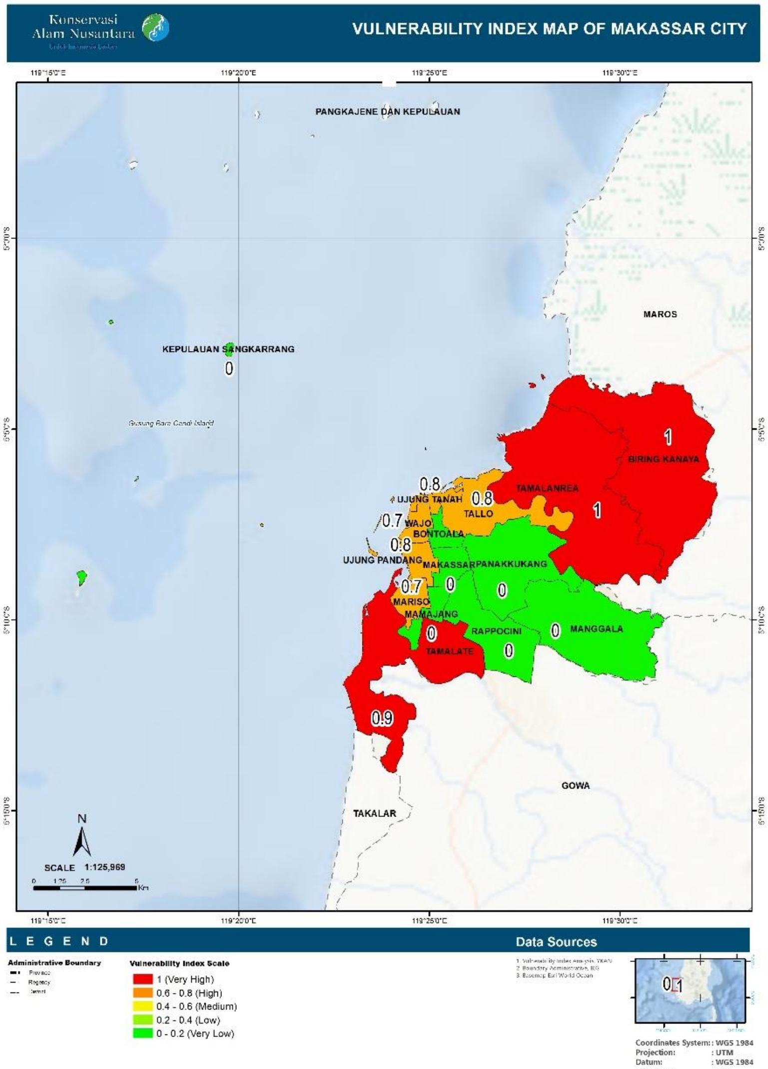


Figure 58 Vulnerability Index Map of Makasar City (Analysis, 2021)

Makassar city is formed in alluvial low laying plain which is heavily influenced by monsoon and its two big rivers, namely Tallo and Jeneberang River. Seismically, Makassar city has a low peak ground acceleration value (0.25-0.3 g) which means that Makassar City has a low potential to be impacted by an earthquake. In fact, there is no recorded of large earthquake event in the past 20 years. Accompanied by the minimum existence of fault line surrounding Makassar City, seismic hazard in Makassar city is quite low. The recorded earthquake which hit Makassar in the past 20 year has a minimum intensity (MMI < 4). With these low intensity earthquakes, the potential tsunami risk due to local tectonic event in Makassar city is also low, with maximum of 1 meter potential tsunami height according to 500 year probability tsunami assessment. With this natural hazard threat, BNPB has scored Makassar City for multi-hazard in 2018 classified as 131.78 or rank 34, which means Makassar City has a moderate risk among other cities/regencies in Indonesia. From the BNPB report (BNPB, 2018), Makassar City is also ranked 20 out of 24 districts/cities in South Sulawesi.

The existing and potential threat for Makassar city comes from hydrometeorological factors. Makassar has a tropical monsoon climate with annual rainfall shows wide variation between months in Makassar due to movement of the Intertropical Convergence Zone.

Table 35 Risk Profile of Makassar City.

District	Index Hazard	Index Exposure	Index Sensitivity	Adaptive Capacity Index	Index Vulnerability	Risk Index
Biring Kanaya	0.49	0.80	0.53	0.33	1.00	**0.80**
Bontoala	0.28	0.00	0.44	0.33	0.00	**0.00**
Makassar	0.00	0.00	0.41	0.33	0.00	**0.00**
Mamajang	0.00	0.00	0.35	0.33	0.00	**0.00**
Manggala	0.69	0.00	0.38	0.33	0.00	**0.00**
Mariso	0.20	0.80	0.30	0.33	0.73	**0.38**
Panakkukang	0.49	0.00	0.40	0.33	0.00	**0.00**
Rappocini	0.20	0.00	0.38	0.33	0.00	**0.00**
Tallo	0.49	0.80	0.33	0.33	0.81	**0.63**
Tamalanrea	0.63	0.80	0.42	0.33	1.00	**0.80**
Tamalate	0.00	0.80	0.36	0.33	0.90	**0.00**
Ujung Pandang	0.00	0.80	0.33	0.33	0.80	**0.00**
Ujung Tanah	0.00	0.80	0.35	0.33	0.86	**0.00**
Wajo	0.00	0.80	0.29	0.33	0.70	**0.00**

Source: Analysis, 2021.

From hazard index analysis, Makassar has only been affected by flood and strong winds disaster. This event also affected certain area, especially area which are close to the river. From the analysis, during this past 20 years, there are districts that is not affected by any disasters which make its hazard index is minimum (0). With this minimum hazard index, thus the risk index is also minimum. But to put in context with potential risk in the future, the vulnerability of the Makassar City could be the main driver for the higher risk in the future. As a big city, the population of Makassar City will keep on growing and provide social vulnerability. The analysis shows that the districts with high vulnerability is districts which adjacent or in border with the sea ranging from the index of 0.7 to 1. From these 8 high vulnerability districts the most vulnerable districts are Biring Kanaya and Tamalanrea District with an absolute index of 1.

Biringkanaya and Tamalanrea has more than 300.000 thousand lives both combine, which are a fifth of the total population in Makassar. Moreover, built area in these two district along with its economical role is also the main factor to contribute high vulnerability index. More than 70% of the land in Makassar City is already built, while the rest is scattered for marshes and mangroves, public parks, fish pond and unoccupied area. These two districts are also located around the Tallo River, which frequently flooded houses and damaged the coastal community. All in all, these contributing factors ultimately gives a high-risk values.

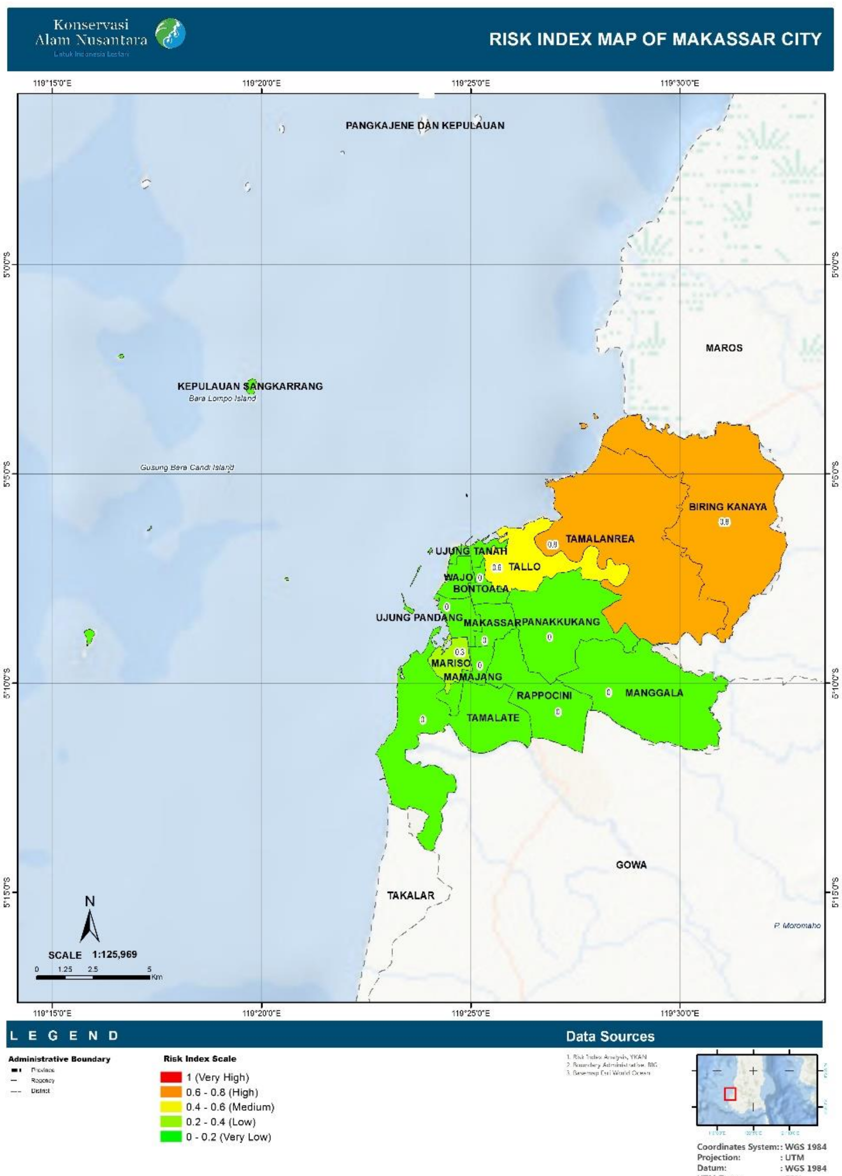


Figure 59 Risk Index Map of Makasar City (Analaysis, 2021).

As mentioned earlier, the danger from natural hazard mainly contributes to risk for the coastal community of Makassar City. As for coral reefs in Makassar City waters, the major risk contributing factor comes from anthropogenic activities mainly from marine accidents and destructive fishings. With human intervention growth as the main contributing factor in anthropogenic disaster, thus a growth in economic such as growth in tourism and fisheries along with population growth, would potentially put more pressure in the coral reef ecosystems.

Accordingly, the risk scenario of Makassar City in monetary terms is presented in the following figure. The calculations were done using the Blue Guide with inputs from the recorded disaster events and risk profiles of the city. The approaching scenario forecasts the total damages and losses for the next 20 years with 5% discount rate to reveal a summary figure based on present currency value.

SCENARIOS

Basic approach (simplified)	
Timeframe (years into the future)	20
Discount rate	5%

In the basic approach, the three scenarios are automatically generated based on the data you entered above. Scenario A assumes that the level of damages and losses will remain the same as it was over the past 10 years. Scenario B assumes an increase by 10% (progressive increase by 2.5% every 5 years). Scenario C assumes an increase by 20% (progressive increase by 5.0% every five years). The discount rate of 5% is applied across all three scenarios to reveal a summary figure based on **present currency values**.

	SCENARIO A		SCENARIO B		SCENARIO C	
Assumption for this scenario	The level of damages and losses will not change, compared to the past ten years	0%	The level of damages and losses will progressively increase by*:	10%	The level of damages and losses will progressively increase by*:	20%
	Year 1	385,700,500,000	Year 1	395,343,012,500	Year 1	404,985,525,000
	Year 2	366,415,475,000	Year 2	375,575,861,875	Year 2	384,736,248,750
	Year 3	348,094,701,250	Year 3	356,797,068,781	Year 3	365,499,436,313
	Year 4	330,689,966,188	Year 4	338,957,215,342	Year 4	347,224,464,497
	Year 5	314,155,467,878	Year 5	322,009,354,575	Year 5	329,863,241,272
	Year 6	298,447,694,484	Year 6	313,370,079,208	Year 6	328,292,463,933
	Year 7	283,525,309,760	Year 7	297,701,575,248	Year 7	311,877,840,736
	Year 8	269,349,044,272	Year 8	282,816,496,486	Year 8	296,283,948,699
	Year 9	255,881,592,058	Year 9	268,675,671,661	Year 9	281,469,751,264
	Year 10	243,087,512,455	Year 10	255,241,888,078	Year 10	267,396,263,701
	Year 11	230,933,136,833	Year 11	248,253,122,095	Year 11	265,573,107,358
	Year 12	219,386,479,991	Year 12	235,840,465,990	Year 12	252,294,451,990
	Year 13	208,417,155,992	Year 13	224,048,442,691	Year 13	239,679,729,390
	Year 14	197,996,298,192	Year 14	212,846,020,556	Year 14	227,695,742,921
	Year 15	188,096,483,282	Year 15	202,203,719,529	Year 15	216,310,955,775
	Year 16	178,691,659,118	Year 16	196,560,825,030	Year 16	214,429,990,942
	Year 17	169,757,076,162	Year 17	186,732,783,779	Year 17	203,708,491,395
	Year 18	161,269,222,354	Year 18	177,396,144,590	Year 18	193,523,066,825
	Year 19	153,205,761,236	Year 19	168,526,337,360	Year 19	183,846,913,484
	Year 20	145,545,473,175	Year 20	160,100,020,492	Year 20	174,654,567,810
	Total damages and losses over 20 years	4,948,646,009,681	Total damages and losses over 20 years	5,218,996,105,867	Total damages and losses over 20 years	5,489,346,202,053
	Annualised average	247,432,300,484	Annualised average	260,949,805,293	Annualised average	274,467,310,103

*In 2.5% increments every 5 years

*In 5.0% increments every 5 years

Figure 60 Monetary Risk Scenarios of Pandeglang Regency (Analysis, 2021).

The summary in Figure 60 above shows the damages and losses forecast in three scenarios A, B, and C. Following the recent monetary values calculation for the past ten years (Section 4.2.1), the forecasted monetary values for the next 20 years counts as IDR 4.95 trillion with an annual average of IDR 247.43 billion (Scenario A). Scenario B takes into account the increasing level of damages and losses by 10% and by that, the total value elevates to IDR 5.21 trillion. The forecasted annual average for Scenario B is IDR 260.95 billion, which takes into account a 2.5% of increments every 5 years. The most extreme scenario,

Scenario C, have a 20% increase of damages and losses from Scenario A, which leads to a higher value of IDR 5.49 trillion in total and an annual average of IDR 274.47 billion, with a 5% increments every 5 years.

5. Risk and Disaster Management Profile of Klungkung Regency

5.1 Overview of Klungkung Regency

Klungkung Regency is divided into four sub-district administrative areas, namely Nusa Penida, Banjarangkan, Klungkung, and Dawan Districts. This regency is the second smallest area in Bali Province. Nusa Penida District is an archipelago district consisting of three islands, namely Nusa Penida Island, Lembongan Island, and Ceningan Island.

By 30.5% of villages in Klungkung Regency are located in coastal areas with a beach length of 77.7 km so that they have economic potential in the fisheries sector. One of the largest fisheries products produced is seaweed in the Nusa Penida District. At this time the production of seaweed cultivation has begun to decrease as a result of the rapid development of tourism in the region, so that the economic driving sector has begun to shift to the tourism sector.

Table 36 Area size , number of islands and the number of Villages / Sub-districts in the Coastal Delineation of Klungkung Regency.

No	District	Area (Km^2)	Percentage of Regency Area	Amount of Island	Amount of Sub-district
1	Nusapenida	213.93	66.68	3	16
2	Banjarangkan	45.73	12.15	0	13
3	Klungkung	29.05	9.67	0	18
4	Dawan	37.38	11.50	0	12
TOTAL		**320.85**	**100**	**3**	**59**

Source: Klungkung Regency in Figures 2020, BPS, 2020.

It is recorded that the population of the Klungkung Regency is 178,300 people. With a population growth of 0.44% in 2019, from year to year, there is an increase in population and if this number is not limited it can cause several population problems. The population density per km2 is getting higher, reaching 566 people / km^2. The most populous district is Klungkung District with a density of 2,029 people / km^2. Nusa Penida which is an archipelago district has the lowest population growth rate, which is only 0.07 in 2019.

Table 37 Demographic Conditions in the Coastal Delineation of Klungkung Regency

No	District	Amount of Population	Rate of Population Growth	Percentage of Population	Population Density per km^2	Sex Ratio
1	Nusapenida	61,135	0.07	28.36	285.7705	102.98
2	Banjarangkan	46,633	0.61	21.64	1,195.773	100.62
3	Klungkung	65,016	0.65	30.16	2,094.675	98.63

No	District	Amount of Population	Rate of Population Growth	Percentage of Population	Population Density per km^2	Sex Ratio
4	Dawan	42,758	0.43	19.84	1,159.275	99.20
TOTAL		**215,542**	**0.44**	**100**	**4,735.49**	**100.39**

Source: Klungkung Regency in Figures 2020, BPS, 2020.

Based on the RTRW of Bali Province 2009-2029[19] and the RTRW for Klungkung Regency 2013-2033[20], an urban system was developed that supports regional development, which is evenly distributed and hierarchical, covering the Klungkung Regency area as the East Bali urban system with the Semarapura Urban Area service center which functions as PKW. PKW or Regional Activity Center is an urban area that functions to serve provincial or several regency / city scale activities. The PKW area of the Semarapura Urban Area includes urban areas in the Semarapura Kaja Sub-District, Semarapura Tengah Sub-District, Semarapura Kangin Sub-District, Semarapura Kelod Sub-District, Semarapura Kelod Kangin Sub-District, and Semarapura Kauh Sub-District.

In the Bali Province RTRW, the provincial strategic area has been determined from the point of view of the function and environmental support capacity of the Underwater TWA in Nusa Lembongan, Klungkung Regency. In the Regency RTRW, the coastal areas of Klungkung Regency have also appointed as nature reserve and conservation areas in the form of:

- Mangrove forested coastal area, whose distribution includes mangrove forests (mangroves) covering an area of 230.70 hectares, including:
    a. an area of 202 hectares of mangrove forest in Lembongan is designated as Protected Forest (HL) Lembongan;
    b. An area of 18.70 hectares in Lembongan; and c. An area of 10 (ten) hectares in Ceningan.
- Marine Nature Park (TWA) covering 300 hectares of Lembongan Sea.
- Coastal conservation areas and small islands which include:
    a. The sacred area conservation area includes:
        1. around Watu Klotok Beach, Gelgel Village, Klungkung District;
        2. around Goa Lawah Beach, Pesinggahan Village, Dawan District; and
        3. Around Ped Beach, Ped Village, Nusa Penida District.

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[19] Bali Provincial Regulation Number 16 of 2009 concerning the Bali Provincial Spatial Plan for 2009-2029

[20] Klungkung Regency Regional Regulation Number 1 of 2013 concerning the 2013-2033 Klungkung Regency Spatial Plan

b. The conservation and protection of coastal ecosystems include:
    1. mangrove forest area of Nusa Lembongan, covering an area of 202 (two hundred two) ha;
    2. the coral reef area of Nusa Lembongan; and
    3. seagrass area.
c. maritime conservation areas include:
    1. the fishing settlement area of Kusamba Village; and
    2. fishing settlement areas in Batununggul, Toyapakeh and Jungutbatu Villages.

In the division of the National Fisheries Management Area, Klungkung Waters is included in the Fishery Management Area (WPPNRI) 573. In the direction of the fisheries management plan of WPPNRI 573[21], one of the areas designated as a marine conservation area is in Klungkung Regency with management authority under the regional government. The direction is in the form of the Nusa Penida Marine Protected Area, Klungkung Regency, Bali Province. The area has an area of 20,057 hectares and has a high marine biodiversity. There are about 149.05 Ha of coral reef with 286 types of coral. The sub-district is included in the world coral triangle area (coral triangle). This area is designated as a conservation area through Klungkung Regent Regulation No. 12/2010.

Based on the RZWP3K of the Province of Bali[22], which covers Klungkung waters, the directions for the development of the general designation area include:

- KPU-W (Tourism Zone): coastal / coastal natural tourism subzone and small islands in Klungkung Regency, namely Jumpai Beach
- KPU-PL (Port Zone):
    - DLKr and DLKp Gunaksa Port subzone in Klungkung Regency
    - WKOPP PPI Kusamba subzone in Klungkung Regency
- KPU-LN (Other Use Zones): the fishing base subzone in Klungkung Regency includes Tegal Besar Beach, Lepang, Kusamba Village, Segara-Br. Kusamba, Pesinggahan, and Belatung;

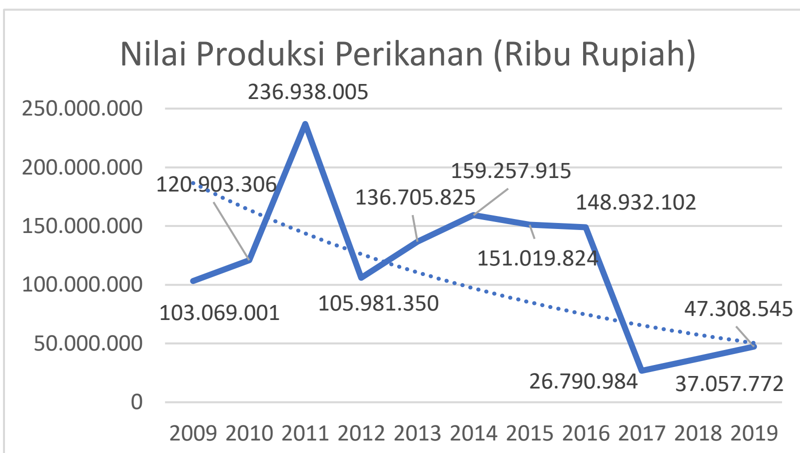
[21] Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 77 / KEPMEN-KP / 2016 concerning the Fishery Management Plan for the State Fisheries Management Area of the Republic of Indonesia 573

[22] The Draft Provincial Regulation of Bali Concerning the 2020-2040 Coastal Zone and Small Islands Zoning Plan of Bali Province

- KKP (Marine Protected Area): Nusa Penida MPA, covering the waters around the Nusa Penida Islands, Klungkung Regency
- NTSC (Specific National Strategic Areas): KSNT waters around Nusa Penida in Klungkung Regency with the KSNT zone code

In the economic aspect, the sectors that drive the regional economy can be seen from the contribution of these sectors to the Gross Regional Domestic Product (GRDP). GRDP is basically the amount of added value generated by all business units in a certain area, or is the sum of the value of final goods and services produced by all economic units in an area. Based on data from Klungkung Regency in Figures 2020 (BPS, 2020), the GRDP value of Klungkung Regency reached 9119.83 billion rupiah in 2019, with the most contributing sectors being Agriculture, Forestry and Fisheries. Meanwhile, looking at the GRDP growth in the last few years based on constant prices, the densest growth of GRDP in Klungkung Regency was 5.44% in 2019, with the sectors with the highest growth rates, namely sectors 1) Transportation & Warehousing; 2) Other Services; and 3) Mandatory Government Administration, Defense and Social Security.

From the fisheries sub-sector, the value of fishery production in Klungkung Regency has shown a downward trend in the last 10 years with a production value in 2019 of 47,308,545 rupiah, while the highest production value occurred in 2011 with a production value of 236,938,005 rupiah. Seen from the value of fishery production in tons, it also shows a decline, especially in 2016 to 2017, with the highest value in 2011 reaching 108,715.6 tons until in 2019 it only reached 2253.26 tons.



5.2 Summary of Past Disaster Events in Klungkung Regency

5.2.1 Past disaster events due to natural hazards and sudden onset in nature

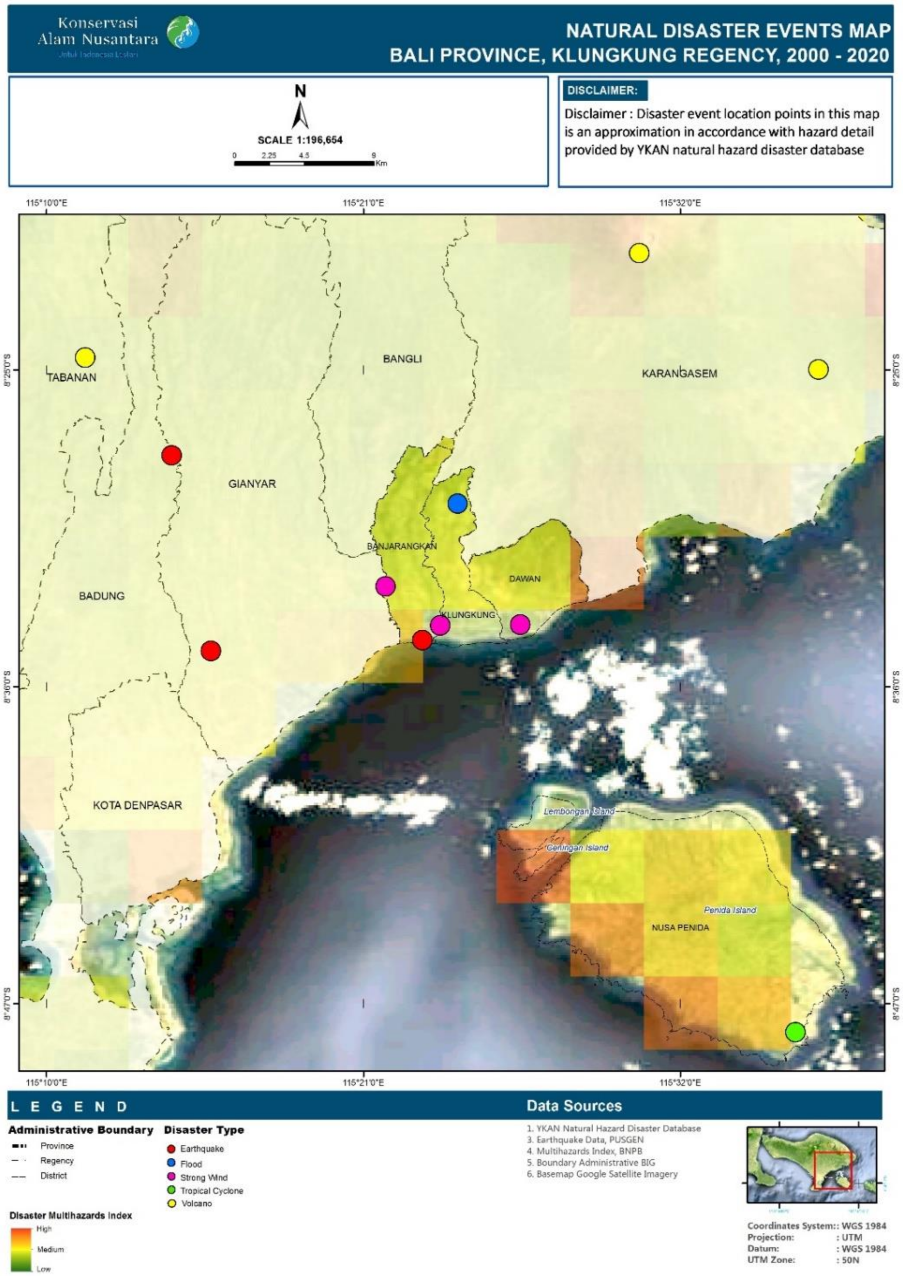


Figure 61 Map of Natural Disaster Events in Klungkung Regency 2000-2020 (Analysis, 2021).

Bali Island geographically is a part of the Little Sunda archipelago, and geologically placed on the subduction zone of the Eurasian and Australian tectonic plate. It meets the java sea in the north and the India Ocean in the south as a border. This island is placed on the ring of fire and subduction zone. There are ten volcanos in Bali with two of them are active i.e.. Mount Agung, and Mount Batur. Another geographically feature is Bali is placed on the equatorial zone. Thus it has a tropical climate. Based on the Map of Natural Disaster events (Figure 61), mainly the events are distributes in main island. In Nusa Penida Island there is a record of tropical cyclone (TC) occurred on this area.

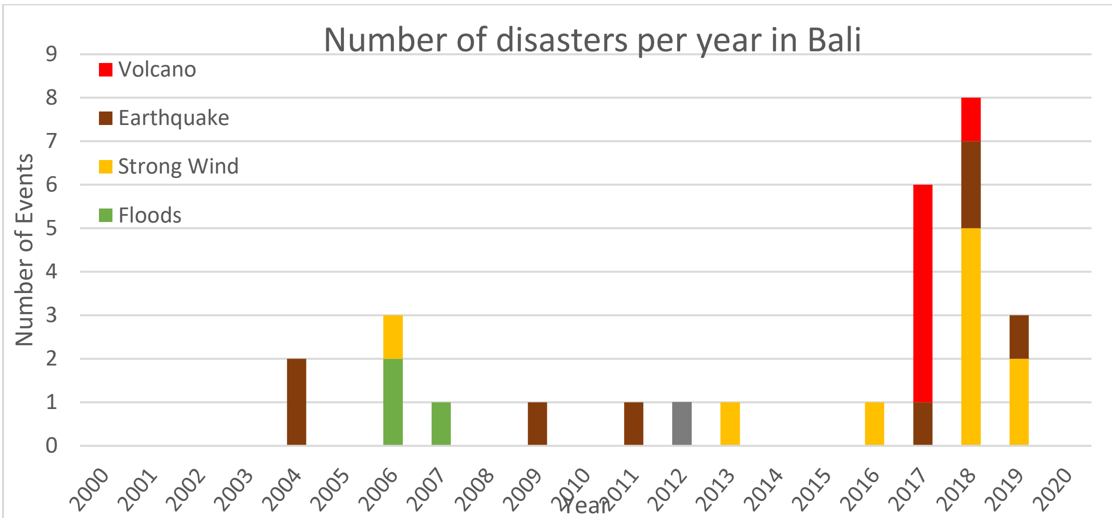


Figure 62 Number of Disasters due to natural hazards in Klungkung Regency 2000-2020 (Analysis, 2021)

Due to its feature mentioned above, Bali has a lot of natural hazard potential. Based on the collected data, this study found 168 events in the last 20 years. However, the research area focuses only on the Klungkung regency which placed on the eastern side of the top neck of the island. The peak of disaster events happened between 2010 and 2013 with the most events occurred in 2012. The most occurred events were strong wind, flood, coastal surge, and landslide (Figure 62).

Among 28 events, Th hydrometeorological hazard is the dominant. The most occurred events are strong wind which occurred nine times. There are three floods event occurred n the last ten years (2010-2020). The main factor behind the events is the location of this area which situated at relatively open to the India Ocean so, it get the direct influence from the monsoon wind.

This regency has threat from geological hazard such as volcano eruption especially from Mount Agung and Mount Batur, earthquake and tsunami. Based on this study's record the most events from geological hazard is volcano and earthquake. The Mount Agung Volcano has erupted several times and it has affected the Klungkung regency.

Table 38 Summary of Impacts of Disaster Due to Natural Hazards in Klungkung Regency.

District Name	Frequency Index	Severity Index	Hazard Index
Banjarangkan	0.20	0.60	0.35
Dawan	0.80	0.60	0.69
Klungkung	0.40	1.00	0.63
Nusa Penida	0.80	0.20	0.40

Source: Analysis, 2021

Based on Table 38 above, the Highest Hazard index is Dawan district with the hazard index value is 0.69. the reason behind is because it has the most frequent event. In the second place, 0.63, Klungkung District has the highest severity index with less frequency index than Dawan District. The least hazard index is Banjarangkan District due to the least frequent of the events.

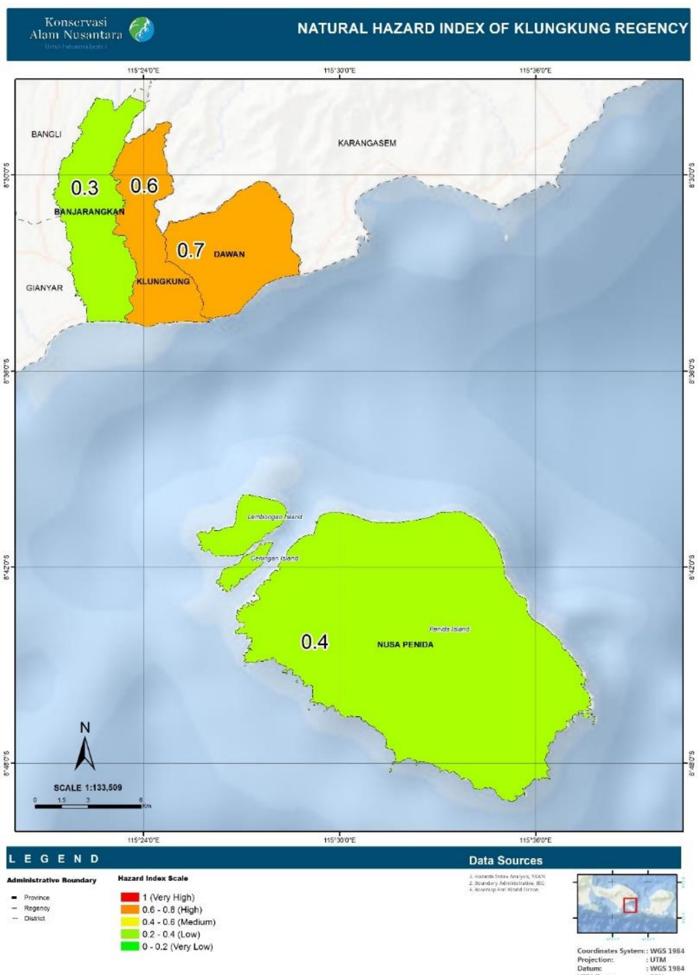
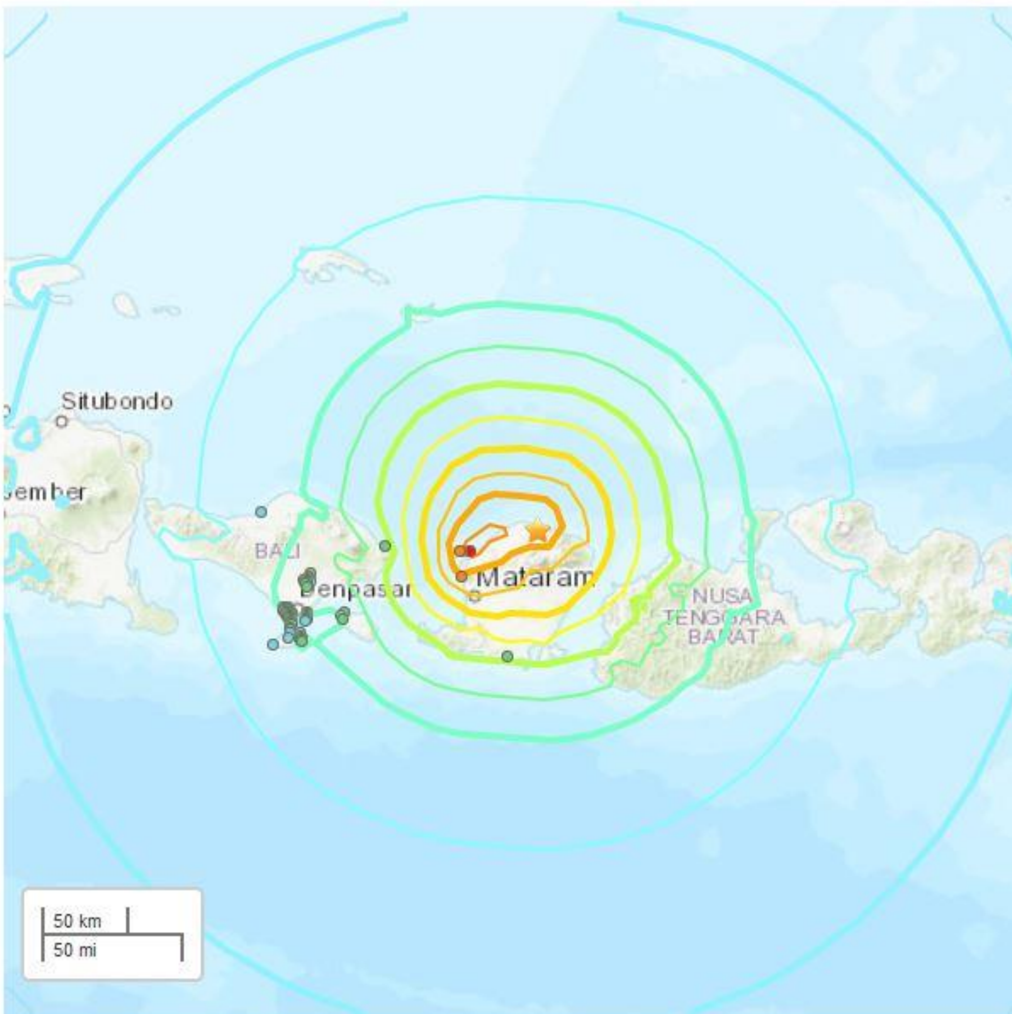


Figure 63 Natural Hazard Index Map of Klungkung Regency (Analysis, 2021)

Based on Natural Hazard Index map (Figure 63), Dawan District and Klungkung District are classified as medium natural hazard index. On the other hand, Low natural hazard index classification goes to Banjarangkan District and Nusa Penida District.

Based on the record, this Regency has been impacted by Lombok’s earthquake in 2018. The MMI scale in this area was V – VI scale (Figure 64. It was quite destructive. It destructed several houses and prayer place. The details of this event is explained in Box 3.



SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.0464	0.297	2.76	6.2	11.5	21.5	40.1	74.7	>139
PGV(cm/s)	<0.0215	0.135	1.41	4.65	9.64	20	41.4	85.8	>178
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Worden et al. (2012) Version 1: Processed 2020-06-06T16:07:00Z
△ Seismic Instrument ○ Reported Intensity ★ Epicenter ▭ Rupture

Figure 64 MMI Scale During Lombok's Earthquake 2018 (USGS 2018).

Unfortunately, based on the records of the impact of the existing disaster events, the valuation value of the damages and losses is not properly recorded. Hence, The damages and losses estimation from past hazards/stressors was done using the Blue Guide Calculator (The Nature Conservation, 2020) (Figure 65).

HAZARD/STRESSOR 1 (Most damaging)		HAZARD/STRESSOR 2		HAZARD/STRESSOR 3		HAZARD/STRESSOR 4	
List the most damaging hazard/stressor	Earthquake	List the second-most damaging hazard/stressor	Floods	List the third-most damaging hazard/stressor	Strong wind	List the fourth-most damaging hazard/stressor	Volcanoes
How many times has this occurred over the past ten years?	8.0	How many times has this occurred over the past ten years?	3.0	How many times has this occurred over the past ten years?	10.0	How many times has this occurred over the past ten years?	6.0
The annual probability rate (APR) for this hazard is:	0.8	The annual probability rate (APR) for this hazard is:	0.3	The annual probability rate (APR) for this hazard is:	1.0	The annual probability rate (APR) for this hazard is:	0.6
What currency will you use for monetary figures?	USD	What currency will you use for monetary figures?	USD	What currency will you use for monetary figures?	USD	What currency will you use for monetary figures?	USD
Damages (monetary values)		Damages (monetary values)		Damages (monetary values)		Damages (monetary values)	
Damages to homes	621,600,000,000	Damages to homes	1,530,000,000	Damages to homes	2,535,000,000	Damages to homes	1,545,000,000
Damages to business assets	39,300,000,000	Damages to business assets	25,000,000,000	Damages to business assets	3,000,000,000	Damages to business assets	0
Damages to public infrastructure	90,000,000	Damages to public infrastructure	0	Damages to public infrastructure	0	Damages to public infrastructure	0
Other damages (e.g. loss of land from erosion)	0	Other damages (e.g. loss of land from erosion)	0	Other damages (e.g. loss of land from erosion)	0	Other damages (e.g. loss of land from erosion)	0
Total damages	660,990,000,000	Total damages	26,530,000,000	Total damages	5,535,000,000	Total damages	1,545,000,000
Direct losses (monetary values)		Direct losses (monetary values)		Direct losses (monetary values)		Direct losses (monetary values)	
Losses in produce		Losses in produce	0	Losses in produce	0	Losses in produce	0
Losses in income		Losses in income	0	Losses in income	0	Losses in income	0
Other direct losses		Other direct losses	0	Other direct losses	0	Other direct losses	0
Total direct losses	0	Total direct losses	0	Total direct losses	0	Total direct losses	0
Indirect losses (monetary values)		Indirect losses (monetary values)		Indirect losses (monetary values)		Indirect losses (monetary values)	
Prolonged losses from produce sales	0	Prolonged losses from produce sales	0	Prolonged losses from produce sales	0	Prolonged losses from produce sales	0
Prolonged income losses	0	Prolonged income losses	0	Prolonged income losses	0	Prolonged income losses	0
Other indirect losses	1,275,000,000	Other indirect losses	754,500,000	Other indirect losses	120,000,000	Other indirect losses	6,154,620,000,000
Total indirect losses	1,275,000,000	Total indirect losses	754,500,000	Total indirect losses	120,000,000	Total indirect losses	6,154,620,000,000
Hazard 1: Total damages and losses	662,265,000,000	Hazard 2: Total damages and losses	27,284,500,000	Hazard 3: Total damages and losses	5,655,000,000	Hazard 4: Total damages and losses	6,156,165,000,000
Hazard 1: Annualised damages and losses	529,812,000,000	Hazard 2: Annualised damages and losses	8,185,350,000	Hazard 3: Annualised damages and losses	5,655,000,000	Hazard 4: Annualised damages and losses	3,693,699,000,000
The combined damages and losses from all four hazards/stressors over ten years have been:			6,851,369,500,000				
On an annual basis, the combined damages and losses over ten years have been:			4,237,351,350,000				

Figure 65 Past Damages and Loss Estimation of Klungkung Regency (Analysis, 2021).

The damages and losses estimation from past hazards/stressors was done using the Blue Guide Calculator (The Nature Conservation, 2020) and the results were showed in Figure 65. In brief, the most frequent and damaging natural hazards in Klungkung Regency are earthquake, followed by flood and strong wind, and volcano. Over ten years, earthquakes give damages and losses estimation of approximately IDR 662.26 billion in total with the annualised value reaches IDR 529.81 billion, while floods were estimated to possess damages and losses of approximately IDR 27.28 billion in total with annualised value of about IDR 8.18 billion. Further, strong winds count IDR 5.66 billion in total damages and losses with an annualised value of the same amount, while volcanoes reach the highest value of IDR 6.15 trillion in total with an annualised value of IDR 3.69 trillion. The combined damages and losses monetary value from all the hazards/stressors over ten years was calculated to be around IDR 6.85 trillion with IDR 4.24 trillion calculated in an annual basis.

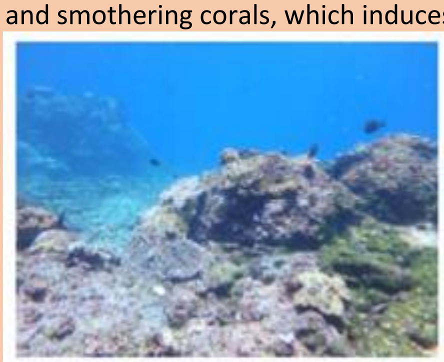
Box 3: Bali's Earthquake 2004

On 2 January 2004 Bali has been struck by an earthquake with 6.2 SR.[23]. this earthquake caused 1 fatalities, 40 injuries and more than 4000 affected people. The source of the earthquake was 37 km south of Denpasar. The earthquake occurred in three minutes. The effect of this earthquake was black out in meteorological station, and PT Telkom. The injuries mainly because they were crush by the building ruins. This erathqake also struck Lombok island[24].

Lombok's Earthquake 2018

The earthquake has struck Lombok on 05 August 2018. This earthquake was triggered by the activity of Flores Thrust Fault. The centre of this source was at 32 km NE of Mataram city in the depth of 10 km[25]. This earthquake also struck Bali and Nusa Tenggara causing 436 fatalities in total. In Klungkung Regency, there were 1 injury and 1 affected. The earthquake impacted on 18 houses 53 educational facilities, and 8 public facilities[26, 27].

This earthquake also hit the corals in Nusa Lembongan and Nusa Penida island. The coral fragments due to broken coral was found in the coral reefs area and on the shore. The previous researcher (Tito & Ampou, 2020) found the broken coral fragments during the research in 2018 two months after the earthquake. Some Scleractinian corals are dead, sediments were dumped on adjacent reefs and the skeletal debris of corals were noticed. Branching corals, belonging to the genera *Acropora* sp. and *Montipora* sp., were broken into small pieces and some washed away. Fractures of branching corals are spread over the land. Heaped up of living corals were discovered in many places particularly in reef flats area. Sediments straightly stress corals by diminishing the availability of light energy, obstructing coral recruitment and smothering corals, which induces coral disease as well.



Evidence of damaged corals due to Lombok's Earthquake (Tito & Ampou, 2020).

[23] Sejarah Kegempaan Pulau Bali Dan Sumbawa http://balai3.denpasar.bmkg.go.id/sejarah-gempa-merusak

[24] Gempa Melanda Lombok https://nasional.tempo.co/read/37856/gempa-melanda-lombok

[25] Gempa 6,5 SR di Lombok Hari Ini Dipicu Aktivitas Sesar Naik Flores. https://tirto.id/gempa-65-sr-di-lombok-hari-ini-dipicu-aktivitas-sesar-naik-flores-cTvw

[26] Rumah Hingga Tempat Ibadah di Bali Rusak akibat Gempa Lombok https://www.kompas.tv/article/30361/rumah-hingga-tempat-ibadah-di-bali-rusak-akibat-gempa-lombok

[27] Ini Bangunan di Bali yang Terdampak Gempa Lombok https://malang.kompas.com/read/2018/08/05/21330491/ini-bangunan-di-bali-yang-terdampak-gempa-lombok

5.2.2 Past disaster events due to anthropogenic hazards

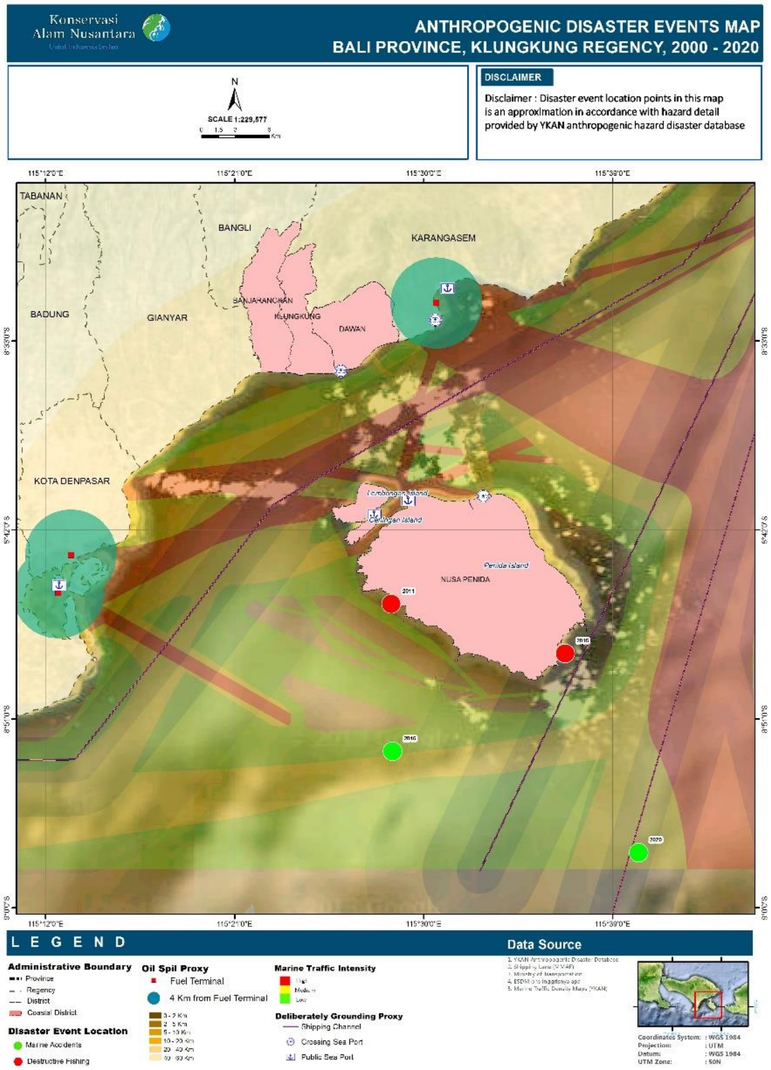


Figure 66 Map of Anthropogenic Disaster Events in Klungkung Regency 2000-2020 (Analysis, 2021).

In general, the occurrence of disasters due to anthropogenic hazards that occurred in Klungkung Regency, Bali Province was dominated by events related to destructive fisheries and boat accidents (Figure 67). From the 20 years recorded data, there is a balance between the number of destructive fishing and marine accidents, where all of them happened in Nusa Penida (Figure 66). Two incidents regarding the destructive fisheries consist of one case with fish bombs and one case with fish poison. Other 50% of the marine accidents are a shipwreck and a ship accident.

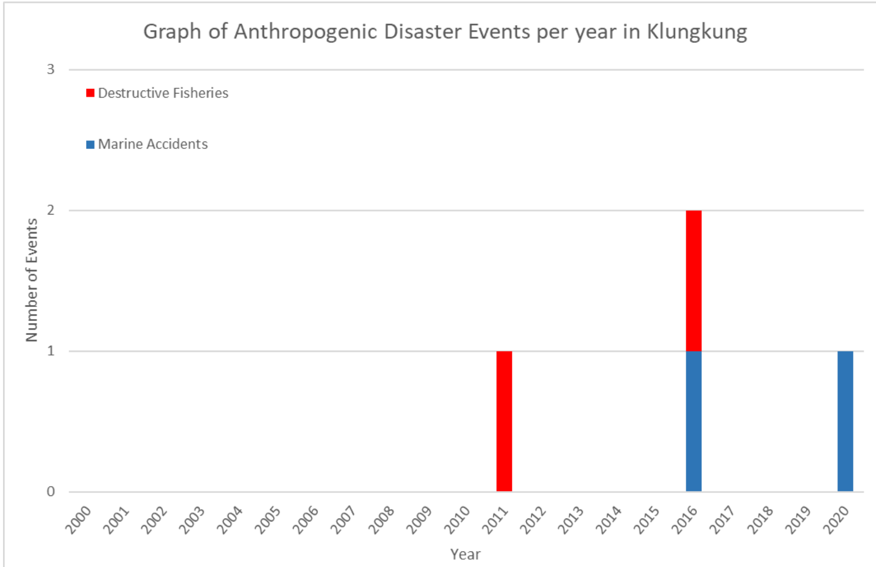


Figure 67 Anthropogenic Hazard events in Klungkung Regency (Analysis, 2021).

When compared with the previous decade, the incidence of disasters due to anthropogenic hazards recorded in Klungkung from 2000 to 2010 has no record of incidents, in the period 2011 - 2020 it increased to 4 events. The pattern of the number of disasters due to anthropogenic hazards that occurred in Klungkung, Bali Province is shown in Figure 67.

Anthropogenic hazards recorded in this study were causing threats to human safety or damage and loss of livelihoods. Apart from that, disasters due to anthropologenic hazards can also potentially impacting the health of the surrounding environment. Based on records, it was found that during the last 20 years, there was still a small amount of destructive fishing activity found. However, there were several unsettling cases of poison use carried out by a 10-person crew in the coastal waters of Penangkidan and Sompang on November 7, 2011. Apart from this, damage to coral reefs which was reported was a result of fish bomb and poison to catch fish.

Table 39 Anthropogenic Hazard Index of Klungkung Regency.

District	Destructive Fishing	Marine Accident	Oil Spill	Anthropogenic Hazard Index
Banjarangkan	0	0	0	0.00
Dawan	0	0	0	0.00
Klungkung	0	0	0	0.00
Nusa Penida	2	2	0	1.00

Source: Analysis, 2021.

Based on the anthropogenic hazard index in Klungkung Regency (Table 39), the hazards had only been occurred in Nusa Penida District, thus by the probability and the past disaster events, the hazard index for this regency is 1.00 (Figure 68) for Nusa Penida District while the others counted as zero. Zero does not mean that the hazard will not exist. According to the probability weigh, the hazard still can be occurred in the future.

Apart from destructive fishing activities, there have also been several boat accidents that have caused the loss of important livelihood assets for the coastal community, namely one ship sank. The lack of recorded events in Klungkung Regency could mean that activities in the area are relatively safe but can also mean recording incidents that are still incomplete which opens the possibility that there are events that have not been recorded properly.

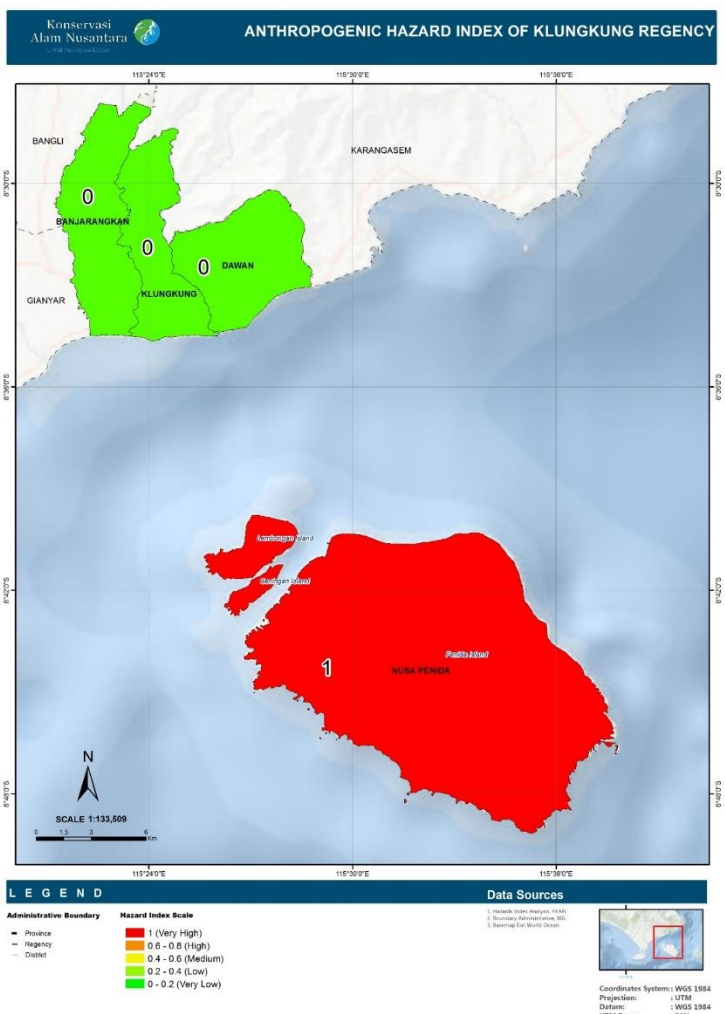


Figure 68 Map of Anthropogenic Disaster Hazard Index of Klungkung Regency 2000-2020 (Analysis, 2021)

5.2.3 Past disaster events due to natural and anthropogenic hazards and slow onset in nature

The island of Bali is part of the Lesser Sunda Islands which stretches from Bali to NTT, has several coral genera of around 60 and is still included in the coral triangle area (Hadi, et al., 2019). This area is the exit from Arlindo (Arus Lintas Indonesia) and is also known as refugia where many biotas are trapped and then develop so that the biodiversity remains high. For example, there are 36 species of mushroom coral found in Bali and 39 species of mushroom coral on Komodo Island. The existence of these mushroom corals represents around 77-83% of mushroom corals in the world (Hadi, et al., 2019) With the high biodiversity of coral reefs on the island of Bali, such as in Klungkung Regency, the tourism sector is based on the coral reef ecosystem. increasingly in demand by tourists. However, industrial development and excessive tourism activities such as the construction of a jetty at Semaye Hamlet Beach, Suana Village, Nusa Penida District, which was carried out by PT. Cavendish on suspicion of carrying out local reclamation activities to dredging coral reefs, could cause polemics with local communities and damage the ecosystem of coral reefs.

Climate change, which is marked by warming sea surface temperatures, inevitably can slowly threaten the sustainability of tourism based on these coral reef ecosystems. Although in the southern region of Bali, the sea surface temperature rise is around 0.1-0.2°C per decade. (Sofian, 2015). The results of coral reef health observations as shown in the 2019 report on the status of Indonesia's coral reefs do not mention the cause and effect of the condition of coral reefs in the southern region of Bali or Klungkung specifically but provide an overview of the coral reef ecosystem on the island of Bali as a whole which indicates a tendency for environmental degradation. and coral reef ecosystems. Of the 19 observation points, 12 locations of coral reef ecosystem points are in bad condition and rising sea surface temperatures can worsen the health condition of coral reefs in Klungkung waters in the future.

Table 40 Status of Coral Reef in Bali Island.

Location	Num of Station	Very Good	Good	Fair	Bad
Bali	19	1	4	2	12

Source: Hadi, et al., 2019.

Climate change events that triggered phenomena such as ENSO also caused massive coral bleaching in 1998 in Nusa Lembongan and Nusa Penida which then also recurred in 2010 (Donner, Rickbeil, & Heron, 2017). Then the coral bleaching event caused by rising sea surface temperatures was observed again in 2016 in Nusa Penida. The condition of coral reef cover in 2012 included 83% live coral cover and 17% dead coral; whereas in 2016 at the same point of observation, there was an increase in dead coral to 31% and a decrease in live coral cover to 69% (Susiloningtyas, Handayani, & Amalia, 2018). This is also in line with a report from LIPI which states that coral cover in Bali has decreased from 60.3% (2015) to 29.6% (2016) (Hadi, et al., 2019).

The problems regarding slow-onset reef quality degradation was not caused by bleaching only. Human activities might also play an important role to threaten the ecosystem. Such infrastructures built for transportation and tourism purpose, although found to be beautiful by the people, can also have negatve impacts in the long term for the coastal and marine ecosystems in the vicinity. As was shown previously in Table 17 in section 2.3.5, threats from anthropogenic factor in Klungkung Regency which could potentially threaten coastal ecosystem especially coral reefs are the coastal tourism centre. With coastal population of 215,542 people, which mainly reside adjacent to the sea, there has been a relatively low threat to the surrounding coastal ecosystem. Apart from the coastal areas, human activities around the many rivers in the mainland could also contribute to the threat by supplying sediments and wastewater onto the river. Over the largest river in the regency, Telaga Waja River has a port around the mouth that could potentially threaten the coastal ecosystem. Other than that, the regency is supported by five other ports which are intended for fisheries and allowing easier transportation back and forth to Nusa Penida and elsewhere. The regency has no airports, so the main transportation between islands is only by marine route. Despite that, the marine tourism centre in Klungkung is considered high with around 207 hotels present across the mainland and Nusa Penida coastal areas. These hotels rely on the various marine tourism activities and thus could potentially harm the surrounding reefs. Supporting that of mainland and marine transportations, Manggis Oil Depot (TBBM Manggis) was built to provide constant fuel supply for the surrounding areas.

5.3 Stakeholder Mapping and Local Institutional Capacity of Klungkung Regency

Coral reef conservation and protection has been of high importance in Klungkung Regency. It has been so since the enactment of Nusa Penida as the Nusa Penida Marine Protected Area (Nusa Penida MPA), which was stipulated in the Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia number 90 of 2018 on the Nusa Penida Marine Protected Area in Bali Province. In carrying out this role, various programs are routinely run by the Agency under the Ministry of Marine Affairs and Fisheries, the Nusa Penida Marine Protected Area Technical Implementation Unit (*Unit Pelaksana Teknis Kawasan Konservasi Perairan/UPT KKP*), and the Denpasar Coastal and Marine Resources Management Center

(*Balai Pengelolaan Sumberdaya Pesisir dan Laut/BPSPL Denpasar*). These stakeholders are also collaborating with the Klungkung Food Security and Fisheries Agency (*Dinas Ketahanan Pangan dan Perikanan/DKPP*), Technical Implementation Unit for Animal Husbandry, Fisheries and Marine Affairs of Nusa Penida District (*UPT Peternakan, Perikanan dan Kelautan Kecamatan Nusa Penida/UPT PPK Nusa Penida*), Water Police, Nusa Penida Police, Marine Army (*TNI-AL*), and a non-governmental organization, namely the Coral Triangle Center (CTC). One of the challenges that have become the focus of the Nusa Penida MPA management group is the practice of local fishermen using explosives that have an impact on damaging coral reefs. Apart from fishery activities, seaweed farming is an activity of high value in Klungkung Regency. After being designated as a National Priority Rural Area (KPPN) in the 2020-2024 RPJMN, the Klungkung Regent paid attention to the Seaweed Farming Community to help the progress of seaweed farming in Klungkung Regency.

Previous research by Berdej and Armitage (2016) has also identified the UPT KKP and CTC as two central actors in the marine environment conservation in Nusa Penida, Klungkung Regency, Bali. The programs include zoning the Nusa Penida MPA, conducting annual coral reef checks, controlling monthly fisheries activities, and increasing personnel capacity. The aspect of trust has a powerful influence in Klungkung Regency due to the various strategic temples on Nusa Penida island. In this regard, there are indications of the role of religious community groups: The Alit Council and the local Traditional Village, in the transfer of knowledge and local wisdom related to the environment in the Nusa Penida area.

Apart from Klungkung Regency's role as a Marine Protected Area, the Nusa Penida area is also designated as a National Tourism Strategic Area (*Kawasan Strategis Pariwisata Nasional/KSPN*). The determination of the KSPN is translated into various development acceleration programs initiated jointly by the Regional Infrastructure Development Agency of the Ministry of Public Works and Public Housing, the Ministry of Tourism and Creative Economy, the Klungkung Regency Goverment, Klungkung Tourism Agency, Klungkung Development Planning Agency (*Badan Perencanaan Pembangunan Daerah/Bappeda*), Klungkung Public Works and Housing Agency, as well as the Nusa Penida District Office.

As the southern coast of Bali Province is a tsunami-prone area, the Governor of Bali, together with Klungkung Regency and Klungkung Local Disaster Management Office (*Badan Penanggulangan Bencana Daerah/BPBD*) have collaborated with the Meteorology, Climatology and Geophysics Agency (*Badan Meteorologi Klimatologi dan Geofisika/BMKG*) to provide a backup system for Indonesian Tsunami Early

Warning System (InaTEWS) in Bali by jointly developing a seismic station located in Nusa Penida District, Klungkung Regency. This program was also followed up with capacity building for disaster management attended by staff and personnel from Klungkung BPBD, Klungkung Marine and Fisheries Agency, and Klungkung Agriculture Agency.

There were several relationship conflicts in the Klungkung network related to significant developments in Klungkung Regency. The first conflict was the plan to build the Klungkung Integrated Cultural Center (*Pusat Kebudayaan Terpadu Klungkung*) and the Klungkung Regional Hospital which the Bali Provincial Government approved and the Bali Province Public Works, Spatial Planning, and Housing Agency (*Pekerjaan Umum, Penataan Ruang, Perumahan dan Kawasan Permukiman/PUPRPKP*). This plan was opposed by the Bali People's Struggle Democratic Front *(Front Demokrasi Perjuangan Rakyat/Frontier)* and The Indonesian Forum for Environment (*Wahana Lingkungan Hidup Indonesia/WALHI*) in Bali. This protest was due to the planned location being in a Category I Disaster Prone Area (*Kawasan Rawan Bencana I/KRB I*). The Environmental Impact Assessment team for the Klungkung Integrated Cultural Center plan was from Udayana University Institute of Research and Community Service (*Lembaga Penelitian dan Pengabdian kepada Masyarakat Universitas Udayana/LPPM Unud*). The argument in defense of the LPPM Unud team was related to the potential for the use of the Integrated Cultural Center area as a disaster evacuation location with various facilities deemed irrelevant by the protesters of Frontier and WALHI.

Also, identified private stakeholders, namely PT. Cavendish who built a jetty at Semaye Village Beach, Suana Village, Nusa Penida District. The online news media indicates that a jetty construction has caused damage to coral reefs in Semaye village. It was stated that the project socialization had been carried out with various parties (Head of Klungkung District, Klungkung DKPP, UPT KKP, Head of Nusa Penida District Office, CTC, Policy, and Army) in 2015. The Klungkung Investment and One Stop Integrated Services Agency (*Dinas Penanaman Modal dan Pelayanan Terpadu Satu Pintu/DPMPTSP*) stated that they never issue a permit for the construction. Another source stated that PT. Cavendish has a permit from the Directorate General of Sea Transportation, Ministry of Transportation.

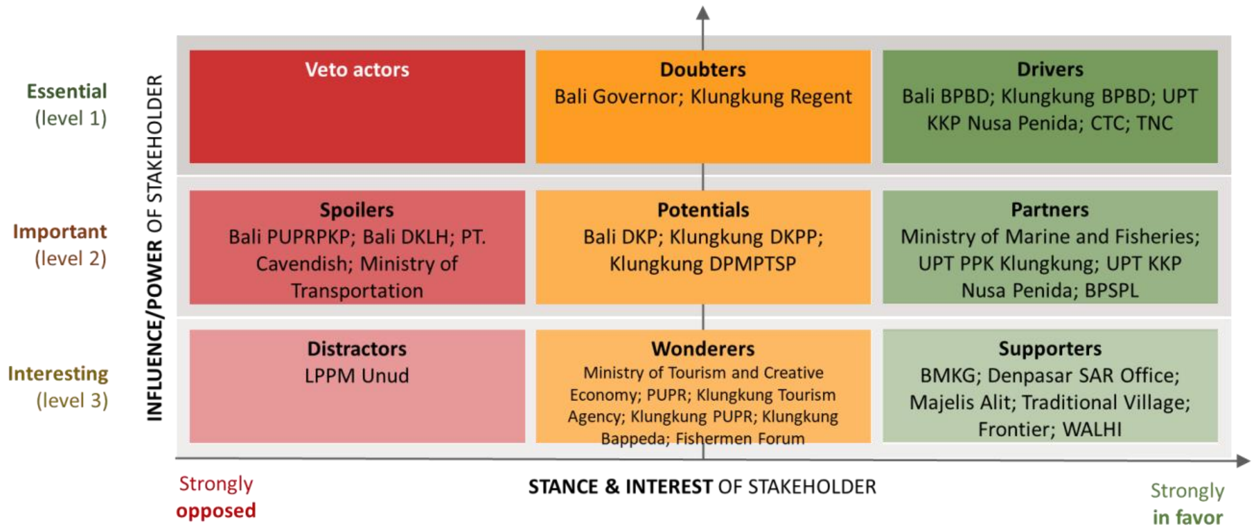


Figure 69 Klungkung Regency Stakeholder Map (Analysis, 2021).

Spoilers in the stakeholder matrix of Klungkung Regency are Bali DPUPRPKP, Bali DKLH, PT. Cavendish, and the Ministry of Transportation due to development projects that contradict KRB (Klungkung Integrated Cultural Center) which caused conflict since it was rejected by several supporting actors and might damage coral reefs (construction of a jetty by PT Cavendish). The Bali Governor and the Klungkung Regent were categorized as skeptical actors because there were indications of support for programs related to environmental and coral reef management and DRR, but also providing support for development projects that trigger conflict.

There are 36 important stakeholders identified in Klungkung Regency consisting of 9 central government institutions, 6 provincial government institutions, 12 regency government institutions, 3 NGOs, 1 business actor, 1 research institute, and 4 community groups. Referring to the stakeholder matrix in Figure 69, identified stakeholders in Klungkung Regency are mapped as follows. In Figure 70, the driving actors identified are BPBD Bali, BPBD Klungkung, UPT KKP Nusa Penida, CTC, and TNC. It is necessary to pay close attention to several spoilers related to major development conflicts in disaster-prone areas and damage to the environment in Klungkung Regency, namely PUPRKP Bali, DKLH Bali, PT Cavendish, and the Ministry of Transportation.

Based on the information that can be gathered from official documents as well as news available online, the relationships between identified stakeholders in Klungkung Regency are mapped in the social network diagraph below.

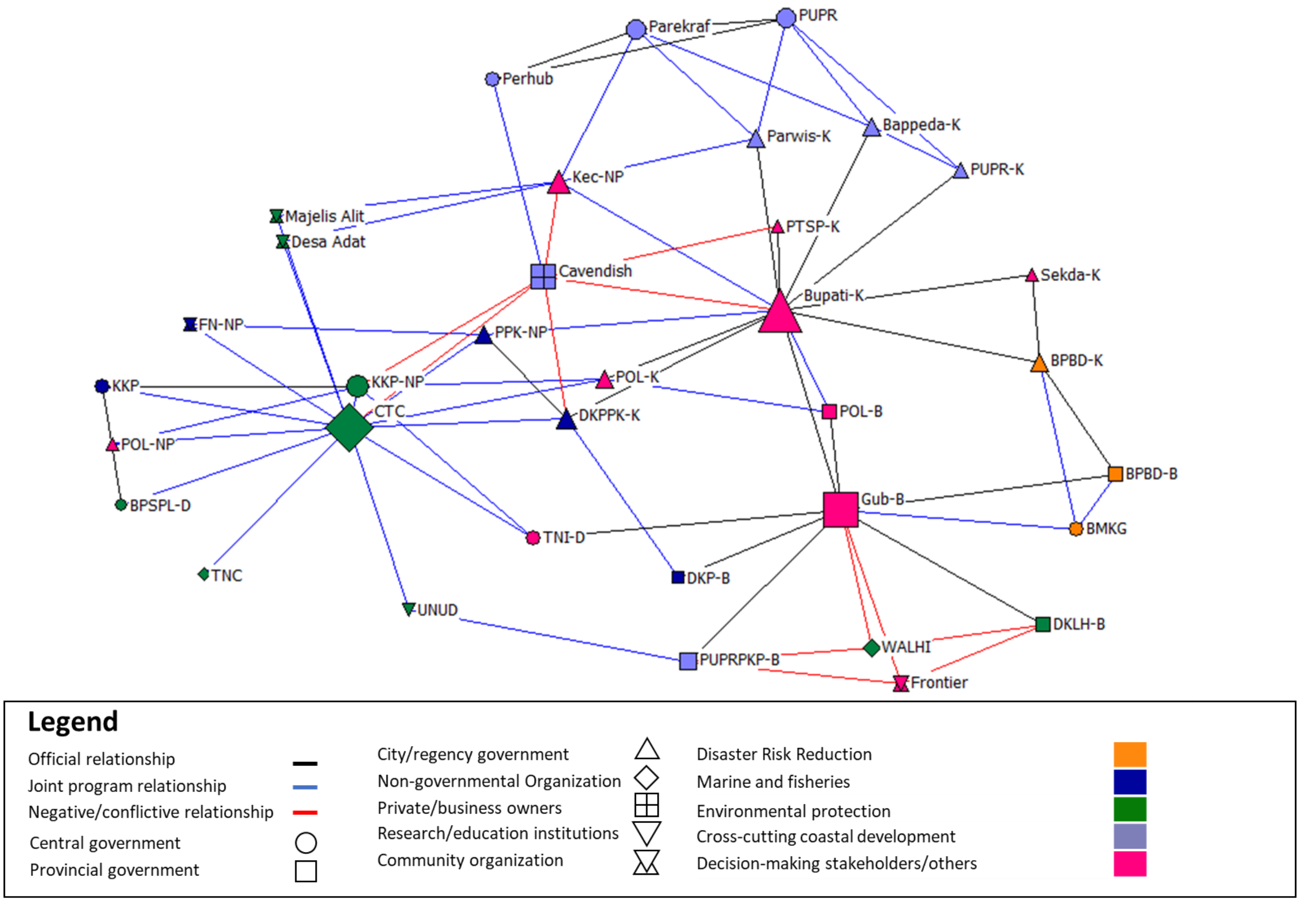


Figure 70 Social Network Analysis Diagraph between stakeholders in Klungkung Regency (Analysis, 2021).

The network graphic above depicts 3 types of relationships, namely (1) relationships stipulated in official regulations, (2) cooperative relationships from indications of carrying out joint programs in disaster management and nature conservation, (3) negative relationships due to conflicts in terms of disaster management and nature conservation. In this network, 35 actors and 114 relationships were identified. Among them are 23 relationships stated in regulations/official documents, 79 joint program relationships, and 12 negative relationships. The degree centrality and betweenness centrality values of actors in the network is shown in the table below.

Table 41 Degree and betweenness centrality values of stakeholders in Klungkung Regency.

Stakeholder	Degree
Coral Triangle Center	14
Klungkung Regent	13
Bali Governor	10
PT. Cavendish	7
Nusa Penida District Office	6

Stakeholder	Betweenness
Klungkung Regent	221.6226
Coral Triangle Center	174.779
Bali Governor	156.0405
PT. Cavendish	70.82301
Nusa Penida District Office	42.42936

Source: Analysis, 2021

The Klungkung stakeholder network, as shown in the picture above, there is normal coordination between the central, provincial and district governments, especially in important central government programs, such as the management of KKPN, KSPN, and disaster management. There is a single very central non-government supporting actor, CTC. Various sources of information obtained online indicate CTC's participation in almost all main activities carried out by UPT KKP Nusa Penida in protecting coral reefs and the environment in general in the Nusa Penida KKPN area.

Besides, two conflict issues were indicated in the network, namely the construction of the Klungkung Integrated Cultural Center, which the Bali Provincial Government promoted, and the construction of a jetty that damaged the environment. Both developments have received negative responses from various NGOs and local government agencies. The negative relationship is depicted in red in the network image above.

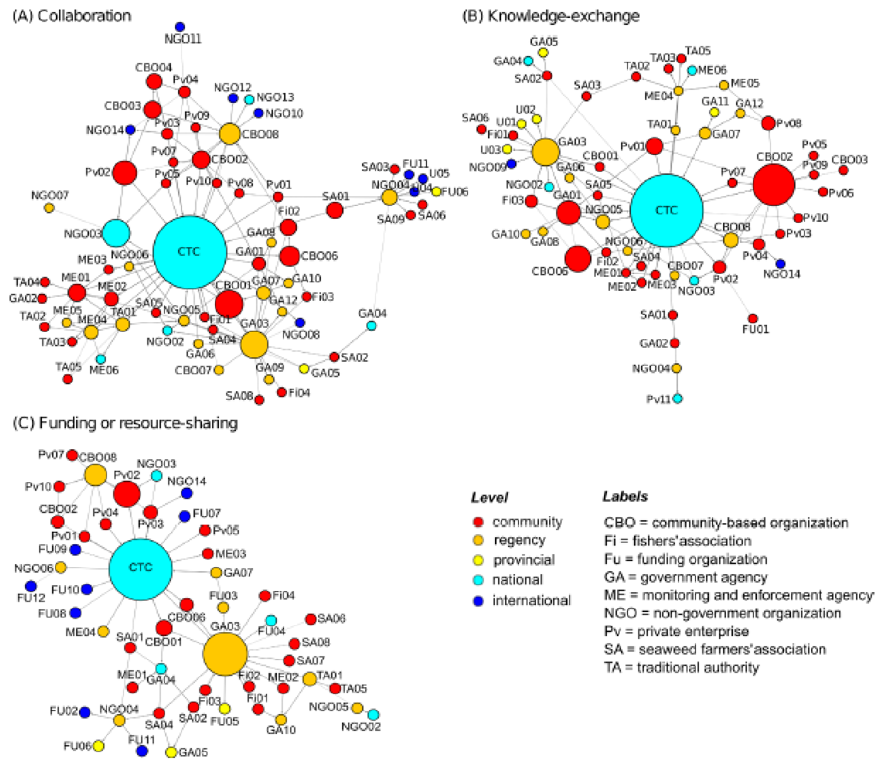


Fig 2. Network maps of the Nusa Penida MPA network. Network maps illustrate relationships (represented by lines) between organizations (represented by circles) associated with the network. The size of the circle indicates its betweenness centrality (bigger circles = higher betweenness) and the colour of each circle indicates its level. Betweenness measures based on: (A) collaborative relations (n = 67), (B) knowledge-exchange relations (n = 59) and (C) funding or resource-sharing relations (n = 50). Labels are composed of the type of organization, and a unique number to distinguish them from others in the group.

doi:10.1371/journal.pone.0147142.g002

Figure 71 Social Network Analysis Diagraph of Nusa Penida MPA Management in Berdej and Armitage (2016)

There is a previous research related to networking among stakeholders in water conservation in Klungkung Regency by Berdej and Armitage (2016). The study resulted in 3 types of networks, namely collaboration networks, information exchange, and funding. The significant difference between the networks in Berdej and Armitage (2016) shown in Figure 71 from our assessment is due to the different contexts of the networks created and the different data collection methods used. The network in this report focuses on both disaster management and protection of the marine environment, while their study focused only on environmental protection. In addition, the availability of primary data in the research of Berdej and Armitage (2016) allows the creation of 3 different types of networks based on these three relationships.

Despite already having a Risk Analysis Map, Klungkung Regency has not established a Disaster Management Plan and Disaster Contingency Plan in the regency level. On the other hand, the Risk Analysis

Map has been considered in the Klungkung Mid-term Regency Development Plan (*Rencana Pembangunan Jangka Menengah Daerah/RPJMD*). The RPJMD has contained disaster points such as post-disaster livelihood recovery target of 100%, disaster safe schools, and provision of telecommunication devices (HT) for an emergency. Moreover, several state-owned companies have had established Business Continuity Plans (BCP). They are the PDAM and Ngurah Rai International Airport (Angkasa Pura II).

The local budget is relatively small in Klungkung compared to other regions (1,105.7 billion Indonesian Rupiah in 2020). The budget allocated for Klungkung BPBD is approximately only 0,46% of the regency budget in 2020.

Institutional capacity might be higher at the Bali Provincial level than in Klungkung Regency. While Klungkung Regency still has not established disaster contingency plans, Bali Province has established several contingency plans against floods, tsunami, and volcanic eruptions. These contingency plans have been tested on a Table-Top Exercise regularly and also attended by Klungkung BPBD. Moreover, Klungkung BPBD still does not have any operational 24/7 Emergency Operational Center (EOC) and still relies on the Bali Provincial BPBD's EOC.

Bali Governor Office and Bali Province BPBD have several MoU with national agencies, such as BMKG and BASARNAS. BMKG and Bali Province plan to develop a backup plan station of the Indonesian Tsunami Early Warning System (InaTEWS) in Klungkung Regency. Meanwhile, there was an established MoU between BASARNAS and Bali Governor on disaster management and logistics. Some information on Bali Province and Klungkung Regency experience in Gunung Agung volcanic eruption indicated a good disaster emergency response and recovery practice. Despite not any emergency SOP was found at the regency level, Klungkung Regency allocated around 1.5 billion Indonesian Rupiah for post-disaster recovery due to the eruption impacts. Logistics post was already established in several locations in Klungkung Regency.

By using the SPDAB Tool developed by CARI! Team, the final score for Klungkung Regency is **35.9%** as shown in spiderweb diagram in Figure 72. The 26 measure indicators are divided into 4 pillars, namely: (1) Governance, Policy, and Planning Standard, (2) Preparedness and Socio-Economic Strengthening Service Standard, (3) Critical Infrastructure Protection and Recovery Preparedness Standard, and (4) Disaster Emergency Service Standard. The strongest pillar in Klungkung Regency is Disaster Emergency Service

Standard (4th Pillar), while the weakest is Preparedness and Socio-Economic Strengthening Service Standard (2nd Pillar). Average score of each Pillar is shown in Table 42.

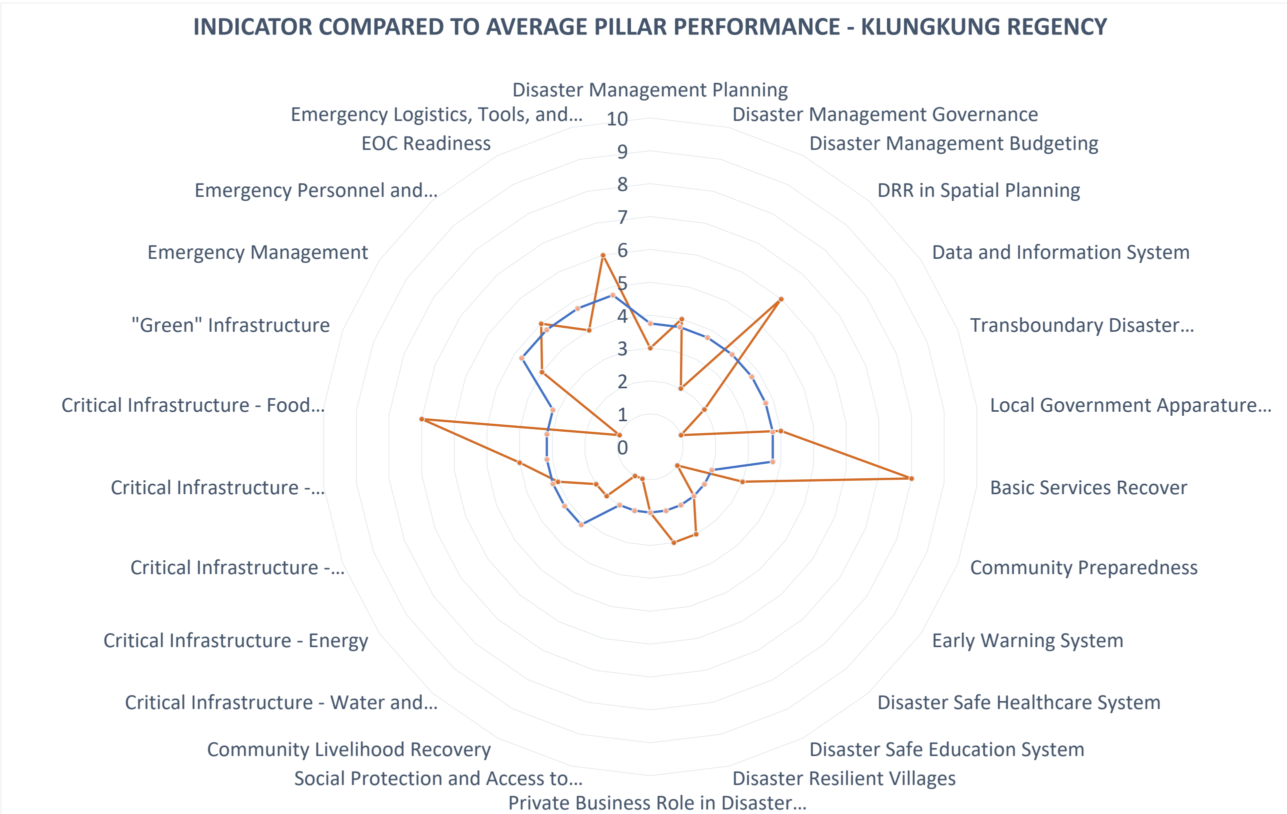


Figure 72 CARI! SPDAB Tool Output Spiderweb Capacity Diagram for Klungkung Regency (Analysis, 2021).

Table 42 SPDAB Pillar Average Indicator and Final Score in Klungkung Regency.

SPDAB Pillar	**Average Indicator Score**
PILLAR 1: Governance, Policy, and Planning Standard	3.75
PILLAR 2: Preparedness and Socio-Economic Strengthening Service Standard	2.00
PILLAR 3: Critical Infrastructure Protection and Recovery Preparedness Standard	3.17
PILLAR 4: Disaster Emergency Service Standard	4.75
	Final SPDAB Score = **0.359**

Source: Analysis, 2021.

5.4 Risk Profile, Valuation, and Scenario of Klungkung Regency

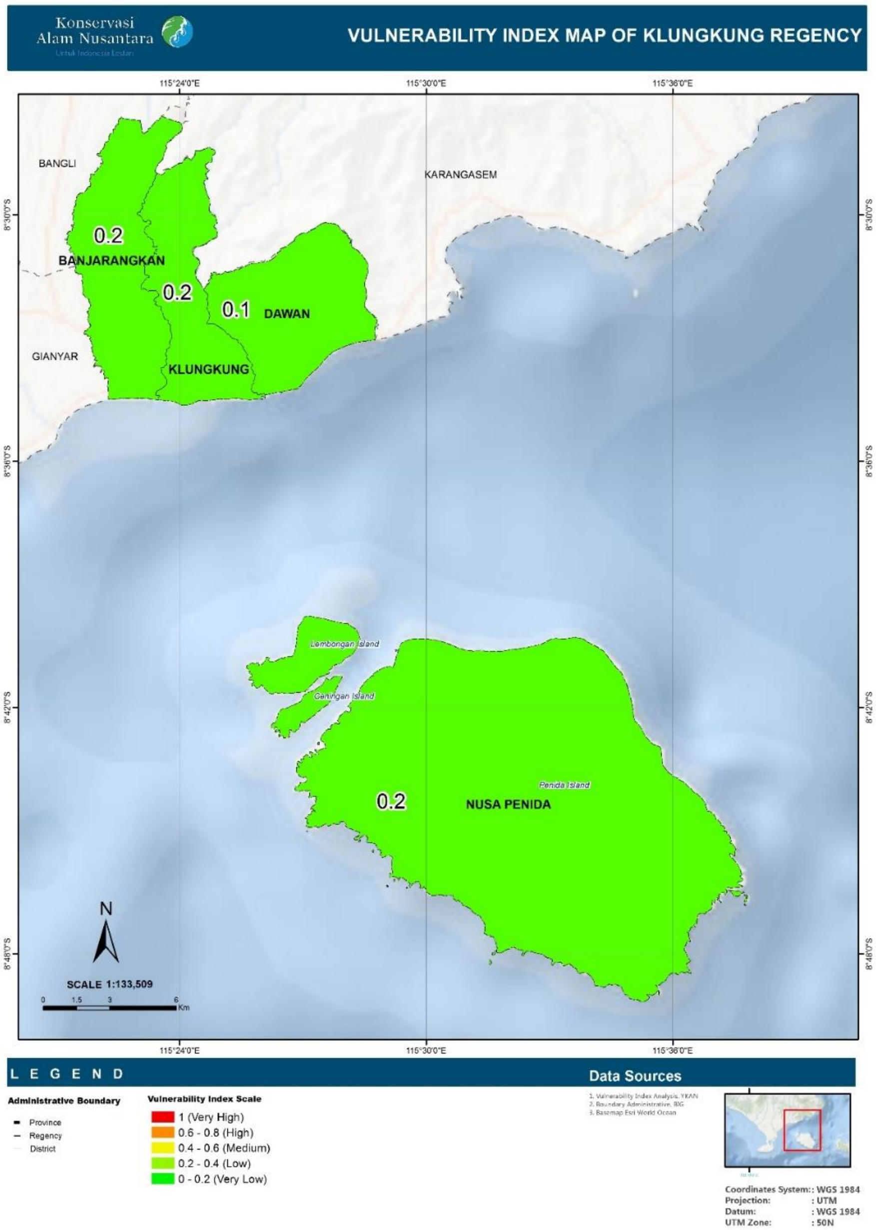


Figure 73 Vulnerability Index Map of Klungkung Regency (Analysis, 2021)

Vulnerability index in Dawan placed as the least vulnerable in Klungkung Regency since it has the least sensitivity index. The highest risk was Klungkung District since it has the highest sensitivity and the 2nd highest hazard index. Klungkung District is the largest urban area in a whole regency, hence it makes the sensitivity index high. The most significant hazard were the earthquake, floods, and strong wind. Those hazards gave the most impact on the community and physical aspects.

In this regency, there are 47,888 people at risk since they are classified as the most vulnerable people due to their age.

This study has adapted the exposure index from Bappenas (2018). The exposure in all districts in Klungkung Regency was low with a value of 0.2. The reason behind this was because this regency placed on a relatively stable coastal area with a sea-level rise under 0.73 mm/ year. The tide rang was >4 m and the mean significant wave height still under 0.75 m.

Table 43 Risk Profile of Klungkung Regency.

District	Index Hazard	Index Exposure	Index Sensitivity	Adaptive Capacity Index	Index Vulnerability	Risk Index
Nusa Penida	0.40	0.20	0.41	0.36	0.23	0.30
Banjarangkan	0.35	0.20	0.40	0.36	0.22	0.28
Klungkung	0.63	0.20	0.46	0.36	0.26	0.40
Dawan	0.69	0.20	0.32	0.36	0.18	0.35

Source: Analysis, 2021.

Table 43 states that the high-risk districts are Klungkung, followed by Dawan, Nusa Penida, and Banjarangkan.

The risk index based on IRBI (2018) was 163.39 which classified in the medium risk class. In the previous report (BNPB, 2018), from nine regency/city in Bali province, Klungkung sat in the 3rd position on the highest risk nomination, while it sat on the 154th place in Indonesia.

Hazard Index in District Banjarangkan is the lowest while the others share relatively the same index. The detail about it can be found in sub-section 5.2.2. Based on the hazard data, frequently destroyed assets are houses and public facilities such as the place for praying.

The sources of the earthquake are from the subduction zone area, even though the source can be far from this district the impact can be very destructive to this regency. As an example, Lombok's earthquake 2018 affected this regency, based on several media reports that there were damages in some building and public facilities. Moreover, even though there was no record of the tsunami in the last 20 years the 500 years return period of Probabilistic Tsunami Hazard Analysis state that this regency is prone to the tsunami to the height of 9- 10 m. Hydrometeorological hazard occurred in this regency in the form of strong wind and floods. The strong wind was the most frequent hazard in Klungkung Regency, and the impact relatively not really destructive. Flood hazard in this regency was relatively categorize not too frequent, it was not destructive but it affected the people.

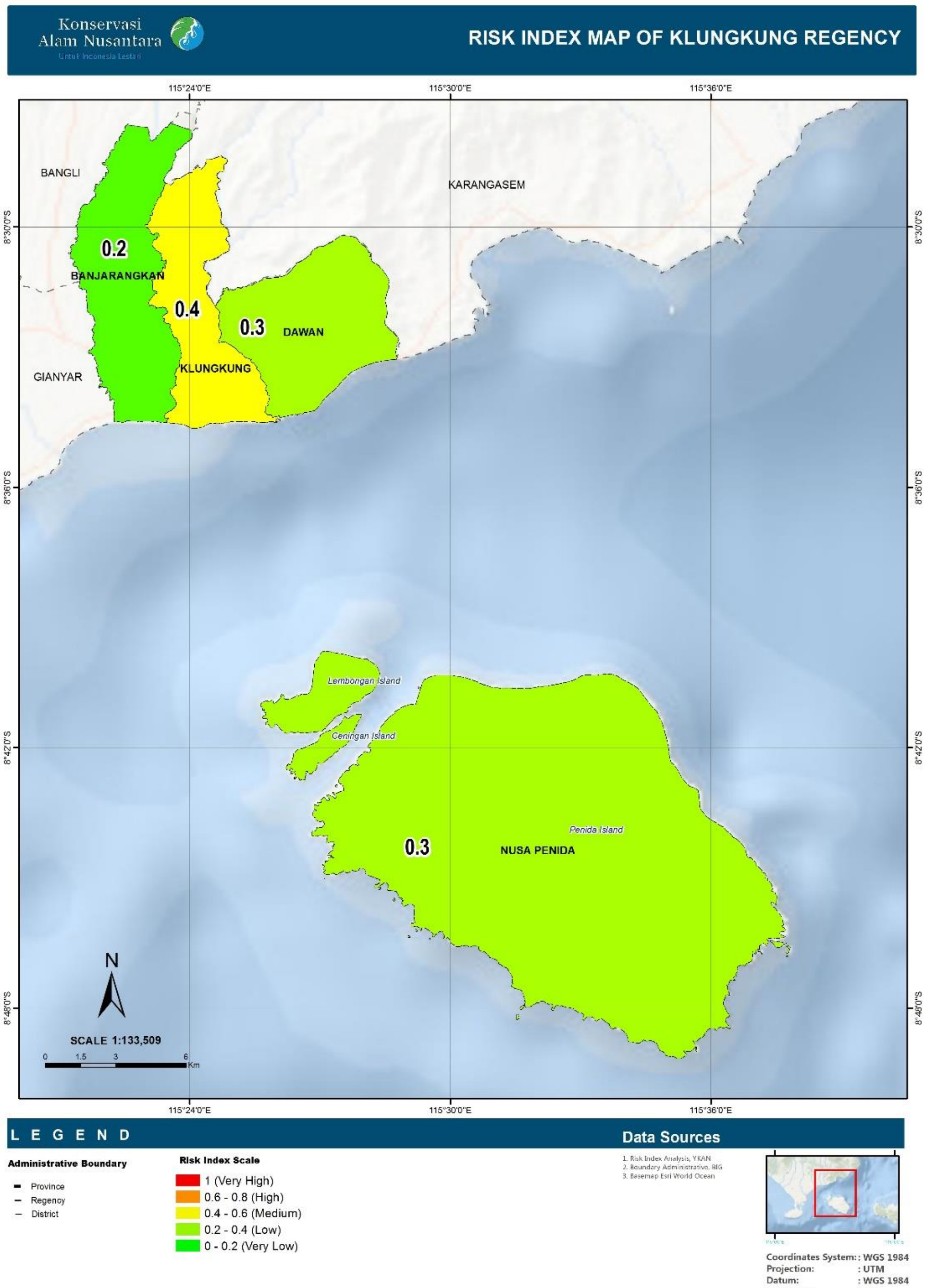


Figure 74 Risk Index Map of Klungkung Regency (Analysis, 2021)

Based on the Risk Index Map (Figure 74), it shows that Klungkung District Possess medium classification of risk index. Dawan District and Nusa Penida District have the low risk index, while Banjarangkan possess very low hazard index.

The anthropogenic risk mainly caused by destructive fishing. The corals showed that there were several signs of fish bombing and fish poisoning. Based on the hazard record there were only four events that occurred in the last 2 decades. The coral's condition in Nusa Penida, Klungkung regency is classified as healthy since the live coral percentage reach 61.7%. The live corals at the depth of 5-15 m cover were good to very good. This zone was dominated by Scleractinian corals. The mortality index at 3 meters depth was 0.00-0.01 while at the depth of 10 meters was 0.00-0.025 (Tito & Ampou, 2020). Furthermore, Nusa Lembongan island has 250 ha coral reefs edge formation. This reef edge has a role to protect from abrasion. The coral reefs in this area are categorized from good to exceptionally good with the average coverage of live corals at depth of 3 m were 68.45% while 48.82 % at 10 m depth. The dominating corals in this area were branching, massive and soft coral species (Prasetia I. N., 2017). The coral reefs in the southern part have coverage of live corals under 40%. In the western part, the live coral's percentage was 21-80% and it was the same as the eastern side.

The damage of coral in Klungkung regency happened due to extreme weather such as cyclone which made the temperature not stable which leads to bleaching. Furthermore, the strong wave which also the effect of cyclone breaks the hard and firm corals. Other storms also decrease the live corals up to 28% at crystal bay and up to 10% in Nusa Penida Marine Protection. On the other hand, the effect of cyclone breaks the hard and firm corals. On the other hand, another natural hazard such as earthquakes also breaks the Scleractinian corals. Lombok’s Earthquake that happened in 2018 makes that corals type dead and broken. The broken coral fragments can be found in the northern and southern part of Nusa Penida and Nusa Lembongan island after two months of the event (Tito & Ampou, 2020)

The damage caused by anthropogenic mainly happened due to fish poisoning using cyanide and fish bombing in the past. Seaweed cultivation has a role in decreasing the live corals in the western part of Nusa Lembongan island. Tourism also has a role in bleaching the corals. Most of the diving spot in Nusa Penida and Nusa Lembongan possess coral bleaching. However, there is still good news that from 2012 to 2016 the coverage of live corals is increased by approximately 20 to 30% (Prasetia I. N., 2017); (Susiloningtyas, Handayani, & Amalia, 2018); (Susiloningtyas & Pratiwi, 2018); (Tito & Ampou, 2020).

Accordingly, the risk scenario of Klungkung Regency in monetary terms is presented in the following figure. The calculations were done using the Blue Guide with inputs from the recorded disaster events and risk profiles of the regency. The approaching scenario forecasts the total damages and losses for the next 20 years with 5% discount rate to reveal a summary figure based on present currency value.

SCENARIOS

Basic approach (simplified)	
Timeframe (years into the future)	20
Discount rate	5%

In the basic approach, the three scenarios are automatically generated based on the data you entered above. Scenario A assumes that the level of damages and losses will remain the same as it was over the past 10 years. Scenario B assumes an increase by 10% (progressive increase by 2.5% every 5 years). Scenario C assumes an increase by 20% (progressive increase by 5.0% every five years). The discount rate of 5% is applied across all three scenarios to reveal a summary figure based on **present currency values**.

	SCENARIO A		SCENARIO B		SCENARIO C	
	Assumption for this scenario		Assumption for this scenario		Assumption for this scenario	
	The level of damages and losses will not change, compared to the past ten years	0%	The level of damages and losses will progressively increase by*:	10%	The level of damages and losses will progressively increase by*:	20%
	Year 1	4,237,351,350,000	Year 1	4,343,285,133,750	Year 1	4,449,218,917,500
	Year 2	4,025,483,782,500	Year 2	4,126,120,877,063	Year 2	4,226,757,971,625
	Year 3	3,824,209,593,375	Year 3	3,919,814,833,209	Year 3	4,015,420,073,044
	Year 4	3,632,999,113,706	Year 4	3,723,824,091,549	Year 4	3,814,649,069,392
	Year 5	3,451,349,158,021	Year 5	3,537,632,886,971	Year 5	3,623,916,615,922
	Year 6	3,278,781,700,120	Year 6	3,442,720,785,126	Year 6	3,606,659,870,132
	Year 7	3,114,842,615,114	Year 7	3,270,584,745,870	Year 7	3,426,326,876,625
	Year 8	2,959,100,484,358	Year 8	3,107,055,508,576	Year 8	3,255,010,532,794
	Year 9	2,811,145,460,140	Year 9	2,951,702,733,147	Year 9	3,092,260,006,154
	Year 10	2,670,588,187,133	Year 10	2,804,117,596,490	Year 10	2,937,647,005,847
	Year 11	2,537,058,777,777	Year 11	2,727,338,186,110	Year 11	2,917,617,594,443
	Year 12	2,410,205,838,888	Year 12	2,590,971,276,804	Year 12	2,771,736,714,721
	Year 13	2,289,695,546,943	Year 13	2,461,422,712,964	Year 13	2,633,149,878,985
	Year 14	2,175,210,769,596	Year 14	2,338,351,577,316	Year 14	2,501,492,385,036
	Year 15	2,066,450,231,116	Year 15	2,221,433,998,450	Year 15	2,376,417,765,784
	Year 16	1,963,127,719,561	Year 16	2,159,440,491,517	Year 16	2,355,753,263,473
	Year 17	1,864,971,333,583	Year 17	2,051,468,466,941	Year 17	2,237,965,600,299
	Year 18	1,771,722,766,903	Year 18	1,948,895,043,594	Year 18	2,126,067,320,284
	Year 19	1,683,136,628,558	Year 19	1,851,450,291,414	Year 19	2,019,763,954,270
	Year 20	1,598,979,797,130	Year 20	1,758,877,776,843	Year 20	1,918,775,756,556
	Total damages and losses over 20 years	54,366,410,854,523	Total damages and losses over 20 years	57,336,509,013,704	Total damages and losses over 20 years	60,306,607,172,885
	Annualised average	2,718,320,542,726	Annualised average	2,866,825,450,685	Annualised average	3,015,330,358,644
			*In 2.5% increments every 5 years		*In 5.0% increments every 5 years	

Figure 75 Risk Scenario of Klungkung Regency in Monetary Terms (Analysis, 2021).

The summary in Figure 75 shows the damages and losses forecast in three scenarios A, B, and C. Following the recent monetary values calculation for the past ten years (Section 5.2.1), the forecasted monetary values for the next 20 years counts as IDR 54.37 trillion with an annual average of IDR 2.72 trillion (Scenario A). Scenario B takes into account the increasing level of damages and losses by 10% and by that, the total value elevates to IDR 57.34 trillion. The forecasted annual average for Scenario B is IDR 2.87 trillion, which takes into account a 2.5% of increments every 5 years. The most extreme scenario, Scenario C, have a 20% increase of damages and losses from Scenario A, which leads to a higher value of IDR 60.31 trillion in total and an annual average of IDR 3.01 trillion, with a 5% increments every 5 years.

6. Risk and Disaster Management Profile of Wakatobi Regency

6.1 Overview of Wakatobi Regency

Wakatobi is an archipelago district consisting of 43 islands (inhabited and uninhabited) and four of them are large islands that form the name Wakatobi, namely Wangi-Wangi Island, Kaledupa Island, Tomia Island, and Binongko Island. Most of the villages in Wakatobi are coastal villages, that are 90 villages, while the remaining 10 villages are non-coastal villages.

Wakatobi Regency consists of eight districts, namely Wangi-Wangi District, South Wangi-Wangi District, Kaledupa District, South Kaledupa District, Tomia District, East Tomia District, Binongko District, and Togo Binongko District. The total area of Wakatobi Regency reaches 47,362.43 hectares. The largest district is South Wangi-Wangi District with an area of 12,355.19 hectares or about 26 percent of the total area of Wakatobi Regency.

Table 44 Area, number of islands and the number of Villages / Sub-districts in the Coastal Delineation of Wakatobi Regency.

No	District	Area (Km^2)	Percentage of Regency Area	Amount of Island	Amount of Sub-district
1	Binongko	69.26	15.21	4	9
2	Togo Binongko	33.32	7.32	0	5
3	Tomia	28.46	6.25	12	10
4	East Tomia	43.30	9.51	2	9
5	Kaledupa	37.66	8.27	31	16
6	South Kaledupa	52.33	11.49	55	10
7	Wangi-Wangi	83.43	18.32	5	20
8	South Wangi-Wangi	107.61	23.63	33	21
TOTAL		**455.36**	**100.00**	**142**	**100**

Source: Wakatobi in Figures 2020, BPS, 2020

The population continues to increase, it was recorded that in 2019 the total population of Wakatobi was 114,591 with a sex ratio of 99%, which means that there are 99 male residents for every 100 female residents. The population growth rate of Wakatobi Regency for the 2010-2018 period was 2.57 percent. Based on its population density, in 2019 the population density of Wakatobi Regency will reach 242 / km^2, which means that on average there are 242 residents per square kilometer. Wangi-Wangi District, which is the district capital, has the highest population density among other districts, at 422 people per square kilometer. Meanwhile, Togo Binongko district, which is the most tip district in Wakatobi Regency, has the lowest population density of 130 people per square kilometer.

Table 45 Demographic Conditions in the Coastal Delineation of Wakatobi Regency

No	District	Amount of Population	Rate of Population Growth	Percentage of Population	Population Density per km^2	Sex Ratio
1	Binongko	10,321	0.43	8.96	1.49	99.90
2	Togo Binongko	5,696	-0.65	4.95	1.71	102.85
3	Tomia	8,122	0.08	7.05	2.85	100.89
4	East Tomia	9,367	0.66	8.14	2.16	98.79
5	Kaledupa	12,37	0.57	10.75	3.28	101.99
6	South Kaledupa	8,52	-0.21	7.40	1.63	95.19
7	Wangi-Wangi	28,797	-0.14	25.02	3.45	100.77
8	South Wangi-Wangi	31,871	0.51	27.69	2.96	101.07
TOTAL		**115,064**	**0.16**	**100**	**19.54**	**801.45**

Source: Wakatobi in Figures 2020, BPS, 2020.

Based on the direction of the Sulawesi Island RTR[28], Wakatobi Regency is directed at 1) Development of shipping navigation auxiliary in marine conservation areas that have high biodiversity carried out in the Wakatobi Islands Marine National Park (Banda Sea); 2) Rehabilitation and strengthening of the functions of national parks, marine national parks, and marine tourism parks are carried out in the Wakatobi Islands Marine National Park (Banda Sea); 3) Maintaining the function of the geological nature reserve area which has a unique landscape is carried out in the Wakatobi karst area (Wakatobi Regency); 4) The maintenance and preservation of coral reefs and the prevention of sedimentation in the estuary area which can disrupt the preservation of the ecosystem in the coral triangle area is carried out in the waters of the Tukangbesi Islands (Wakatobi); 5) The Maintenance and development areas for sustainable food agriculture which are supported by processing and service industries to achieve national food security is carried out in Wakatobi Regency; and 6) Development of marine tourism allotment areas supported by the availability of tourism infrastructure and facilities is carried out in the Wakatobi Islands Marine National Park (Banda Sea).

[28] Presidential Regulation of the Republic of Indonesia Number 88 of 2011 concerning the Spatial Plan for the Island of Sulawesi

Derived from the provincial policy, through the RTRW of Southeast Sulawesi Province[29], Wakatobi Regency is directed as a Promotion Area Activity Center (PKWp), namely in Wangi-Wangi, and as a Usuku Local Activity Center (PKL) in Wakatobi Regency. PKL centers are urban areas that has function to serve district / city scale activities or several districts. In addition, a protected area in the form of a Nature Reserve and Nature Conservation, namely the Wakatobi Islands Marine National Park, has been determined as covering an area of 1,390,000 hectares.

Further regulated in the RTRW of Wakatobi Regency[30], protected areas in coastal areas include:

1. Nature Reserve Area, Nature Conservation and Cultural Conservation:
    a. Mangrove Forested Coastal Areas: Mangrove forested coastal areas with biodiversity in the Districts of Wangi-Wangi, South Wangi-Wangi, Kaledupa, South Kaledupa, East Tomia and Togo Binongko
    b. National Park Area: Wakatobi Marine National Park covers a Core Zone covering an area of + 1,300 Ha, a Marine Protection Zone covering an area of + 36,450 Ha, an extensive Tourism Zone + 6.180 Ha.
2. Other Protected Areas: Animal Refuge Areas, namely Seabird Migration Areas
    a. South Wangi-Wangi district: Oroho Island and Simpora Island
    b. Tomia district: Sawa Island
    c. East Tomia district: Lentea Tomia Island
    d. Togo Binongko district: Moromaho Island
3. The area designated for marine / marine tourism as referred to in verse (1) letter a, consists of:
    a. Patuno tourism area in Wangi-Wangi district;
    b. Matahora tourism area, Liya and Kapota integrated ecotourism in South Wangi-Wangi district;
    c. Hoga tourism area in Kaledupa district;
    d. Peropa tourism area in South Kaledupa district;
    e. Tolandono tourism area in Tomia District;
    f. Huntete tourism area in East Tomia district;

[29] Southeast Sulawesi Provincial Regulation Number 2 of 2014 concerning Regional Spatial Planning of Southeast Sulawesi Province for 2014 - 2034

[30] Wakatobi Regency Regional Regulation Number 12 of 2012 concerning Wakatobi Regency Spatial Planning 2012 - 2032

g. Palahidu tourism area in Binongko district; and.
h. Areas that have a panoramic view of the underwater sea and beaches, which are in Wangi-Wangi, South Wangi-Wangi, Kaledupa, South Kaledupa, Tomia, East Tomia, Binongko and Togo Binongko Districts.

In the division of the National Fisheries Management Area, Wakatobi Waters are in the WPPNRI 714. In the direction of the WPPNRI 714 fisheries management plan, stipulate a marine conservation area in the form of the Wakatobi Marine National Park (TNL) with an area of 1,390,000 hectares. Based on the RZWP3K Direction of Southeast Sulawesi Province, the development directions for Wakatobi Regency are 1) Capture Fisheries Zone, Pelagic Fishing Sub Zone (KPU-PT-P); and 2) Port Zone, work environment area and port interest area (KPU-PLDLK): Tomia District; South Wangi Wangi District; Togo Binongko District; South Kaledupa District; East Tomia District; Wangi Wangi District; and Binongko District.

In the economic aspect, the sectors that drive the regional economy can be seen from the contribution of these sectors to the Gross Regional Domestic Product (GRDP). Based on data from Wakatobi Regency in Figures 2020 (BPS, 2020), the value of GRDP of Wakatobi Regency reached 4.356 trillion rupiah in 2019, with the most contributing sectors being Agriculture, Forestry and Fisheries. Meanwhile, looking at the GRDP growth in the last few years based on constant prices, the densest growth of Wakatobi Regency's GRDP was 6.6% in 2019, with the sectors the highest growth rates are 1) Provision of accommodation and food and drink; 2) Construction; and 3) Health Services and Social Activities. In 2019 the fish cultivation production in Wakatobi Regency reached 45.78 tons with a fish production value of 4,690,210,000 rupiah (BPS Wakatobi, 2019). The number of fishermen consisting of Full-fledged Fishermen is 5,682 and 592 Main Taking Fishermen, with the number of boats / motorboats used in fishing activities in the form of 1) motor boat (3957); 2) Outboard motorboats (1,165); 3) Engineless boats (1,333).

6.2 Summary of Past Disaster Events in Wakatobi Regency

6.2.1 Past disaster events due to natural hazards and sudden onset in nature

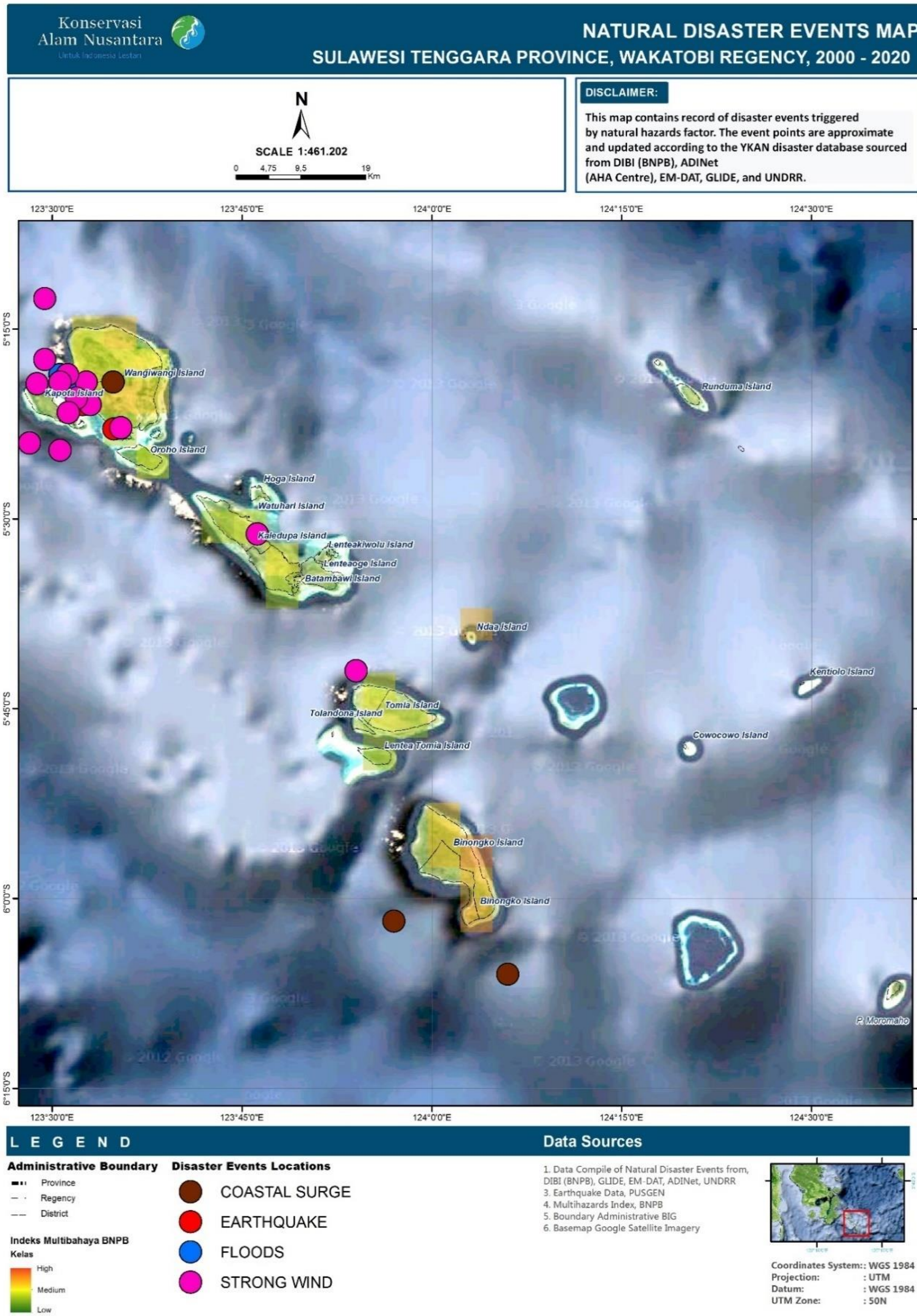


Figure 76 Map of Natural Disaster Events in Wakatobi Regency 2000-2020 (Analysis, 2021).

The Wakatobi archipelago consists of islands that are highly dependent on marine activities. The landscape of the islands in Wakatobi is a formation of coral clusters. Apart from being a separate district, Wakatobi is also unique for its large marine national park. With such geographical conditions, the Wakatobi Islands are exposed to hydrometeorological factors in the monsoon season. Thus, interrelated disasters such as strong winds can occur quite frequently in Wakatobi. From the results of the analysis of disaster data collected, there were 23 natural disasters recorded in the 20 years period from 2000-2020. Most disasters occurred in the time period between 2009-2013 (Figure 77), however, in 2011 there were minimal disasters in Wakatobi.

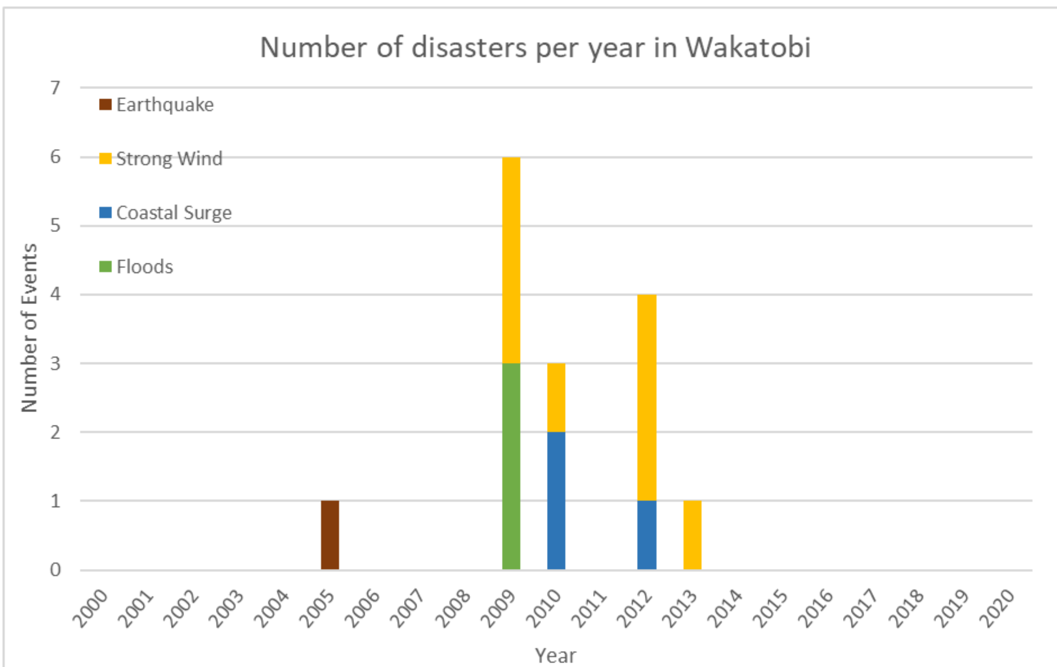


Figure 77 Number of Disaster Events due to Natural Hazards in Wakatobi District (Analysis, 2021).

In 2009, with the highest number of events, namely 6 incidents, natural disasters were dominated by hydrometeorological disasters such as strong winds and floods. As shown in Figure 77, there are only 3 flood occurrences in Wakatobi at the year. The floods mainly caused by river runoff which was derived from heavy rain event during the time. The fact that it only happens in Wangi-Wangi district makes the district to be the most vulnerable to flood. There, although only 7 houses affected in total, but 45 hectares of plantation area damaged. Apart from that, the strong winds have the possibility to damage coastal life. Combined with the heavy rain and additional river runoff, strong wind occurrence can have more impact. Early in 2009, DIBI recorded two strong wind accompanied with runoff flood that have affected 95 houses in total. During the last 20 years, in total 15 occurrences of strong winds found with more than 1000 people affected and over 200 houses damaged.

Table 46 Summary of Impacts of Disaster Due to Natural Hazards s in Wakatobi Island.

District Name	Frequency Index	Severity Index	Hazard Index
Binongko	0.20	0.40	0.28
Kaledupa	0.20	0.40	0.28
Kaledupa Selatan	0.20	0.40	0.28
Togo Binongko	0.20	0.60	0.35
Tomia	0.20	0.40	0.28
Tomia Timur	0.20	0.40	0.28
Wangi-wangi	0.80	0.80	0.80
Wangi-wangi Selatan	0.80	1.00	0.89

Source: Analysis, 2021.

Based on the Table 46, the highest hazard index goes to Wangi-Wangi Selatan District and Wangi-Wangi District, 0.89 and 0.80. The reason behind is because those districts have high severity Index as well as frequency index.

Because of Wakatobi's location in Central Indonesia, tropical cyclone does not have any direct impact to Wakatobi but only indirect impact such as strong wind occurred. An example of tropical cyclone occurrence in Wakatobi was Tropical Cyclone Heidi in 2012[31]. Formed in the south of West Nusa Tenggara Province, it caused extreme wind speed up to 40 km/h in the regency. During the time of the event, a report was submitted in DIBI regarding strong wind occurrence in Wangi-Wangi Island. Although was not reported in detail, but there is high possibility that the two events are linked together. A total of 5 people were affected and 1 house were damaged by the events.

[31] https://megapolitan.kompas.com/read/2012/01/13/19554559/siklon.heidi.pengaruhi.gelombang.laut.indonesia

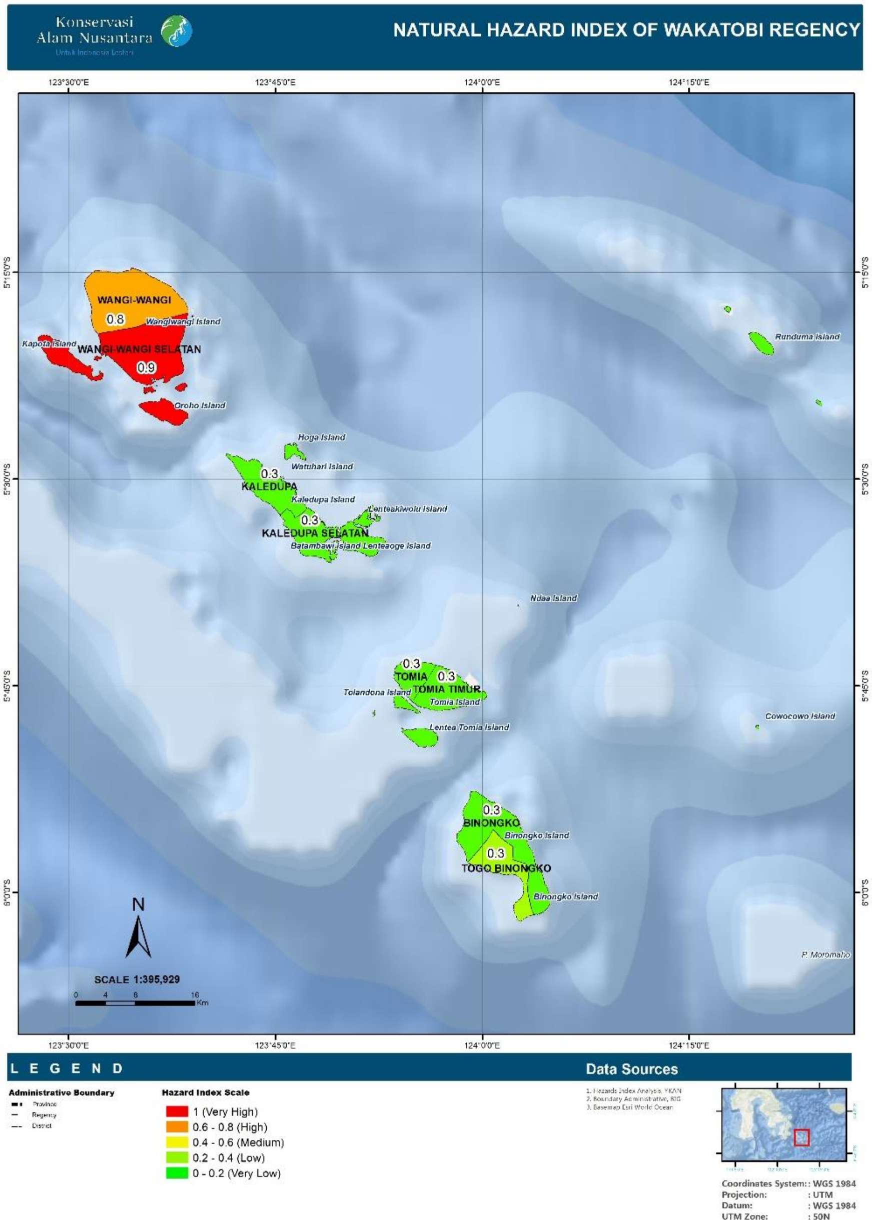


Figure 78 Natural Hazard Index Map of Wakatobi Regency

Based on map of Natural Hazard Index of Wakatobi Regency, Very high hazard index goes Wangi-Wangi Selatan District. Moreover, Wangi-Wangi District possess high hazard index, while the other districts have low hazard index.

By the coastal surge, which happened twice in Togo Binongko and once in Wangi-Wangi. In the later district, at least 250 people were affected and 50 houses damaged. However, in Togo Binongko only 10 houses damaged but 11 people found dead by the surge. With the landscape and thin land cover in

Wakatobi, flooding as a result of heavy rain and coastal surge always submerges areas with a low and confined topography. Meanwhile, as an area consisting of a cluster of islands, storms that hit the Wakatobi area at certain seasons can hamper the transportation activities of island residents.

Judging by the economical terms, the monetary valuation of the damages and losses has not properly recorded previously. Taking into account the recorded database of past natural disaster events, the damages and losses estimation from past hazards/stressors was calculated using the Blue Guide Calculator (The Nature Conservation, 2020) and the results were showed in Figure 79**.**

HAZARD/STRESSOR 1 (Most damaging)		HAZARD/STRESSOR 2		HAZARD/STRESSOR 3	
List the most damaging hazard/stressor	Earthquake	List the second-most damaging hazard/stressor	Strong Wind	List the third-most damaging hazard/stressor	Coastal surge
How many times has this occurred over the past ten years?	2.0	How many times has this occurred over the past ten years?	3.0	How many times has this occurred over the past ten years?	3.0
The annual probability rate (APR) for this hazard is:	0.2	The annual probability rate (APR) for this hazard is:	0.3	The annual probability rate (APR) for this hazard is:	0.3
What currency will you use for monetary figures?	IDR	What currency will you use for monetary figures?	IDR	What currency will you use for monetary figures?	IDR
Damages (monetary values)		Damages (monetary values)		Damages (monetary values)	
Damages to homes	7,575,000,000	Damages to homes	6,105,000,000	Damages to homes	1,800,000,000
Damages to business assets	0	Damages to business assets	50,000,000	Damages to business assets	0
Damages to public infrastructure	750,000,000	Damages to public infrastructure	0	Damages to public infrastructure	0
Other damages (e.g. loss of land from erosion)	0	Other damages (e.g. loss of land from erosion)	0	Other damages (e.g. loss of land from erosion)	0
Total damages	8,325,000,000	Total damages	6,155,000,000	Total damages	1,800,000,000
Direct losses (monetary values)		Direct losses (monetary values)		Direct losses (monetary values)	
Losses in produce	0	Losses in produce	0	Losses in produce	0
Losses in income	0	Losses in income	0	Losses in income	0
Other direct losses	0	Other direct losses	0	Other direct losses	0
Total direct losses	0	Total direct losses	0	Total direct losses	0
Indirect losses (monetary values)		Indirect losses (monetary values)		Indirect losses (monetary values)	
Prolonged losses from produce sales	0	Prolonged losses from produce sales	0	Prolonged losses from produce sales	0
Prolonged income losses	0	Prolonged income losses	0	Prolonged income losses	0
Other indirect losses	0	Other indirect losses	450,000,000	Other indirect losses	30,000,000
Total indirect losses	0	Total indirect losses	450,000,000	Total indirect losses	30,000,000
Hazard 1: Total damages and losses	8,325,000,000	Hazard 2: Total damages and losses	6,605,000,000	Hazard 3: Total damages and losses	1,830,000,000
Hazard 1: Annualised damages and losses	1,665,000,000	Hazard 2: Annualised damages and losses	1,981,500,000	Hazard 3: Annualised damages and losses	549,000,000
The combined damages and losses from all four hazards/stressors over ten years have been:			16,760,000,000		
On an annual basis, the combined damages and losses over ten years have been:			4,195,500,000		

Figure 79 Past Damages and Loss Estimation of Wakatobi Regency (Analysis, 2021).

In brief, the most frequent and damaging natural hazards in Wakatobi Regency are earthquake, followed by strong wind and coastal surge. Over ten years, earthquakes give damages and losses estimation of approximately IDR 8.32 billion in total with the annualised value reaches IDR 1.67 billion, while strong winds were estimated to possess damages and losses of approximately IDR 6.6 billion in total with annualised value of about IDR 1.98 billion. Coastal surges were found to produce higher monetary values than tsunami in terms of damages and losses, reaching IDR 1.83 billion in total and IDR 549 million annualised. Further, the combined damages and losses monetary value from all the hazards/stressors over ten years was calculated to be around IDR 16.76 billion with IDR 4.19 billion calculated in an annual basis.

6.2.2 Past disaster events due to anthropogenic hazards

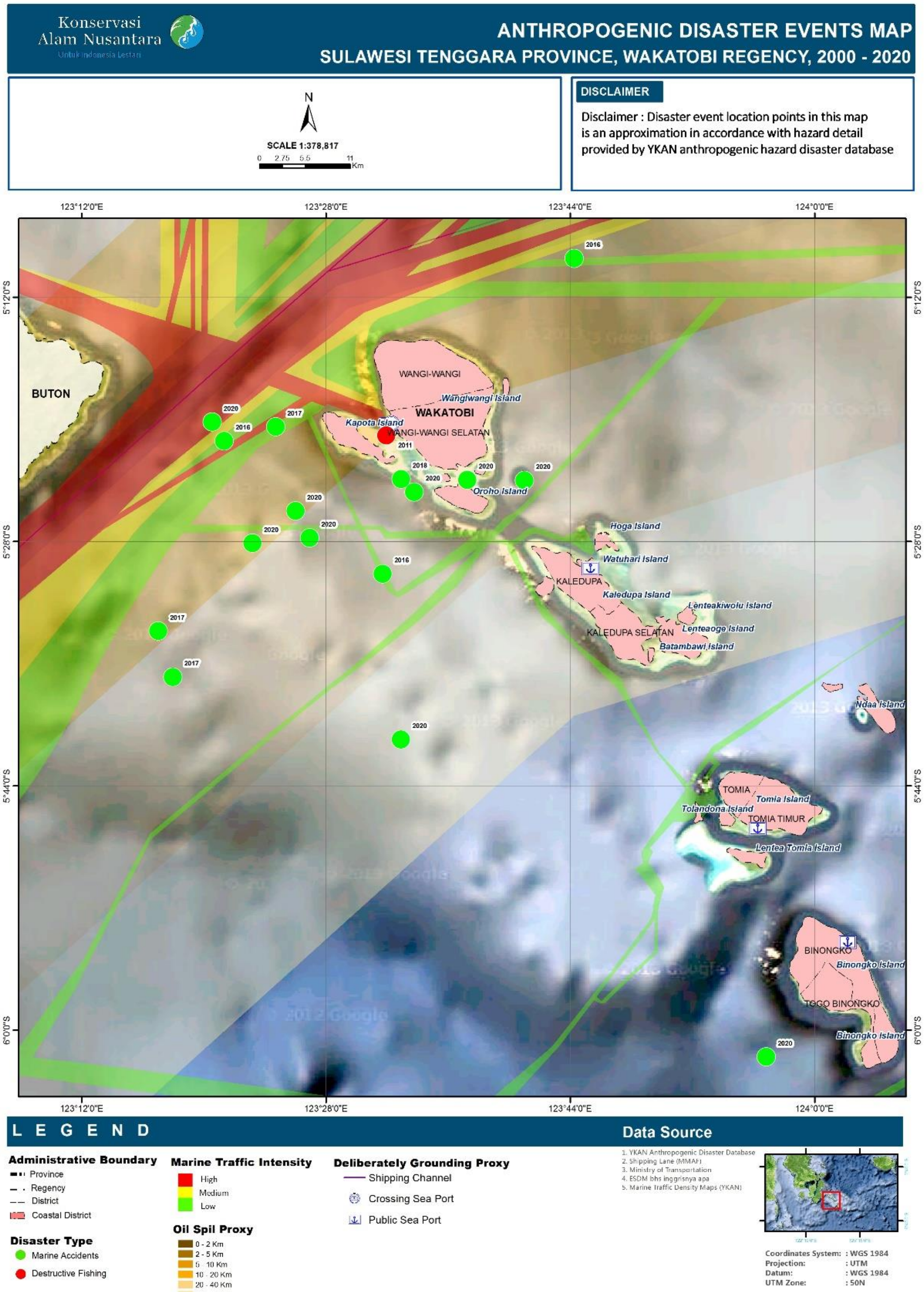


Figure 80 Map of Anthropogenic Disasters in Wakatobi Regency 2000-2020 (Analysis, 2021).

In general, disasters due to anthropogenic hazards that occur in Wakatobi, Southeast Sulawesi Province are dominated by events related to marine accidents. From the data collected in the past 20 years, the number of disasters caused by anthropogenic hazards in Wakatobi Regency, Southeast Sulawesi Province was 17 events, consisting of one destructive fishing activity and 16 marine accidents (Figure 81) where most of them happened around the shipping line in Wangi-Wangi Island (Figure 80). After 2011, the incidence of destructive fishing was vanished completely but marine accidents were actually increased. When compared to the previous decade, the incidence of disasters due to anthropogenic hazards recorded in Wakatobi was increased by 100%, where no anthropogenic hazard recorded between 2000 and 2010.

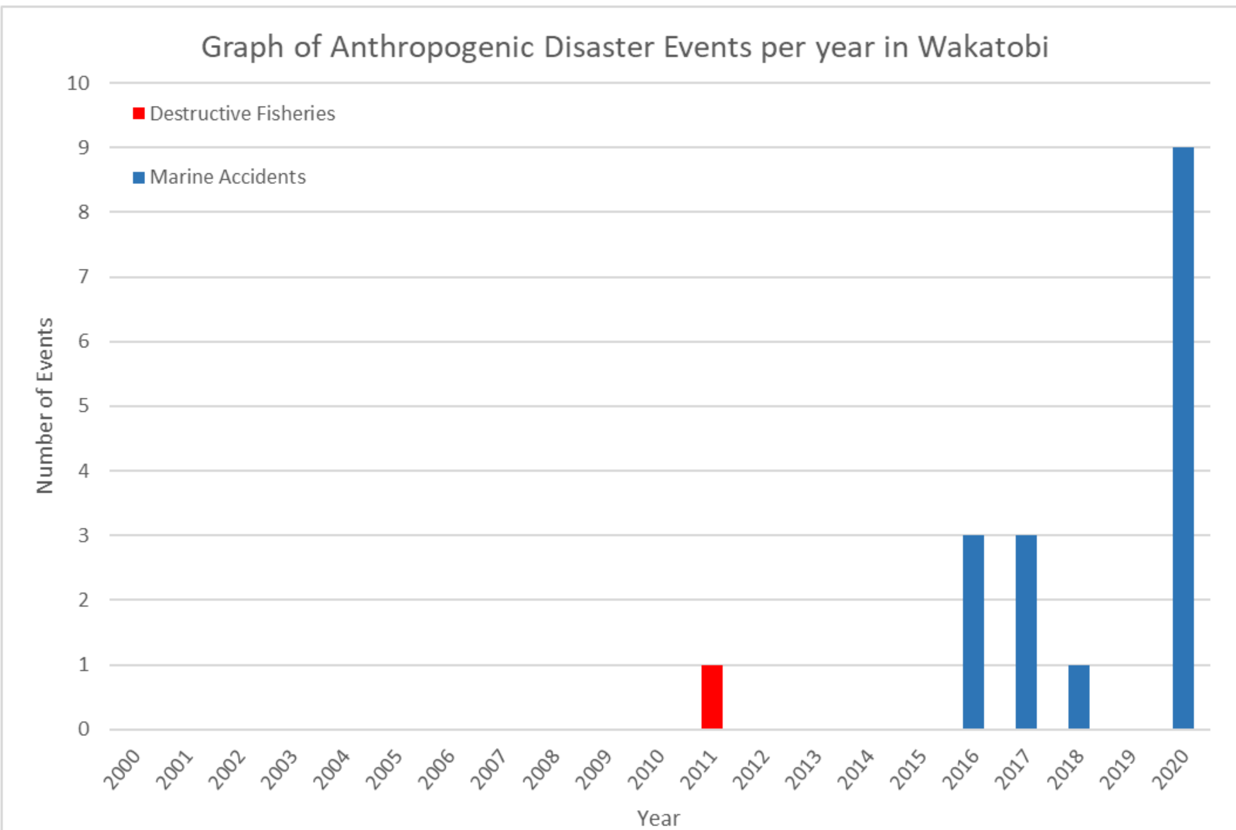


Figure 81 Number of Anthropogenic, Sulawesi Tenggara Province, Wakatobi Regency Period 20 Last Years (Analysis, 2021).

Anthropogenic hazards recorded in this study were causing threats to human safety or damage and loss of livelihoods. Apart from that, disasters due to anthropogenic hazards can also potentially impacting the health of the surrounding environment. Based on records, it was found that over the past 20 years, only a few destructive fishing activities have occurred in Wakatobi Regency. The latest one was on the November 31st of 2011, where fishermen who came from Wangi-Wangi Selatan District were raided by the police because they were suspected for the blast fishing activity by the evidence of a fish bomb ready to explode. No coral reef damage recorded from this case, but fish bomb was proven to destroy marine ecosystem within 4 meters radius (Fox and Caldwell, 2006), and such conditions indicate that these activities have not completely disappeared and have the potential to flare up again if they are not monitored and addressed properly.

Regarding the ship accidents, two people were recorded to be disappeared in the 22nd of April and the 9th of June 2020 at Kaledupa and Lasalimu waters, respectively, where the cause of the accidents were unknown. In addition, about 14 ships damaged, three ships lost, and one sinking ship. A majority of the ship accidents came from the engine trouble, but some of them of them which were using longboats, experience fracture on the body and fallen propeller. No further damage recorded for these kinds of marine accidents. From an economic aspect, the marine accident at least caused the loss of important livelihood assets for coastal communities. Although in terms of quantity it is still relatively small when compared to the other areas, the impact caused by marine accidents has resulted in direct impacts on humans. Therefore, more attention and effort are needed to reduce these impacts, to avoid threats, reducing and transferring hazard risk.

Table 47 Anthropogenic Hazard Index in Wakatobi Regency (Analysis, 2021).

District	Destructive Fishing	Marine Accident	Oil Spill	Anthropogenic Hazard Index
Binongko	0	1	0	0.14
Kaledupa	0	3	0	0.41
Kaledupa Selatan	0	0	0	0.00
Togo Binongko	0	0	0	0.00
Tomia	0	0	0	0.00
Tomia Timur	0	0	0	0.00
Wangi-wangi	0	8	0	1.00
Wangi-wangi Selatan	1	3	0	0.50

Source: Analysis, 2021

With all the anthropogenic events recorded in Wakatobi, the hazard index becomes relatively high in Wangi-Wangi by 1.00, followed by Wangi-Wangi Selatan in the same island and Kaledupa (Table 47). Interestingly, Tomia island have 0 index value despite not being the least-developed island in the region and located just around the Wakatobi Marine National Park (Figure 80). Looking to the map of Anthropogenic Hazard Index (Figure 82) below, it seems like the closer the proximity of the island to the mainland Sulawesi, the more anthropogenic disasters happened, and the higher anthropogenic hazard index presented.

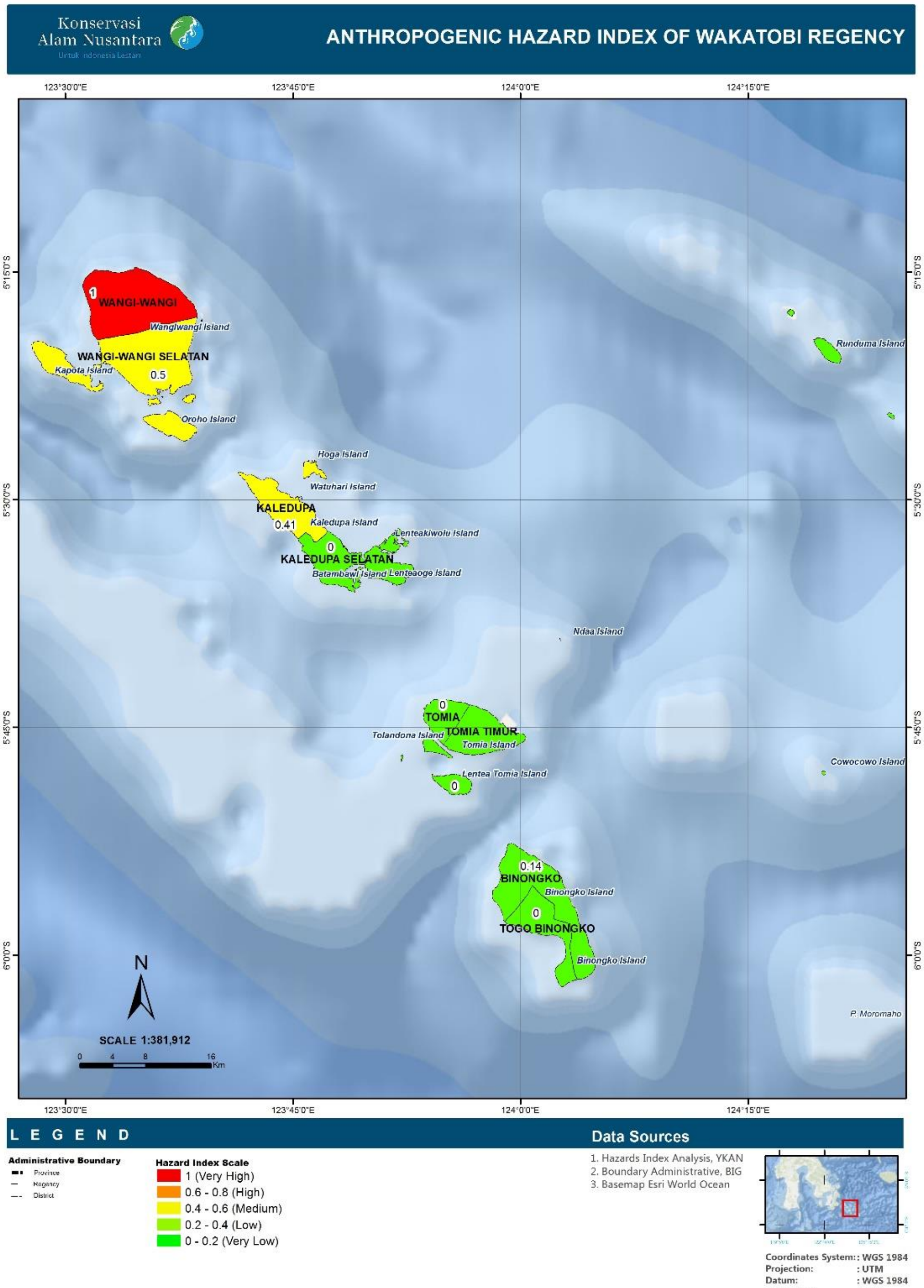


Figure 82 Anthropogenic Hazard Index Map of Wakatobi Regency (Analysis, 2021).

6.2.3 Past disaster events due to natural and anthropogenic hazards and slow onset in nature

The waters in the Wakatobi Islands have the highest diversity of coral reefs and types of marine life in the world, especially fish. It has 25 pristine coral reef clusters with 396 species of various forms, from 599 registered species of coral in the world (Yulius, et al., 2015). With many coral reef ecosystems and their potential, Wakatobi Regency has received the largest portion of the Special Allocation Fund (DAK) for Tourism in Indonesia for two consecutive years. In general, there was an increase in DAK of around Rp 6 billion between 2018 and 2019. This tourism DAK consists of physical DAK of more than Rp 16 billion and the rest for non-physical DAK.

However, the increase in sea surface temperature that occurs in the waters in Wakatobi can disrupt the balance of the ecosystem and damage the coral reefs. With an increase in sea surface temperature of 0.2^{o} C per decade in Wakatobi waters, the damage or bleaching of coral reefs that occur in Wakatobi can increase. Recent findings of the coral reef status in Wakatobi are shown in **Error! Not a valid bookmark self-reference.** below. According to Donner (2017) In 2009 and 2010, coral bleaching has occurred in Wakatobi due to El Nino activity, while the survey conducted by TNC in 2011 and 2012 also indicated that there was coral bleaching in Wakatobi. On average, 65% of the corals are affected by coral bleaching but coral mortality is estimated to be less than 5%. The coral classes that are relatively resistant to bleaching are *Pocillopora sp*., *Stylophora sp.*, *Montipora* sp. and *Acropora sp*.

There are several factors indicating that the incidence of coral bleaching in Wakatobi was caused by rising sea surface temperatures and high intensity of sunlight penetrating marine waters. Those are:

1. Massive coral bleaching events throughout the national park; including Symbiodinium-containing *clionaids* colony which is known to have high tolerance of temperature (Marlow et al, 2018)
2. Rising sea surface temperatures from February to May 2010; and
3. The number of corals that are still alive and recovering when the sea surface temperature returns to normal (Wilson, Ardiwijaya, & Prasetia, 2012). Meanwhile, according to Hadi et al (2019), the status of coral reefs in Wakatobi is in a relatively good condition, considering that 9 out of 15 observation points of coral reefs are in fairly good condition.

Table 48 Status of Coral Reef in Wakatobi Regency.

Location	Number of Station	Very Good	Good	Fair	Poor
Wakatobi (Sulawesi Tenggara)*	15	0	0	9	6

Source: Hadi, et al., 2019.

The problems regarding slow-onset reef quality degradation was not caused by bleaching only. Human activities might also play an important role to threaten the ecosystem. Such infrastructures built for transportation and tourism purpose, although found to be beautiful by the people, can also have negatve impacts in the long term for the coastal and marine ecosystems in the vicinity. As was shown previously in Table 17 in section 2.3.5, threats from anthropogenic factor in Wakatobi Regency which could potentially threaten coastal ecosystem especially coral reefs are the airports activity. With coastal population of 114,510 people, which most of them are residing adjacent to the sea, there has been a relatively low threat to the surrounding coastal ecosystem. Since Wakatobi comprises of small islands, more than 10 small ports and four main ports/harbours were built to support people's lives and accelerate marine transportations in the areas. The shipping line around Wakatobi is concentrated in Wangi-Wangi, as the most developed region in the regency. While the major shipping line is already shown in Figure 80, minor shipping line between islands could not be projected since the boats used don't have any GPS system onboard. The ships and boats that sail around those shipping line could potentially harm the rich biodiversity of corals in the Wakatobi Marine National Park and surrounding. Further, a total of two airports in Wangi-Wangi and Tomia Islands were also built around the coastal areas to boost tourism around the regency, this was considered high threat to the coastal ecosystem since the airports will increase people and goods transport activity, which in turn will increase the possibility to harm the surrounding coastal ecosystem. Tourism centre in Wakatobi were mostly marine based, and for this, 6 hotels and 15 motels were built for tourism support.

6.3 Stakeholder Mapping and Local Institutional Capacity of Wakatobi Regency

Wakatobi Regency has regulated about the roles of key institutions in disaster management in the Wakatobi Regency Regulation No. 2 of 2017 concerning the Implementation of Disaster Management. This Regional Regulation states the central role of a Type A Wakatobi Disaster Management Office (*BPBD Wakatobi*) in disaster management in Wakatobi Regency. In addition, there is the Community Early Preparedness Forum (*Forum Kesiapsiagaan Dini Masyarakat/FKDM*) which consists of representatives from community organizations, universities, educational institutions, community leaders, traditional leaders, religious leaders, youth leaders, and other elements of society. FKDM's main function is to convey aspirations and providing inputs to the Regent regarding community awareness. In addition, BPBD coordinates with Wakatobi Regional Development Planning, Research and Development Agency (*Bappelitbangda*), Environmental Agency (*DLH*), Civil Service Police Unit (*Satpol PP*), and Resort Police (*Polres*) in prevention, mitigation, preparedness, and emergency response for disaster management.

The Ministry of Tourism and Creative Economy has designated Wakatobi Regency as one of the "superior" National Tourism Strategic Zone (*Kawasan Strategis Pariwisata Nasional/KSPN*) in Indonesian Government Regulation No. 50 of 2011 concerning the National Tourism Masterplan (*RIPPARNAS*) 2010-2025. However, from various news reports, there is no indication of significant transportation or other infrastructure development programs that potentially damage or disrupt the Wakatobi Marine National Park (*Taman Nasional Perairan/TNP*) conservation area.

The protected area in Wakatobi Regency is the Wakatobi TNP, as mandated in the Decree of the Minister of Forestry and Environment No. 7661 of 2002 as revised in the Decree of the Minister of Forestry and Environment No. 425 of 2020. The Wakatobi National Park Center (*Balai Taman Nasional Wakatobi/BTNW*) was formed by the Ministry of Environment and Forestry as the Technical Implementation Unit (*Unit Pelaksana Teknis/UPT*) which is responsible for managing Wakatobi National Park. Since the establishment of Wakatobi in 2002, two NGOs, TNC and WWF, have carried out programs in Wakatobi Regency until 2012[32]. Until now, WWF still has several programs running in TNL Wakatobi. In addition, the Wakatobi National Park Center partners with community groups and local NGOs, including: the Kahedupa Toudani Forum (Forkani), the Dewara Group, Kahedupa Sara Barata customary leaders, and the Wakatobi Rural Forestry Communication Center (*Sentra Penyuluhan Kehutanan Perdesaan/SPKP*)[33]. There was some information about the initiation of the partnership between the Wakatobi National Park Center and Rare, which is planned to start in early 2020, but there is no information regarding its continuation after the Covid-19 pandemic.

[32] See "*Satu Dekade Pengelolaan Taman Nasional Wakatobi: Keberhasilan dan Tantangan Konservasi Laut* (One Decade of Wakatobi National Park: Achievement and Challenges of Marine Conservation)" by Sunda Banda Seascape

[33] KSDAE KLHK in "*Wadah Sosialisasi Kemitraan Konservasi Balai TN Wakatobi* (Partnerships in Wakatobi National Park Conservation)" http://ksdae.menlhk.go.id/info/6293/wadah-sosialisasi-kemitraan-konservasi-balai-tn-wakatobi-.html

The Dewara group, a local community group whose role in environmental protection in Wakatobi National Park has been recognized and given two awards by the Ministry of Environment and Forestry. Dewara was appointed by the Ministry of Environment and Forestry as a KLHK[34] Partner in the Social Forestry Partnership scheme, in the form of a Forestry Partnership Recognition and Protection Decree (Kulin KK). The traditional sasi system (opening and closing system of the marine resources utilization) has been carried out effectively until recently in Dawara Village by the Dewara group.

Additional local community groups who are involved in environment conservation and sustainable natural resources management were identified from online meeting with TNC field officer in Wakatobi. Among them were assisted by TNC and WWF joint program during their formation and formalization so they are able to scale-up: Forkani (Forum Kahedupa Toudani), Komanangi (Wangi-wangi Fishermen Community), Komunto (Tomia Fishermen Community), and Foneb (Binongko Fishermen Community). Further, these groups have collaborated with other NGOs and donors, such as BlueVentures, GEF, and SwissContact. In addition to these groups, two customs local groups (*kelompok adat*): Sara Barata Kahedupa and Sara Adat Kawati were also advocated by TNC group to be involved in Wakatobi national park conservation and conservation affairs. Initiated contacts between TNC and ecotourism-based youth groups were also identified: Posaka, Akka Molu, and Goje Goje group.

There are 32 actors identified in Wakatobi Regency. The position of each stakeholder is mapped in the matrix of stakeholder positions and points of view in the figure below. It can be concluded that all actors are in a neutral and supportive position. From our desk study which was conducted on internet sources, significant conflicts related to disaster management and the environment in Wakatobi Regency has not been identified. In the matrix below, the driving actors includes Wakatobi BPBD, the BTNW, and the Indonesian Ministry of Forestry and Environment. The role of the BTWS shows the most prominence, in environmental protection in Wakatobi Regency. Meanwhile, the Ministry of Marine and Fisheries, Wakatobi DKP, Wakatobi Bappelitbangda, and Wakatobi Regent are categorized as skeptical actors because they do not show significant participation in environmental protection and disaster management according to online information. In this stakeholder matrix of Wakatobi Regency, no significant conflict was identified so that no actor was classified as a veto actors, spoilers, and distractors.

[34] https://hijauku.com/2020/11/15/belajar-mengelola-pesisir-dari-nelayan-kaledupa-di-wakatobi/

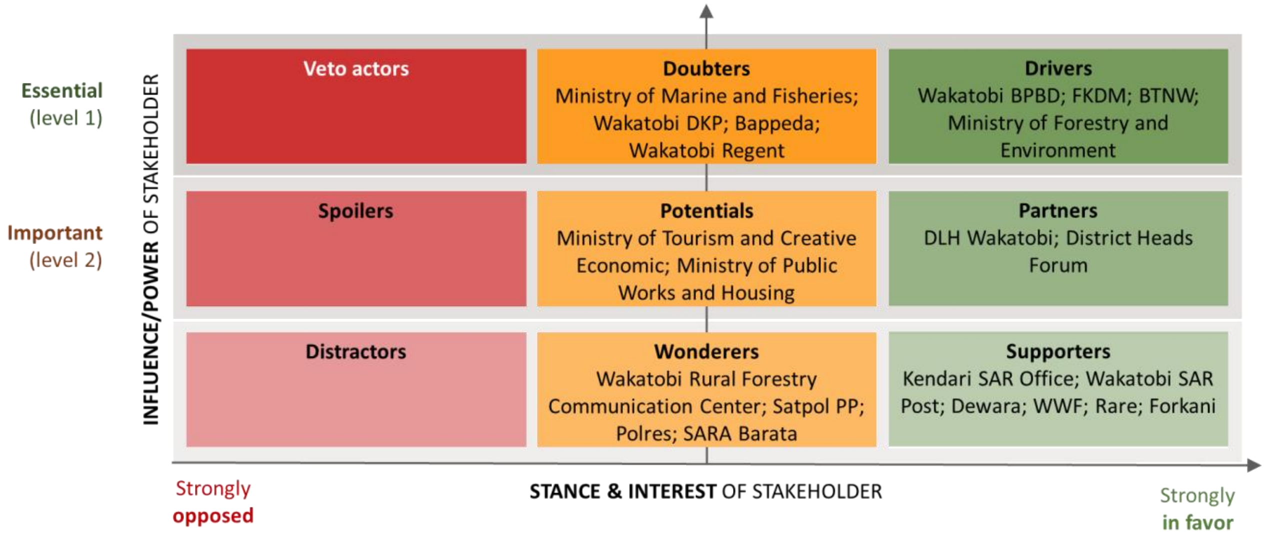


Figure 83 Wakatobi Regency Stakeholder Map (Analysis, 2021).

Figure 84 below is the social network diagraph of stakeholders in Wakatobi Regency, in which 32 actors and 97 relationships were identifiedincluding formal relationships based on regulations and official documentsand indications of joint programs between 2 or more stakeholder agencies. The stakeholder network in Wakatobi Regency does not identify conflict relationships among any stakeholder. Compared to other district networks, this network has the smallest number of identified actors and the number of relationships. This can indicate the lack of documentation and media coverage of activities and conflicts related to disaster management and environmental conservation in Wakatobi Regency that are available online.

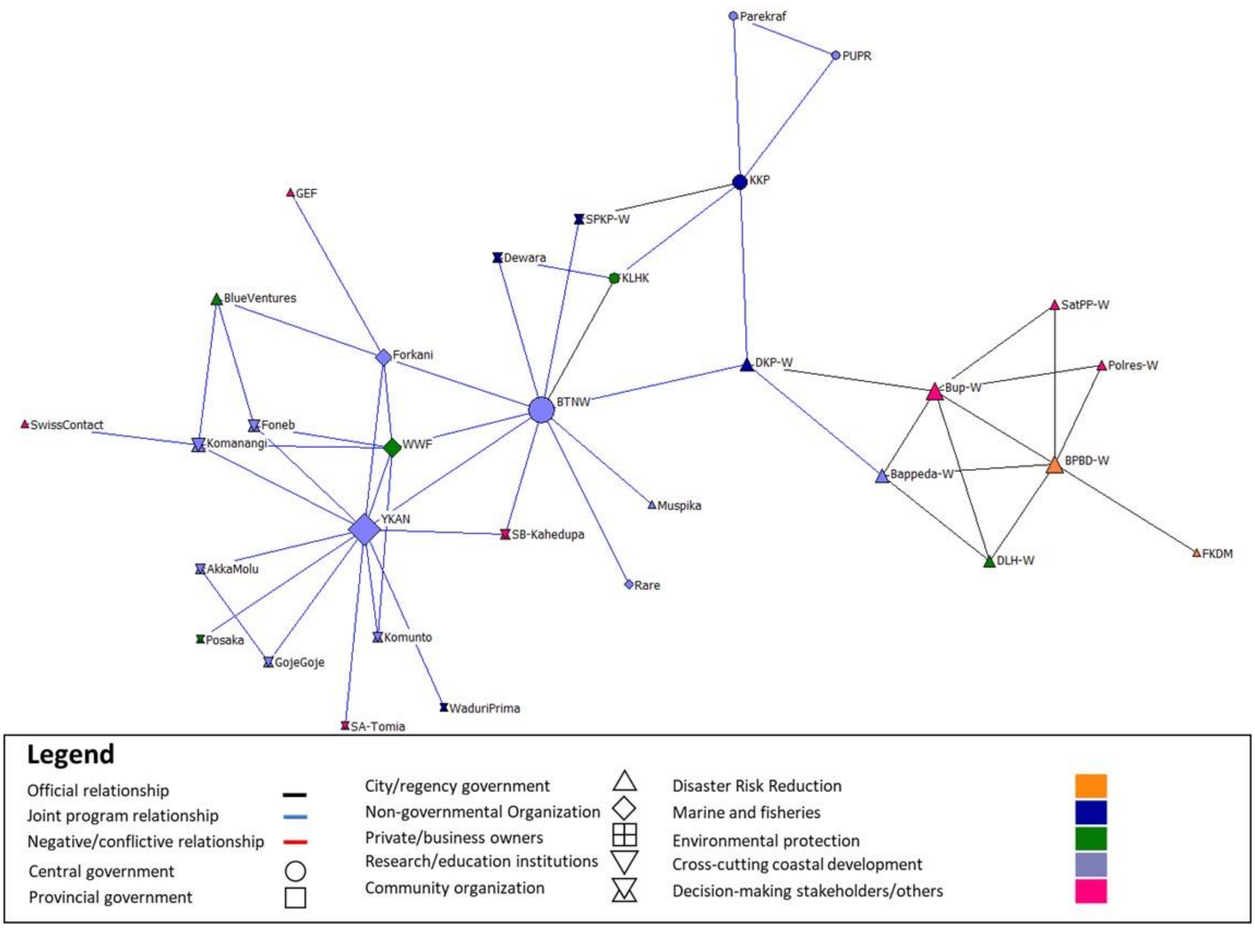


Figure 84 Stakeholder Network Diagraph in Wakatobi Regency (Analysis, 2021).

Furthermore, Table 49 below shows the institutions with the highest degree of centrality and betweenness centrality in Wakatobi Regency, as an initial proxy for the identification of key actors at the location. The centrality degree value shows the number of relationships one actor has. Meanwhile, the betweenness centrality value shows the frequency of one actor bridges two or more other actors, thus indicating the proxy role as coordinator. However, due to the limited data input at secondary sources, this finding needs further validation, especially from primary data sources.

Table 49 Degree and betweenness centrality values of stakeholders in Wakatobi Regency.

Stakeholder	Degree
Wakatobi BPBD	12
Wakatobi Regent	12
TNC (YKAN)	12
BTNW	11
Ministry of Marine and Fisheries	6

Stakeholder	Betweenness
TNC (YKAN)	493
BTNW	490.5
Wakatobi DKP	175
Ministry of Marine and Fisheries	108.5
Wakatobi Regent	102

Wakatobi Bappelitbangda	6
Wakatobi DLH	6

SPKP	93

Source: Analysis, 2021

In the table above, there are 3 actors with the highest centrality degree values, namely the Wakatobi BPBD, the Wakatobi Regent, and The Nature Conservancy. A normal coordination exists in disaster management which has been regulated in the Wakatobi regional regulation. In managing its conservation areas, BTNW collaborates with non-government stakeholders more than with other governmental institutions (only with Wakatobi DKP). Moreover, the non-government stakeholders identified in Wakatobi Regency are a balanced combination of international NGOs, local NGOs, and local community groups. The role of local community organizations appears to be the most significant in Wakatobi Regency compared to other cities and regencies in this study.

From the available information, it is still unknown whether Wakatobi Regency has established a Disaster Risk Assessment and Disaster Management Plan in the regency level. However, a regulation on disaster management was established through the Wakatobi Local Government Regulation no. 02 in 2017[35]. The regulation comprehensive includes all disaster management components and points out several crucial points on institutional capacity against disaster.

The regulation contains points on disaster early warning system but according to sources online, it is not yet known whether a 24/7 EOC is established in Wakatobi (unlikely). The regency has a Type A BPBD and a Community Early Preparedness Forum (*Forum Kesiapsiagaan Dini Masyarakat/FKDM*) which involve representatives from multiple government institutions. From an online source, there is an indication of a lack of personnel in the BPBD.

However, the regulation stands alone was not supported by Disaster Management Plan, Disaster Risk Analysis Map, Contingency Plans, or other SOPs. These documents can whether be not available on the internet or does not exist yet. This will need further confirmation from local personnel/staff.

[35] See Peraturan Daerah Wakatobi no. 2 Tahun 2017 tentang Penyelenggaraan Penanggulangan Bencana

Wakatobi Regency Spatial Plan (2012-2032) mentioned the consideration of disaster management plan several times, but there is no indication whether the DMP is available or not. However, there was mentions on water resource management which considers risks of flood, landslides, and erosion, and evacuation routes along tsunami-prone coastal area and ports in the spatial plan. Information on other institutional capacity is unavailable. There is no indication of non-governmental capacity such as disaster safe hospitals, disaster safe schools, disaster resilient village (*Desa Tangguh Bencana/Destana*), application of Business Continuity Plan in state-owned companies, and disaster insurance companies.

From the available information, using the SPDAB Tool established by the CARI! Team, the score for Wakatobi Regency is **18.8%**. The graph is as shown in Figure 85 below. The 26 measure indicators are divided into 4 pillars, namely: (1) Governance, Policy, and Planning Standard, (2) Preparedness and Socio-Economic Strengthening Service Standard, (3) Critical Infrastructure Protection and Recovery Preparedness Standard, and (4) Disaster Emergency Service Standard. The 1st and 3rd pillar has the highest average score, while the 4th pillar has the weakest average score. Average score of each Pillar is shown in Table 50.

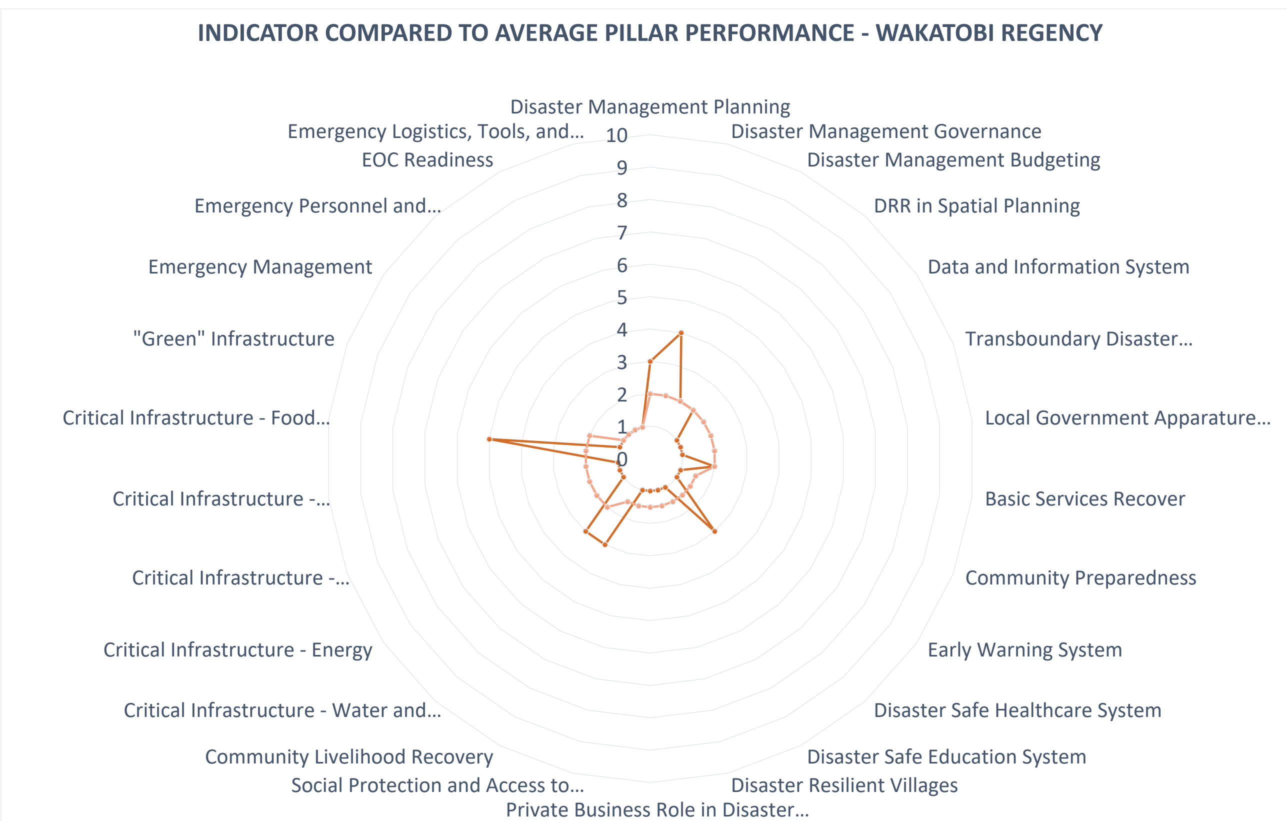


Figure 85 CARI! SPDAB Tool Output Spiderweb Capacity Diagram for Wakatobi Regency (Analysis, 2021).

Table 50 SPDAB Pillar Average Indicator and Final Score in Wakatobi Regency.

SPDAB Pillar	Average Indicator Score
PILLAR 1: Governance, Policy, and Planning Standard	2.00
PILLAR 2: Preparedness and Socio-Economic Strengthening Service Standard	1.50
PILLAR 3: Critical Infrastructure Protection and Recovery Preparedness Standard	2.00
PILLAR 4: Disaster Emergency Service Standard	1.00
Final SPDAB Score = 0.188	

Source: Analysis, 2021.

6.4 Risk Profile, Valuation, and Scenario of Wakatobi Regency

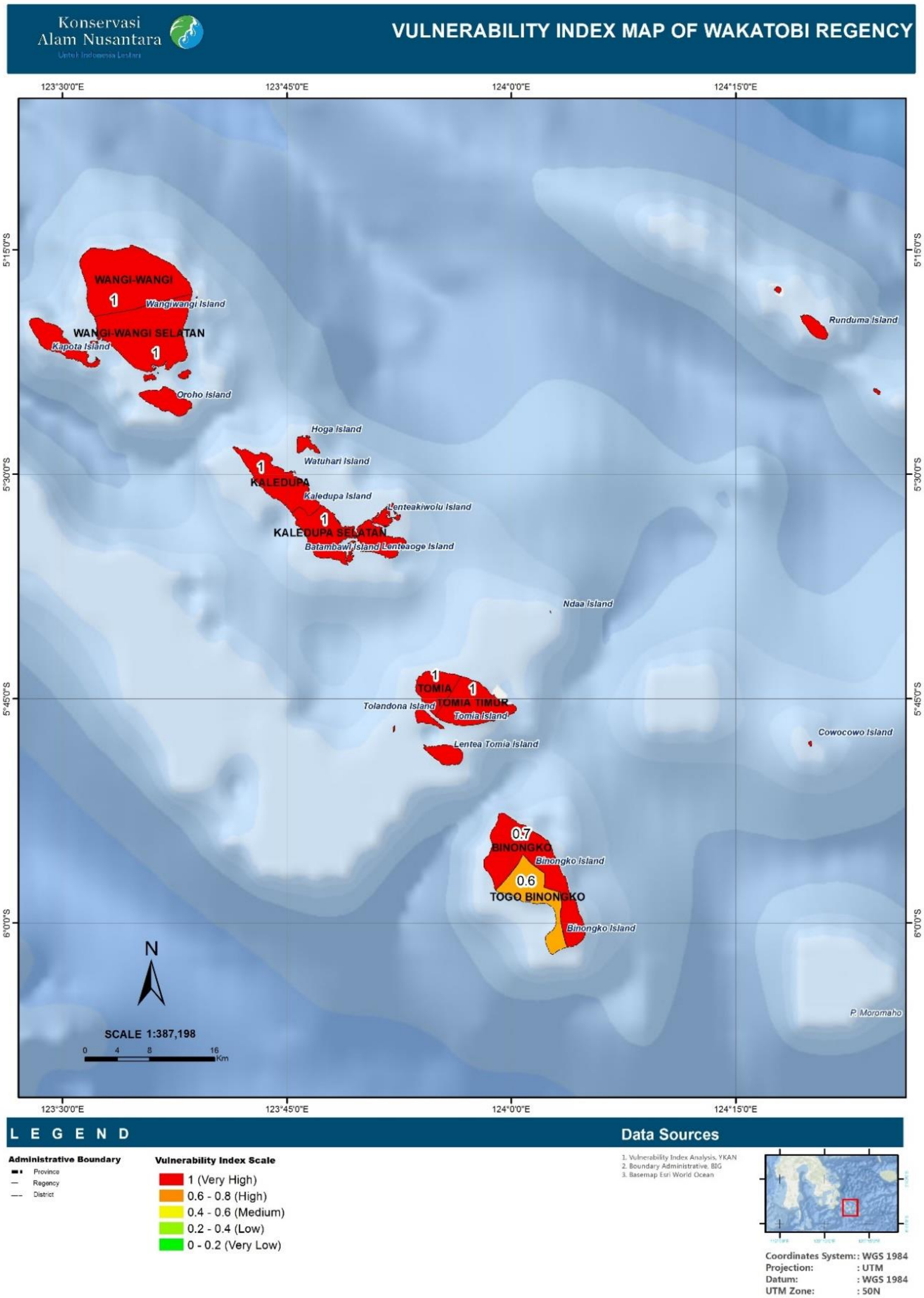


Figure 86 Vulnerability Index Map of Wakatobi Regency (analysis, 2021).

The value of the Disaster Risk Index (IRBI) of Wakatobi Regency for multi-threats is 135.6 with a High risk class and ranked 322 in Indonesia (BNPB, 2018). This shows that Wakatobi indeed is quite vulnerable to disasters, which are mainly strong winds, according to the findings in section 6.2.1. The exposure of the islands is, by far, the highest among all of the study areas by 0.8, except for the districts in Binongko Island by 0.4 (Table 51). The sensitivity of the areas is the highest in Wangi-Wangi Island where Wang-Wangi district topped Wangi-Wangi Selatan by 0.63 to 0.6, while the rest of the districts ranged between 0.32 and 0.50. Having 0.19 as the adaptive capacitive index, the Vulnerability of Rote Ndao Regency was considered the highest in all except Binongko Island. Here, Togo Binongko has the lowest vulnerability index of 0.68 while Binongko have 0.75. With this being said, Binongko is still considered having a very high risk while Togo Binongko is classified as high (Figure 86).

Table 51 Risk Profile of Wakatobi Regency

District	Index Hazard	Index Exposure	Index Sensitivity	Adaptive Capacity Index	Index Vulnerability	Risk Index
Binongko	0.28	0.40	0.36	0.19	0.75	0.46
Kaledupa	0.28	0.80	0.48	0.19	1.00	0.53
Kaledupa Selatan	0.28	0.80	0.29	0.19	1.00	0.53
Togo Binongko	0.35	0.40	0.32	0.19	0.68	0.48
Tomia	0.28	0.80	0.50	0.19	1.00	0.53
Tomia Timur	0.28	0.80	0.35	0.19	1.00	0.53
Wangi-wangi	0.80	0.80	0.63	0.19	1.00	0.89
Wangi-wangi Selatan	0.89	0.80	0.60	0.19	1.00	0.95

Source: Analysis (2021)

Breaking down from the risk index, the fact that Wakatobi Islands are surrounded by large coral reef region promotes more risk at hand. With this said, the Hazard Index of the Wangi-Wangi Island is also the highest among the regions by 0.8 (Wangi-Wangi) and 0.89 (Wangi-Wangi Island). Further, Wakatobi Regency has the highest Risk index with 0.95 for Wangi-wangi Selatan district and 0.89 for Wangi-wangi district. The rest of the districts are calculated between 0.48 to 0.53 where the smallest number accounts for Binongko and Togo Binongko, while the highest 0.53 represented by those districts in Kaledupa and Tomia Islands (Table 52).

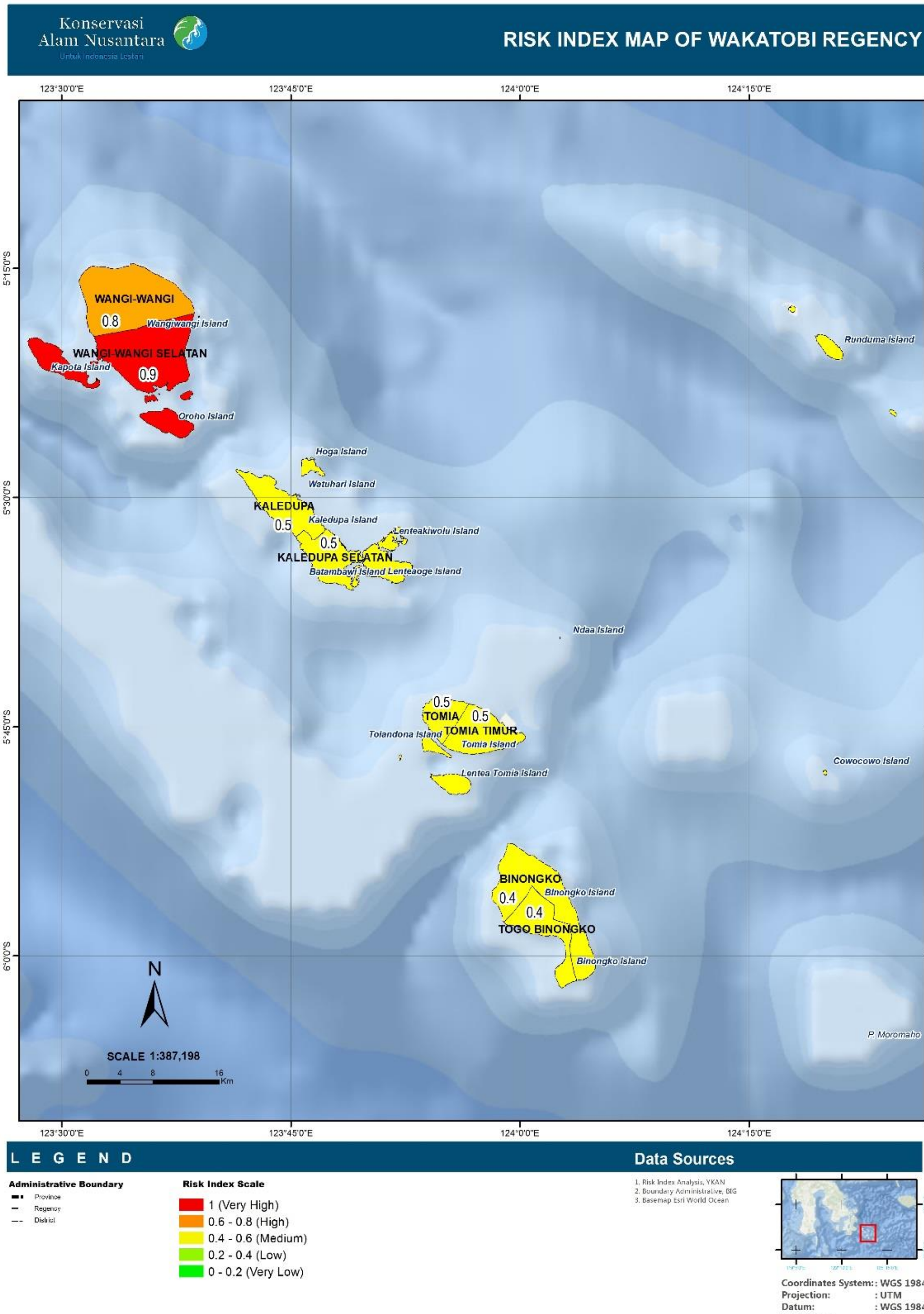


Figure 87 Risk Index Map of Wakatobi Regency (analysis, 2021)

Located in the northern part of Wakatobi, Wangi-Wangi Island are the closest to mainland Sulawesi and thus more people live in the region and more information regarding natural hazards reported. According to section 6.2.1, more strong winds and flooding events were recorded in Wangi-wangi Islands, thus making these Islands the hotspot for such events. If we look closely, some of the different events recorded in Wakatobi Islands are linked together, for example the tropical cyclone events in January 2012 with the strong wind happening afterwards. The tropical cyclone Heidi was formed in the south of West Nusa Tenggara Province and causing extreme wind speed up to 40 km/h. During the time of the event, there was a report in Wangi-Wangi Islands about the occurrence of a strong wind. Although it was not reported in detail, but it is believed that the two events are linked together. Same goes with Cyclone Rusty and the whirlwind activity in February 2013 and the other strong wind-whirlwind activities over the islands. There were also several records of tropical cyclones but there was no information about the impacts for land and/or waters, on the other hand there were a lot of strong wind and coastal surge activities recorded but no storm or cyclone record around the time. For the strong winds, some of which are causing at least 1000 people affected in 2012 only with over 200 houses damaged. Every year there were a lot of cyclones occurred in the southern parts of Indonesia. These analysis shows that when the size and the strength of the southern cyclones are huge, the Wakatobi Regency could not be excluded from the indirect impact of the cyclones, thus the strong wind and coastal surge event are the two events that are going to be occurred frequently, and Wangi-Wangi Island is the most prone to these, with relatively high degree of hazard and vulnerability index producing the highest risk for this island (Figure 87).

Apart from the cyclones, strong winds, and coastal surges, there were only three flooding events recorded in Wakatobi which accounts for the effect of the runoff in Wangi-Wangi. According to the study in 2.3.1, the flood caused by river runoff will not only affects the coastal population, but also the coral reef region. Sedimentation from the upper land will bring forward the excess nutrients and coral disease to the reefs, which contributes to the decline of coral cover in the region (Haapkylä, Seymour, Trebilco, & Smith, 2007). This study also mentioned that the presence of runoff floods in the region may affect the surrounding estuary of Wakatobi Island. However, it is believed that the sedimentation will be less affecting the coral reef sites in the west-southwest Wakatobi Regency since the area is quite far from the coastal areas.

Other natural hazards in Wakatobi were only two earthquakes recorded in 2001 and 2005 affecting Wangi-Wangi. The latest one was the closest to Wangi-Wangi and damaging about a hundred houses there. There was no tsunami and volcano events recorded within the last two decades, thus the Wakatobi Regency considered safe from tsunami and volcano hazard. All in all, the natural hazard affecting Wakatobi were mostly strong wind, followed by a balance between runoff flood and coastal surge, then the earthquake.

Major anthropogenic hazards in Wakatobi until present study, is the ship accidents around Wangi-Wangi Island. The newest case in 2020 were found very close to the reef areas, but the impact was low. There was no detailed report regarding this, thus we can assume that there was no coral reef damage caused by this event. On a different note, Wakatobi Marine National Park has experienced coral mining around two decades ago. A study confirmed that although the coral mining events were declined from 2002 until 2007, the average hard coral cover were declined by half (assuming a decrease of 8% per year). This study also confirms that the coral mining has a devastating and longlasting impact on the coral reef (Caras & Pasternak, 2009) and thus should be monitored more closely.

Following the possible recurring risks that were analysed previously, the risk scenario of Rote Ndao Regency in monetary terms is also calculated and presented in the following figure. The calculations were done using the Blue Guide with inputs from the recorded disaster events and risk profiles of the regency. The approaching scenario forecasts the total damages and losses for the next 20 years with 5% discount rate to reveal a summary figure based on present currency value.

SCENARIOS							
Basic approach (simplified)		SCENARIO A		SCENARIO B		SCENARIO C	
Timeframe (years into the future)	20	Assumption for this scenario		Assumption for this scenario		Assumption for this scenario	
Discount rate	5%	The level of damages and losses will not change, compared to the past ten years	0%	The level of damages and losses will progressively increase by*:	10%	The level of damages and losses will progressively increase by*:	20%
In the basic approach, the three scenarios are automatically generated based on the data you entered above. Scenario A assumes that the level of damages and losses will remain the same as it was over the past 10 years. Scenario B assumes an increase by 10% (progressive increase by 2.5% every 5 years). Scenario C assumes an increase by 20% (progressive increase by 5.0% every five years). The discount rate of 5% is applied across all three scenarios to reveal a summary figure based on **present currency values**.		Year 1	4,195,500,000	Year 1	4,300,387,500	Year 1	4,405,275,000
		Year 2	3,985,725,000	Year 2	4,085,368,125	Year 2	4,185,011,250
		Year 3	3,786,438,750	Year 3	3,881,099,719	Year 3	3,975,760,688
		Year 4	3,597,116,813	Year 4	3,687,044,733	Year 4	3,776,972,653
		Year 5	3,417,260,972	Year 5	3,502,692,496	Year 5	3,588,124,020
		Year 6	3,246,397,923	Year 6	3,408,717,819	Year 6	3,571,037,716
		Year 7	3,084,078,027	Year 7	3,238,281,928	Year 7	3,392,485,830
		Year 8	2,929,874,126	Year 8	3,076,367,832	Year 8	3,222,861,538
		Year 9	2,783,380,419	Year 9	2,922,549,440	Year 9	3,061,718,461
		Year 10	2,644,211,398	Year 10	2,776,421,968	Year 10	2,908,632,538
		Year 11	2,512,000,829	Year 11	2,700,400,891	Year 11	2,888,800,953
		Year 12	2,386,400,787	Year 12	2,565,380,846	Year 12	2,744,360,905
		Year 13	2,267,080,748	Year 13	2,437,111,804	Year 13	2,607,142,860
		Year 14	2,153,726,710	Year 14	2,315,256,214	Year 14	2,476,785,717
		Year 15	2,046,040,375	Year 15	2,199,493,403	Year 15	2,352,946,431
		Year 16	1,943,738,356	Year 16	2,138,112,192	Year 16	2,332,486,027
		Year 17	1,846,551,438	Year 17	2,031,206,582	Year 17	2,215,861,726
		Year 18	1,754,223,866	Year 18	1,929,646,253	Year 18	2,105,068,640
		Year 19	1,666,512,673	Year 19	1,833,163,940	Year 19	1,999,815,208
		Year 20	1,583,187,039	Year 20	1,741,505,743	Year 20	1,899,824,447
		Total damages and losses over 20 years	53,829,446,251	Total damages and losses over 20 years	56,770,209,430	Total damages and losses over 20 years	59,710,972,609
		Annualised average	2,691,472,313	Annualised average	2,838,510,471	Annualised average	2,985,548,630
				*In 2.5% increments every 5 years		*In 5.0% increments every 5 years	

Figure 88 Risk Scenarios of Wakatobi Regency in Monetary Terms (Analysis, 2021).

The summary in Figure 88 shows the damages and losses forecast in three scenarios A, B, and C. Following the recent monetary values calculation for the past ten years (Section 6.2.1), the forecasted monetary values for the next 20 years counts as IDR 53.83 billion with an annual average of IDR 2.69 billion (Scenario A). Scenario B takes into account the increasing level of damages and losses by 10% and by that, the total value elevates to IDR 56.77 billion. The forecasted annual average for Scenario B is IDR 2.84 billion, which takes into account a 2.5% of increments every 5 years. The most extreme scenario, Scenario C, have a 20%

increase of damages and losses from Scenario A, which leads to a higher value of IDR 59.71 billion in total and an annual average of IDR 2.98 trillion, with a 5% increments every 5 years.

7. Risk and Disaster Management Profile of Berau Regency

7.1 Overview of Berau Regency

Berau Regency is located in East Kalimantan Province with the northernmost position, which is directly adjacent to the capital of North Kalimantan Province, namely Bulungan Regency. This has a potential for Berau Regency because it has a strategic role, especially in relation to the distribution and flow of goods and services. Berau Regency has an area of 34,127.17 km2 consisting of land area of 21,951.71 km2 and sea of 11,962.42 km2. If viewed from the area of East Kalimantan Province, the area of Berau Regency is 13.92% of the total area of East Kalimantan, with a percentage of 28.74% of the water area.

Berau Regency, which is one of the oldest districts in East Kalimantan Province. Its territory consists of water and land, therefore, it has abundant natural resources. Berau Regency consists of 13 districts, 10 sub-districts, and 100 villages. 9 out of 13 Districts are areas that have a coastline, namely Kelay, Talisayan, Tabalar, Biduk Biduk, Derawan Island, Maratua, Sambaliung, Batu Putih, and Biatan Districts.

Table 52 Area, number of islands and the number of Villages / Sub-districts in the Coastal Delineation of Berau Regency.

No	District	Area (Km^2)	Percentage of Regency Area	Amount of Island	Amount of Sub-district
1	Tanjung Redeb	24.42	0.07	0	0
2	Sambaliung	2163.37	5.85	0	13
3	Biduk-Biduk	2429.97	6.57	2	6
4	Gunung Tabur	1963.22	5.31	0	10
5	Pulau Derawan	4423.99	11.97	3	5
6	Teluk Bayur	316.98	0.86	0	4
7	Maratua	5616.26	15.19	10	4
8	Tabalar	1837.34	4.97	0	6
9	Biatan	1192.03	3.22	0	8
10	Talisayan	1621.57	4.39	0	10
11	Batu Putih	3575.3	9.67	2	7
TOTAL		**25164.45**	**68.07**	**17**	**73**

Source: Klungkung Berau in Figures 2020, BPS, 2020

This district is the destination area for job seekers from other regions, especially in East Kalimantan. This results in positive population growth every year. In 2019, the population of Berau Regency reached 232,287 people, an increase of 2.55 percent from 2018. The centralization of population settlements in the Berau Regency is concentrated in three sub-districts, namely Tanjung Redeb District, Sambaliung District, and Teluk Bayur District. The area with the largest population is Tanjung Redeb District because it is the capital of Berau Regency which is the center of public facilities and district economic activities. In the districts located on the coast, Sambaliung District is the most densely populated district with a density of 17.03 inhabitants per km^2.

Table 53 Demographic Conditions in the Coastal Delineation of Berau Regency

No	District	Amount of Population	Rate of Population Growth	Percentage of Population	Population Density per km^2	Sex Ratio
1	Tanjung Redeb	69,730	0.36	29.58	22.04	110.26
2	Sambaliung	36,369	4.21	15.43	0.16	117.22
3	Biduk-Biduk	6,432	1.44	2.73	0.12	103.74
4	Gunung Tabur	24,708	4.36	10.48	0.13	120.35
5	Pulau Derawan	11,004	0.74	4.67	0.10	110.60
6	Teluk Bayur	30,144	4.27	12.79	0.75	114.92
7	Maratua	3,531	4.53	1.50	1.01	101.77
8	Tabalar	6,844	3.27	2.90	0.04	112.68
9	Biatan	7,618	4.56	3.23	0.12	114.71
10	Talisayan	13,693	1.79	5.81	0.13	112.66
11	Batu Putih	7,730	2.65	3.28	0.10	113.36
TOTAL		**217,803**	**2.93**	**92.38**	**0.21**	**0.21**

Source: Klungkung Berau in Figures 2020, BPS, 2020

The comparison of the male and female population of Berau Regency can be seen from the sex ratio figures in the picture beside. The gender ratio of Berau Regency in 2019 is 119. From this figure, it can be said that there are 119 male residents among 100 female residents, or in other words, the male population is still more than the female population. The large number of sex ratios is due to the fact that Berau District is one of the destination areas for migrants seeking work in large companies such as mining companies and oil palm companies. In general, these companies require more male workers than women, so that many migrants who come are generally men of productive age.

Based on the direction of the National RTRW, there are Marine Mainstay Areas in Berau Regency which include the Bontang - Berau area and its surroundings with the Leading Sectors of fisheries, mining, and tourism. Based on RTR Kalimantan Island[36], Berau Regency is directed to 1) Management development of

[36] Presidential Regulation of the Republic of Indonesia Number 3 of 2012 concerning the Spatial Plan for the Island of Borneo

marine reserves, marine preserves, and marine tourism parks carried out in Berau Marine Nature Park (Berau Regency); and 2) The maintenance of mangrove forested coastal zone in coastal areas for coastal protection and preservation of marine life is carried out in mangrove forested coastal zone in the Berau Regency coastal areas.

In the RTRW of East Kalimantan Province[37], the policy direction for Berau Regency is in the form of determination: 1) PKW Tanjung Redep, but this area is not a coastal area; 2) PKL or local activity centers and growth centers for surrounding villages and regency industrial centers in Mangkajang; 3) PKL or local activity centers and growth centers for surrounding villages in Tanjung Batu, Talisayan, Sido Bangen; 4) Wildlife Reserve areas located in the Sea of Semama Island 220 Ha in accordance with the KEP. Minister of Agriculture. No. 604 / KPTS / UM / 8/82; 5) Berau Marine Nature Park, in Berau Regency, covering an area of 96,198 hectares in accordance with Government Regulation No. 26 of 2008; 6) Sangalaki Island Marine Park, in Berau Regency, covering an area of 280 hectares in accordance with the KEP. Minister of Agriculture. No. 604 / Kpts / Um / 8/82; and 7) Development Plan for the Allocation of Tourism (per Tourism Object) in the form of Derawan Island Clusters: Berau (Tanjung Redeb Beach, Derawan Island, Sangalaki Island, Semama Island, Kakaban Island and Maratua Island).

These plans were derived from the RTRW of Berau Regency[38], stipulating several protected areas in the coastal areas, which include 1) Semama Island Wildlife Reserve Area; 2) Seagrass area (marine conservation areas) covering an area of approximately 58,593.12 hectares including Maratua District and Derawan Island District; 3) The mangrove forest area covering an area of approximately 317.67 hectares includes Batu Putih District, Biduk-biduk, Derawan Island; 4) Germplasm protection area, namely coral reef protection area covering Derawan Island, Maratua, Batu Putih and Biduk-biduk Districts .; 5) Allocated areas for tourism, marine tourism development include: Derawan Island, Maratua, Biduk-biduk, Batu Putih and Talisayan Districts; 6) The National Strategic Area (KSN) in the form of the Indonesian Maritime Border KSN around the small islands of East Kalimantan covering Maratua Island and Sambit Island; 7) Provincial Strategic Areas (KSP) in the form of Coastal and Marine Areas of the Derawan Islands and its surroundings; as well as the determination of Regency Strategic Areas (KSK) for the importance of environmental support capacity, namely the Coast and Sea of the Derawan Islands, the Marine

[37] East Kalimantan Provincial Regulation Number 01 of 2016 concerning East Kalimantan Provincial Spatial Planning 2016-2036
[38] Berau Regency Regional Regulation Number 9 of 2017 concerning Berau Regency Spatial Planning 2016-2036

Conservation Area of Semama Island and Sangalaki Island and the KSK for the Utilization of natural resources including Kakaban Island; Coastal and Blambangan and Sambit Islands; Coastal and Bilang-bilang Islands and Mataha Island; and the Coasts and Manimbora and Balikukup Islands.

In the division of National Fisheries Management Area, Berau waters are in the WPPNRI 716. Based on the fisheries management plan of WPPNRI 716[39], in general the condition of coral reefs in WPPNRI 716 is still quite good and varied. In Berau waters, 444 hard coral species were found with an additional 63 species requiring further study or about 507 species. Conditions show that the biodiversity in the Berau Marine Protected Area is second only to the Raja Ampat Islands. Seagrass meadows or seagrass beds are found scattered throughout Berau waters with different conditions, with an average cover area of less than 10% to 80%. Eight species of seagrass were identified in the waters of Berau, namely Haloduleunivervis, H. pinifolia, Cyamodocearotundata, Syringodium isoetifolium, Enhalusacoroides, Thalassia hemprichii, Halophilaovat and Halophilaovalis.

In the economic aspect, the sectors that drive the regional economy can be seen from the contribution of these sectors to the Gross Regional Domestic Product (GRDP). Based on data from Berau Regency in Figures 2020 (BPS, 2020), the GRDP value of Berau Regency reached 39 trillion rupiah in 2019, with the most contributing sector being Mining & Excavation. Meanwhile, the combined contribution of the agricultural, forestry, and fisheries business fields is IDR 4 trillion. Meanwhile, looking at the GRDP growth in the last few years based on constant prices, the most densely populated GRDP growth of Berau Regency was 5.55% in 2019, with the highest growth rates sectors are 1) Construction; 2) Electricity and Gas Procurement; 3) Health Services and Social Activities.

[39] Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 83 / KEPMEN-KP / 2016 concerning the Fishery Management Plan for the State Fisheries Management Area of the Republic of Indonesia 716

7.2 Summary of Past Disaster Events in Berau Regency

7.2.1 Past disaster events due to natural hazards and sudden onset in nature

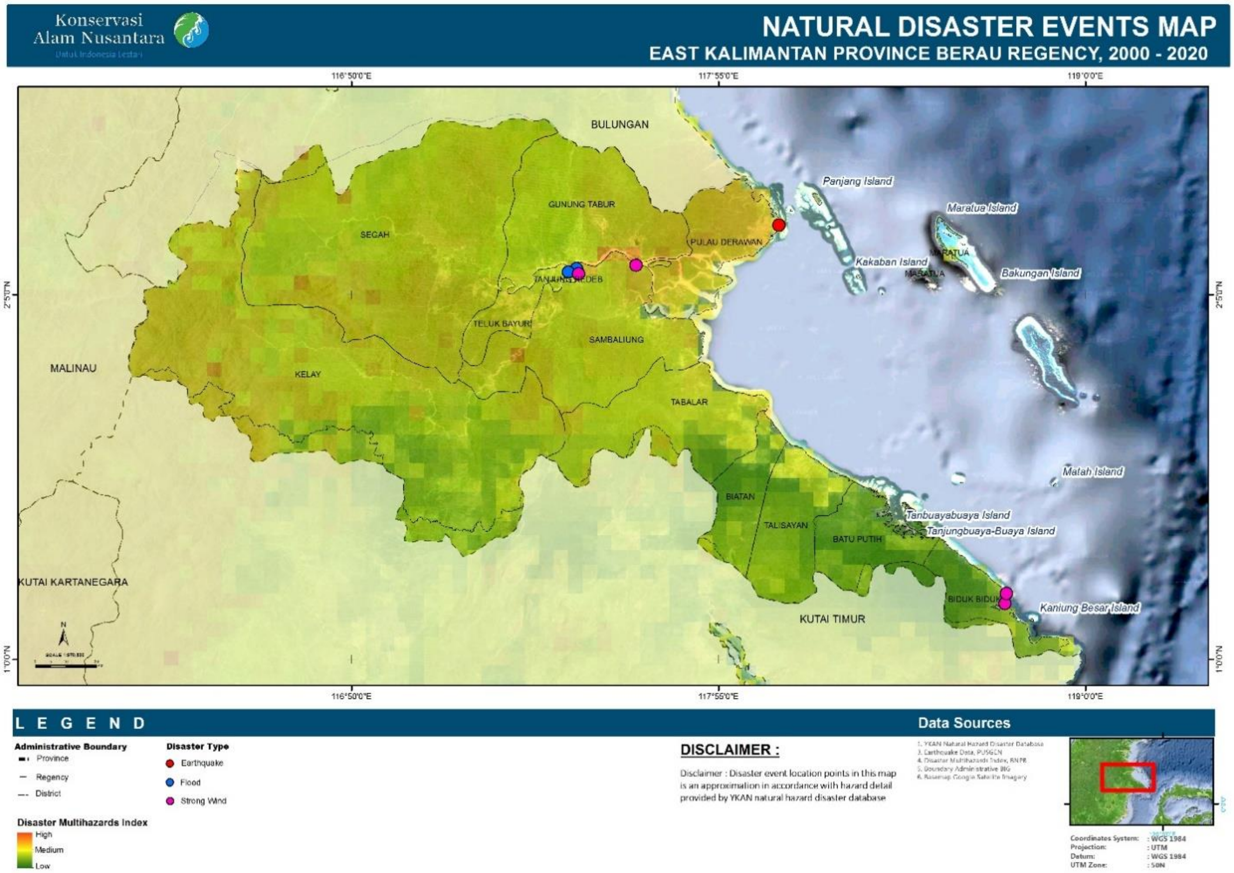


Figure 89 Map of Natural Disaster Events in Map Berau Regency 2000-2020 (Analysis, 2021).

Berau District is threatened by several natural hazards such as earthquakes, tsunamis, floods, ground movements, land-fires and tidal waves / abrasion. The natural disaster events map above (Figure 89) shows the most disaster occurred in the north area around Tanjung Redeb District and surrounding and the rest in around Biduk-Biduk district. According to the records of natural disasters on this study, the coastal area of Berau Regency has a minimum number of seven disasters from 2000-2020. This makes Berau the region with the least natural disaster incidence in this study.

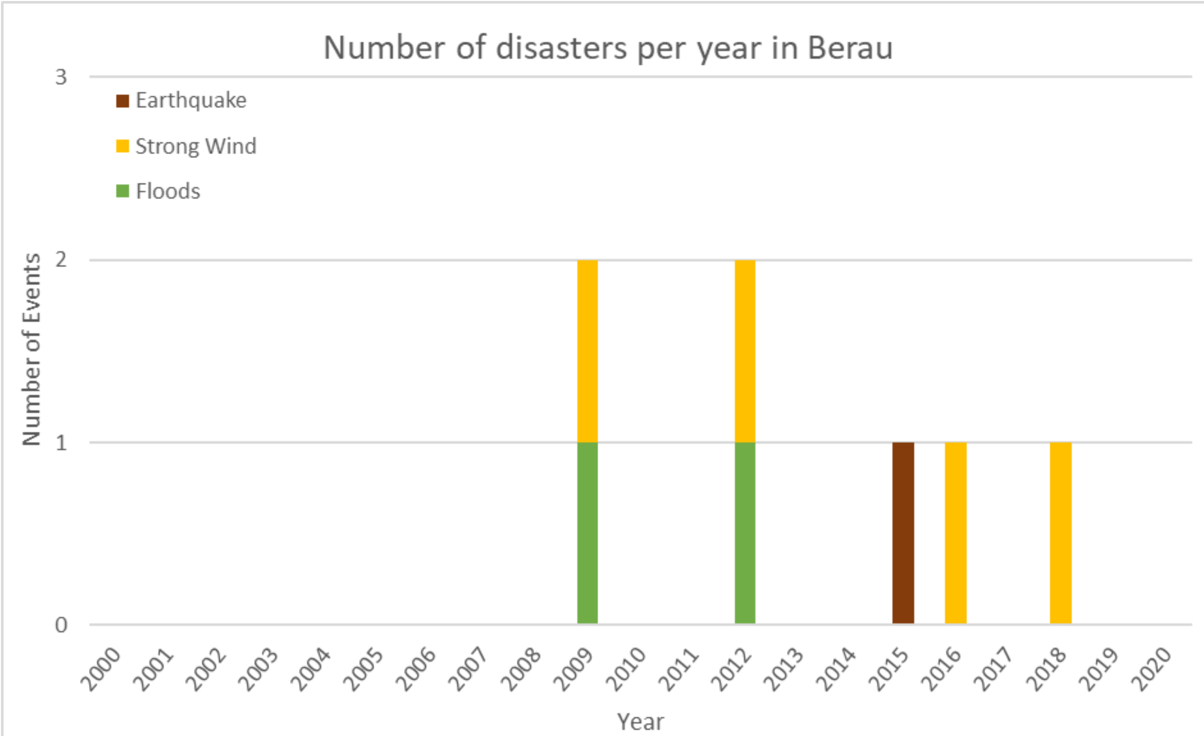


Figure 90 Number of Disasters Due to Natural Hazards in Berau Regency 2000-2020 (Analysis, 2021).

The disaster in Berau Regency seems only existed from the period 2009 to 2019, with the peak of disaster occurred in 2009 and 2012 (Figure 90). The most frequent disaster is strong wind and the second most frequent is flood. Even though Kalimantan is classified as aseismic area, but in this regency, there is an earthquake with III-IV MMI scale and magnitude 6.1. The source was the fault movement in 2015 near North Kalimantan. However, there was no record about the affected people and impacted buildings and infrastructure.

However, Based on Indonesian Risk Disaster Index (IRBI) in 2018 state that this regency categorized as high risk. Indeed, this finding is quite counter-intuitive with the 2018 IRBI so it requires further analysis. There are possibilities that the disaster occurred not well recorded and lack of exposure from the news or another media in the past 20 years of this study period (2000-2020). On the other hand, there is also possibilities that a lot of disaster occurred in the outside of study period.

Table 54 Summary of Impacts of Disaster Due to Natural Hazards s in Berau Regency.

District Name	Frequency Index	Severity Index	Hazard Index
Tanjung Redeb	0.20	0.40	0.28
Sambaliung	0.20	0.20	0.20
Biduk-Biduk	0.20	0.40	0.28
Gunung Tabur	0.20	0.00	0.00
Pulau Derawan	0.20	0.00	0.00
Teluk Bayur	0.20	0.00	0.00
Maratua	0.20	0.00	0.00
Tabalar	0.20	0.00	0.00
Biatan	0.20	0.00	0.00
Talisayan	0.20	0.00	0.00
Batu Putih	0.20	0.00	0.00

Source: Analysis, 2021

This study calculates the hazard index from the index frequency and severity index. The frequency index comes from the past disaster record in the last 20 years (Table 54). All districts possess the same frequency index since the disaster record in this regency is the least ones. On the other hand the severity index is higher in Tanjung Redeb and Biduk-Biduk. The occurred disasters make some impact in those area such as 15 affected people and 86 impacted infrastructures in Tanjung Redeb while in Biduk- Biduk There were 36 affected people and 11 impacted infrastructures. Hence, based on the analysis, as shown in Table 54, Tanjung Redeb and Biduk-Biduk have the highest hazard index in Berau Regency.

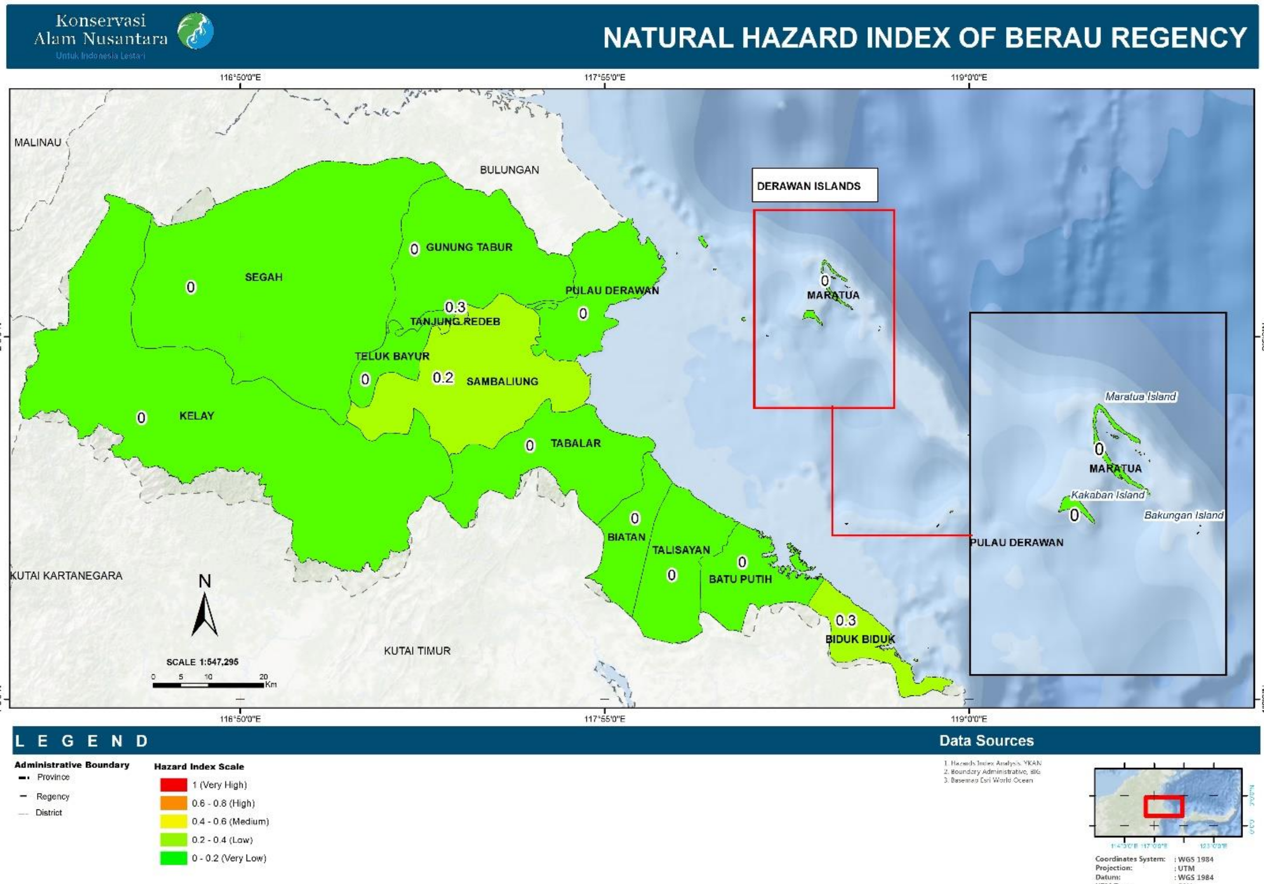


Figure 91 Natural Hazard Index Map of Berau Regency (Analysis, 2021).

The Hazard index is also served in the spatial feature above (Figure 91). Event though Tanjung Redeb is not pexactly placed near the coastal area, still, this area posses the highest hazard index due to its severity. Furthermore Biduk-Biduk is placed exactly in the coastal area and it possesses the same hazard index as Tanjung Redeb. Both districts are classified as low hazard index.

Based on the record of this study, there are hydrometeorological disasters that are influenced by the monsoon factor such as floods and hurricanes that often occurred simultaneously with a heavy rains fall. The economic value from the disaster caused by mentioned disasters are relatively large for the coastal areas. However, without any casualties and minimum displacement, the implication of natural disasters for coastal communities in Berau Regency is relatively small based on the collected data.

Unfortunately, based on the records of the impact of the existing disaster events, the valuation value of the damages and losses is not properly recorded. From the record during the last 20 years, from the whole events, there are 131 in total of affected buildings and infrastructures . The number of affected houses are 74 units and there is also 1 affected school unit and 3 other affected building units. The rests were public facilities and other infrastructures. Hence, The damages and losses estimation from past hazards/stressors was done using the Blue Guide Calculator (The Nature Conservation, 2020) (Figure 92).

Collect and add data on damages and losses from past hazards/stressors over the past ten years.			
HAZARD/STRESSOR 1 (Most damaging)		HAZARD/STRESSOR 2	
List the most damaging hazard/stressor	Strong wind	List the second-most damaging hazard/stressor	Flood
How many times has this occurred over the past ten years?	3.0	How many times has this occurred over the past ten years?	1.0
The annual probability rate (APR) for this hazard is:	0.3	The annual probability rate (APR) for this hazard is:	0.1
What currency will you use for monetary figures?	IDR	What currency will you use for monetary figures?	IDR
Damages (monetary values)		Damages (monetary values)	
Damages to homes	6,000,000,000	Damages to homes	1,050,000,000
Damages to business assets	540,000,000	Damages to business assets	0
Damages to public infrastructure	1,500,000,000	Damages to public infrastructure	0
Other damages (e.g. loss of land from erosion)	0	Other damages (e.g. loss of land from erosion)	0
Total damages	8,040,000,000	Total damages	1,050,000,000
Direct losses (monetary values)		Direct losses (monetary values)	
Losses in produce	0	Losses in produce	0
Losses in income	0	Losses in income	0
Other direct losses	540,000,000	Other direct losses	225,000,000
Total direct losses	540,000,000	Total direct losses	225,000,000
Indirect losses (monetary values)		Indirect losses (monetary values)	
Prolonged losses from produce sales	0	Prolonged losses from produce sales	0
Prolonged income losses	0	Prolonged income losses	0
Other indirect losses	0	Other indirect losses	0
Total indirect losses	0	Total indirect losses	0
Hazard 1: Total damages and losses	8,580,000,000	Hazard 2: Total damages and losses	1,275,000,000
Hazard 1: Annualised damages and losses	2,574,000,000	Hazard 2: Annualised damages and losses	127,500,000
The combined damages and losses from all four hazards/stressors over ten years have been:			9,855,000,000
On an annual basis, the combined damages and losses over ten years have been:			2,701,500,000

Figure 92 Past Damages and loss estimation Berau Regency (Analysis, 2021).

In brief, the most frequent and damaging natural hazards in Berau Regency are strong wind, followed by flood. Over ten years, strong winds give damages and losses estimation of approximately IDR 8.58 billion in total with the annualised value reaches IDR 2.57 billion, while floods were estimated to possess damages and losses of approximately IDR 1.27 billion in total with annualised value of about IDR 127.5 million. Further, the combined damages and losses monetary value from all the hazards/stressors over ten years was calculated to be around IDR 9.85 billion with IDR 2.7 billion calculated in an annual basis.

7.2.2 Past disaster events due to anthropogenic hazards

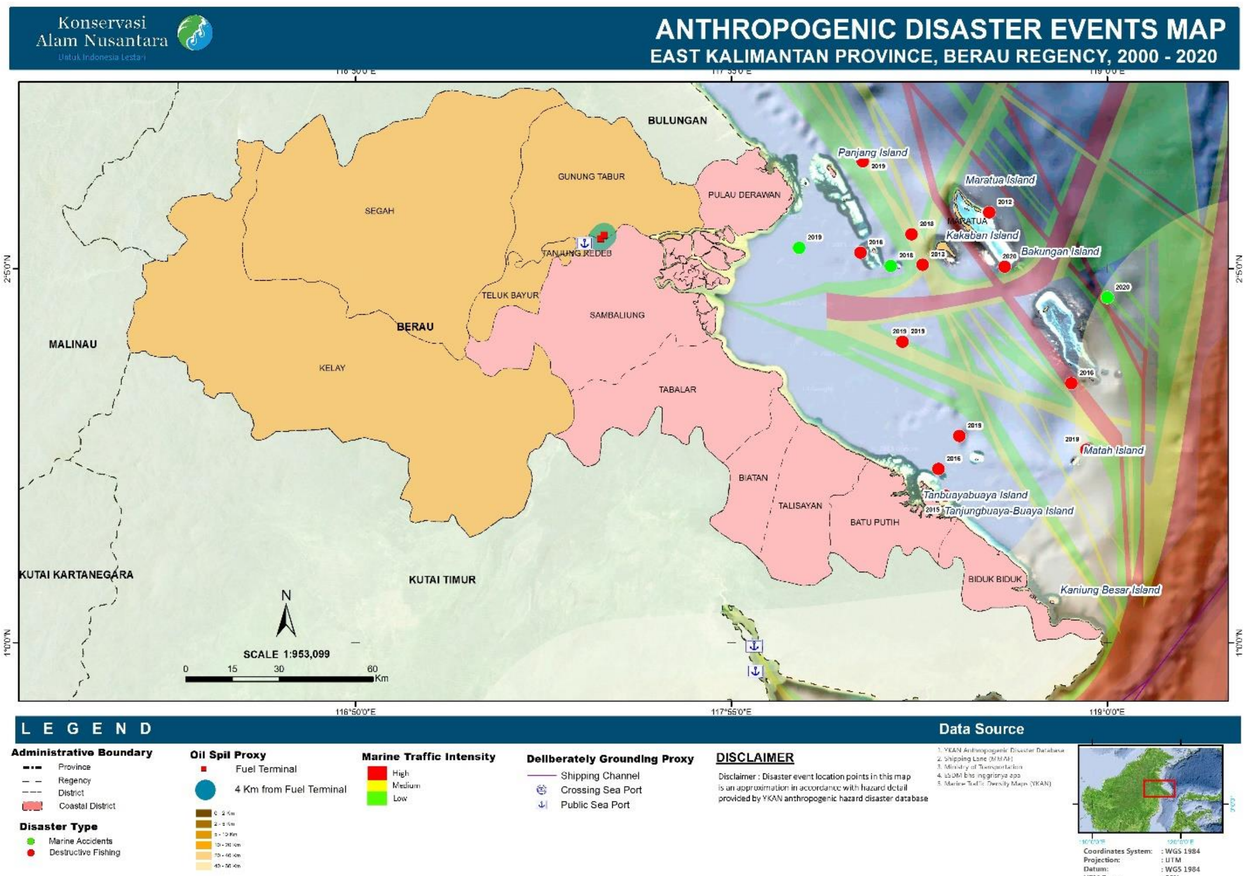


Figure 93 Map of Anthropogenic Disaster Events in Berau Regency 2000-2020 (Analysis, 2021).

In general, the occurred disaster due to anthropogenic hazard in Berau Regency East Kalimantan Province was dominated by destructive fisheries. The map above shows that the anthropogenic disaster events mainly distributes around Maratua island. During the last 20 years, the percentage of destructive fisheries incidents was 76%. There were 13 incidents consisting 9 fish blasting, 3 fish poisoning cases, and 1 trawl fishing case. On the other hand, the number of marine accidents was 24%. There were 2 ship grounding cases and another 2 accidents.

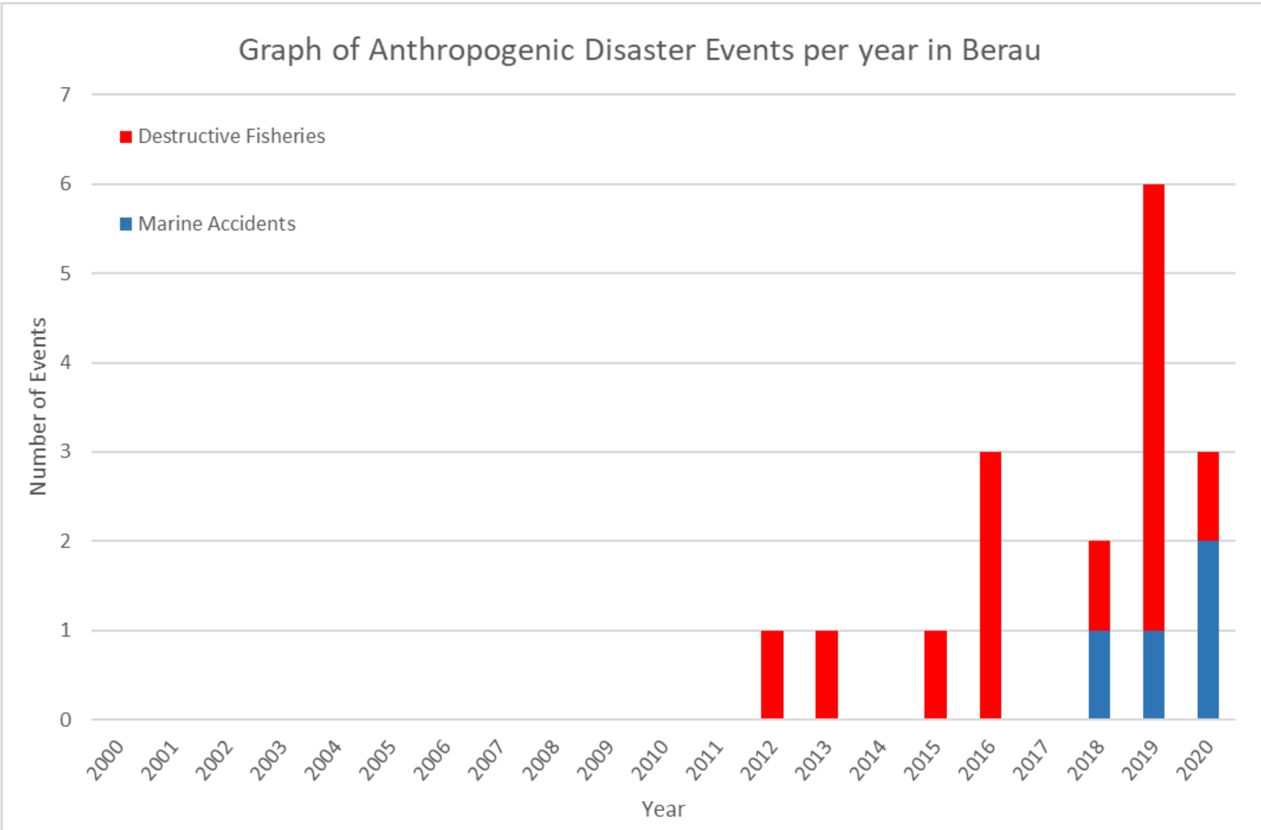


Figure 94 Number of Anthropogenic Disaster Events in Coastal Berau Regency for The Last 20 Years (Analysis, 2021).

The figure above (Figure 94) shows the pattern of the number of disasters due to anthropogenic hazards that occurred in Berau Regency, East Kalimantan Province. The collected data from this study, from 2000 to 2010, there was no record of events. In the period of 2011 – 2020 the event increased to 17 events.

Among the 17 disasters, these disasters have a direct impact on humans in particular to human safety or damage and loss of livelihoods. Apart from direct effect of livelihoods, disasters due to anthropological hazards also have the potential to impact surrounding environment. Based on records, from over the past 20 years, the occurred destructive fishing activities in Berau Regency have the potential to cause the losses in the economic sector seeing from the rampant of illegal fishing that has been occurred.

Over the past 20 years there have been at least nine known cases. This activity causes the increasing of fisheries businesses which jeopardize the health aspects of marine ecosystem. The utilization of the prohibited devices which that potential to damage marine ecosystem becomes one of the frequent cases. The record from this study found several destructive fishing businesses by committing fish blasting to exact eight cases were found as well as one fish poisoning case. The damage of coral reefs also continues to occur even the last known case occurred, in November 2019, some fishermen use fish poisoning fishing method. Then, on January 24, 2018 there were a record state that eight green turtles and two hawksbill turtles died and it was suspected as the result of illegal fishing activities.

Apart from destructive fishing activities, there were also several marine accidents. One person has reported missing, two ship grounded and two ship accident. From the economic aspect, Marine accidents at least cause the loss of important livelihood assets for coastal communities. Although in terms of quantity it is still less than the destructive fishing. Generally marine accidents have a direct impact on humans (loss, damage to ship assets, and ship sinking). Hence, it needs more attention and efforts to reduce these impacts in both avoiding threats and reducing the disaster risk. One of the methods is by using insurance.

Table 55 Anthropogenic Hazard Index of Berau Regency.

District	Destructive Fishing	Marine Accident	Oil Spill	Anthropogenic Hazard Index
Tanjung Redeb	1	0	0	0.11
Sambaliung	0	0	0	0.00
Biduk-Biduk	2	0	0	0.22
Gunung Tabur	0	0	0	0.00
Pulau Derawan	5	2	0	0.89
Teluk Bayur	0	0	0	0.00
Maratua	6	2	0	1.00
Tabalar	0	0	0	0.00
Biatan	0	0	0	0.00
Talisayan	0	0	0	0.00
Batu Putih	1	0	0	0.11

Source: Analysis, 2021.

Parallel to the map of anthropogenic disaster event (Figure 94), Table 55 shows that Maratua district possess the highest Anthropogenic Hazard Index in this regency follow by Pulau Derawan district. Those district geographically are surrounded by sea, with high intensity of marine traffic. Hence, the frequency of events relatively high.

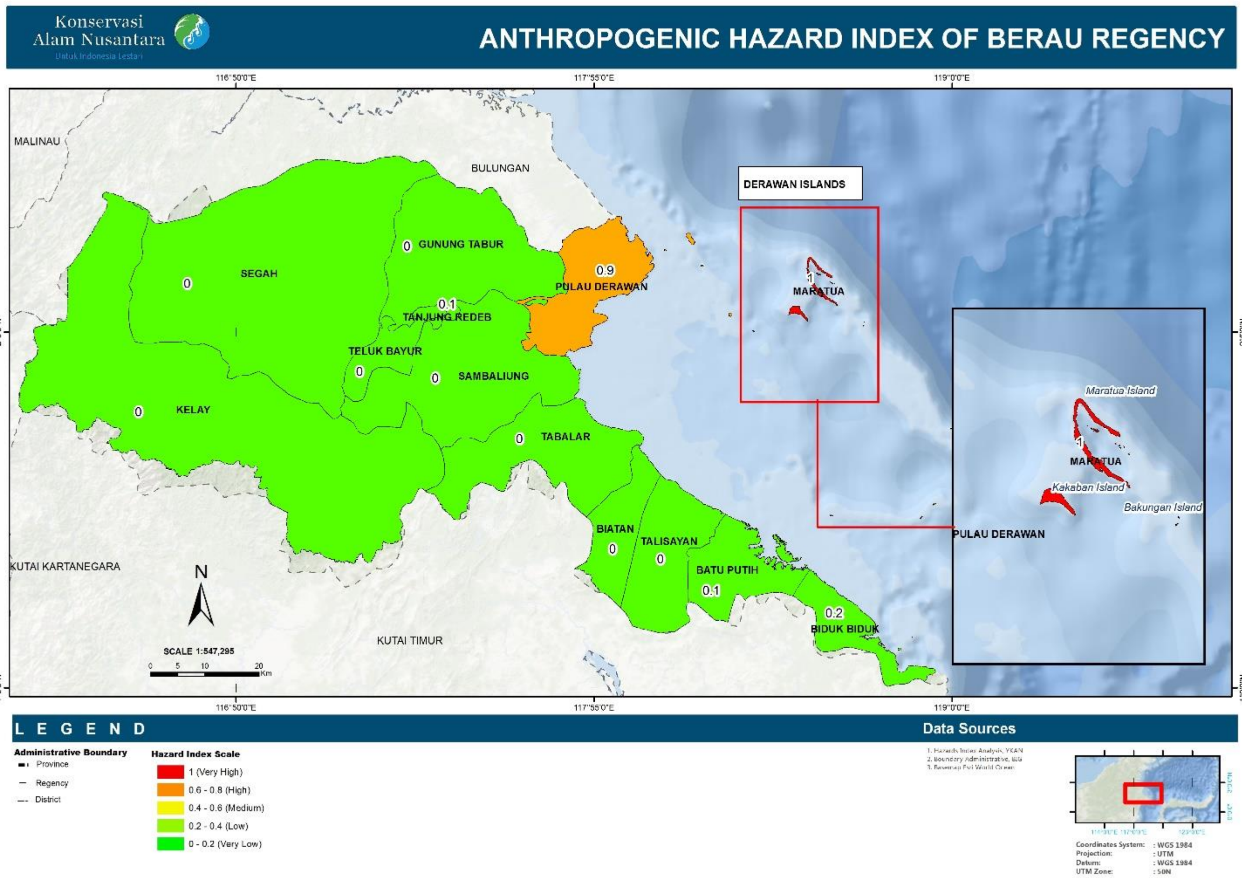


Figure 95 Map of Anthropogenic Hazard Index of Berau Regency (Analysis, 2021).

Figure 95 shows the anthropogenic hazard index in spatial feature. The location of Maratua district and Pulau Derawan district clearly placed in the area of surrounding by sea thus, the disaster due to anthropogenic hazard mainly occurred here. Maratua district is classified as very high hazard index while Pulau Derawan is high hazard index.

7.2.3 Past disaster events due to natural and anthropogenic hazards and slow onset in nature

Berau Regency, East Kalimantan Province has Maratua Island area which has a unique and rich in coastal and marine resources consisting of coral reefs, seagrass beds and mangrove forests. The ecosystem is a natural resource that can benefit people's lives. However, the ecosystem is now in a very worrying condition due to various destructive and extractive activities of the people in order to meet their daily needs. Based on research data by Wiryawan et al. (2017) et al., 2007 coral reef ecosystems in this region have experienced an increase in damage by up to 50% in the last 50 years (P2O LIPI, 2006). The potential of Maratua Island's abundant marine fish resources is widely used in the fishing sector. This sector provides many benefits primarily as a source of public consumption. Fishing activities that are not environmentally friendly have caused damage to the fish resources in this area. This is due to the use of bombs / explosives to catch fish.

The damage to coral reefs in the Derawan Islands is quite alarming. Coral mortality that occurs at all points of Karang Besar location is generally due to pressure in the water area that occurs due to IUU (Illegal, Unreported, Unregulated) Fishing and destructive fishing (Arsyad, 2014). IUU fishing activities are illegal, unreported and unreported fishing activities. The form of IUU Fishing activities that occur is in the form of fishing boats that enter from outside Berau Regency without reporting to the Berau Regency Fisheries Office, without permission or both. Another form of IUU fishing is in the form of irregularities in the use of fishing gear stated in the permit. Destructive capture fisheries are in the form of reef gleaning, the use of poison and explosives, and trawling operations. The monitoring results showed that the percentage for coral mortality was found in all locations, this shows that when the survey team conducted a coral reef data collection, they found that many coral locations were classified as dead or damaged by bombing, operation of fishing gear that was not environmentally friendly and harvesting. and coral mining is generally used as a building material.

This 50% increase in damage indicates that an increase in sea surface temperature could trigger coral bleaching in Berau. With a temperature increase rate of 0.2-0.3 oC, the rate of coral bleaching in a wider area could further increase in the next decade (Sofian 2015). Furthermore, this level of coral damage is also seen in the report from LIPI which states that of the 11 observation points in the Derawan Islands, although there is no complete description of the observation points and their causes and effects, 6 of them have poor coral reef conditions.

Table 56 Status of Coral Reef in Berau Regency

Location	Num of Station	Very Good	Good	Fair	Bad
Derawan Islands (Kalimantan Timur)	11	0	0	5	6

Source: Hadi, et al., 2019.

As this study examined threat from anthropogenic factor as seen in As this study examined threat from anthropogenic factor as seen in Table 17 in section 2.3.5. Threats from anthropogenic factor which could potentially risk coastal ecosystem especially coral reefs are marine activities. With Coastal Population of 94,074 people which mainly reside adjacent to the sea, requires Raja Ampat Regency to support the community with 94 ports, in detail 4 main port (PU) and 90 domestic ports intended for whether fisheries activity or transport activity. The Raja Ampat uniqueness as archipelago regency force this area for having a lot of ports. Hence simultaneously this area has high shipping intensity as well. With those ports the fishing and shipping intensity would be high. This regency has small domestic airports which meets the coastal line thus, the threat becomes medium. This regency has no oil infrastructure. However the existence of oil terminal should be consider since it placed near the coastline. So, it has potential to become as a threat as well. Another anthropogenic threat which could harm the coral reefs is from tourism activity, there are around 99 known hotels in Berau Regency.

Threats from anthropogenic factor which could potentially risk coastal ecosystem especially coral reefs are shipping traffic intensity. With Coastal Population of 217,803 which mainly reside adjacent to the sea, requires Berau regency to support the community with 10 ports, in detail 1 fishing port (PPI) and 9 domestic ports intended for whether fisheries activity or transport activity. With those ports the fishing and shipping intensity is classified as high. This regency has several domestic airports which relatively does not meet with the coastal line. This regency also has oil infrastructure which able to threat the marine ecosystem if there is some accident occurred. Another anthropogenic threat which could harm the coral reefs is from tourism activity, there are around 290 known hotels in Berau Regency.

7.3 Stakeholder Mapping and Local Institutional Capacity of Berau Regency

The main stakeholder for disaster management in Berau Regency is Berau Disaster Management Office (*Badan Penanggulangan Bencana Daerah*/*BPBD*). Annually, Berau Regency must anticipate several types of disasters, namely forest and land fires, floods, landslides, and strong winds. In the disaster management, Berau BPBD coordinates closely with the Berau Resort Police (*Polres*), Berau Military District Command (*Kodim*), and Indonesian Red Cross (*PMI*). Some information was found that these agencies had conducted a Preparedness Rally on November 12, 2020 to anticipate disasters during La Nina. Regency Secretary, Regent, Regional Leaders Cooperative Forum (*Forkopminda*)[40], and East Kalimantan BPBD also attended the preparedness ceremony. Berau BPBD stated that there was a shortage of BPBD personnel, of which from the 150 personnel needed, there are only 80 personnel are in place due to the lack of budget for BPBD in the regency.

In Berau Regency, Derawan Archipelago and its surroundings are designated as a Coastal Conservation Area and Small Islands (KKP3K KDPS) in the Decree of the Minister of Marine Affairs and Fisheries No. 87 of 2016, concerning the Coastal Conservation Area and Small Islands of Derawan Archipelago and its Surrounding Waters in Berau Regency, East Kalimantan Province. This ministerial decree was followed up by the East Kalimantan provincial government by creating the Management and Zoning Plan of the KKP3K KDPS. The preparation of the RPZ KKP3K KDPS involved many stakeholders, including the East Kalimantan Marine and Fisheries Agency, the Faculty of Fisheries and Marine Sciences of UNMUL, TNC, GIZ, and WWF[41]. Previously, the RPZ document draft had been consulted publicly, involving the East Kalimantan Tourism and Culture Agency, the East Kalimantan Communication and Information Agency, the East Kalimantan Forestry Agency, the East Kalimantan Environmental Agency, the East Kalimantan Bappeda. The Ministry of Marine Affairs and Fisheries task force unit, the Pontianak Coastal and Marine Resources Management Agency (BPSPL) is responsible for the formation of a special Local Technical Implementation Unit (*Unit Pelaksana Teknis Daerah/UPTD*) KKP3K KDPS, but the formation of this UPTD has not been implemented. Meanwhile, the KKP3K KDPS management is carried out by the KKP3K KDPS Management Task Team which consists of East Kalimantan DKP and Berau Fisheries Agency, in partnership with the Berau Regency Government, East Kalimantan Provincial Government, Ministry of Marine Affairs and Fisheries, Ministry of Environment and Forestry, German Federal Government (through GIZ), and The Nature Conservancy (TNC/*Yayasan Konservasi Alam Nusantara/YKAN*), YAKOBI, Menapak, YPB, and LEMSA[42]. According to an online meeting with YKAN field officer in Berau, Archipelago Maritime Institution (Lembaga Maritim Nusantara/LEMSA), Indonesia Learning Community (Yayasan Komunitas Belajar Indonesia/YAKOBI), Menapak, Berau Turtles (Yayasan Penyu Berau /YPB), were identified as their NGO partners, along with Bandung Institute of Technology (Institut Teknologi Bandung/ITB), Bogor

[40] See: https://berau.prokal.co/read/news/65105-rapat-koordinasi-bersama-forkopimda.html
[41] See East Kalimantan DKP Official website https://dkp.kaltimprov.go.id/post/rencana-pengelolaan-dan-zonasi-%28rpz%29-kawasan-konservasi-pesisir-dan-pulau-pulau-kecil-kepulauan-derawan
[42] Partner institutions and NGOs are as identified in East Kalimantan Governor Decree no.523.13/k.103/2018

Agricultural Institute (Institut Pertanian Bogor/IPB), Perkumpulan Perisai, Indonesia Tropical Environment Nature Conservation (Konservasi Alam Lingkungan Tropikal Indonesia/KANOPI), Fishers Network (Jaringan Nelayan/JALA), KEHATI Foundation, and Blue Ventures, and Perkumpulan Perisai.

Following the secondary data clarification with YKAN field officer, another collaboration program was identified between KKP3K KDPS Task Team with the East Kalimantan Forestry Agency UPTD, Berau Barat Production Forest Management Unit (*Kesatuan Pengelolaan Hutan Produksi/KPHP*). Meanwhile, Model KPHP in West Berau also established a conservation network consisting of national, provincial, and regency institutions (East Kalimantan BKSDA, B2P2EHD, East Kalimantan Forestry Agency, Berau Forestry Agency, Berau Bappeda, Berau BLH), NGOs including TNC, GIZ, FORCLIME, WWF, Cifor, Bestari, OWT, Menapak, Kanopi, Yakobi, Likos, Mata, Lingkungan, TBI, Bioma, Pinjalin, and other local community groups. FORCLIME-FC is a forest conserservation program initiated by KLHK with funding from KFW and AusAID. The program has many partner implementation NGO and community groups: West Berau KPHP, Pegat Batumbuk Forest Management Institution (Lembaga Pengelola Hutan Desa Kampung Pegat Batumbuk/LPHD), and Demonstration activities in 10 villages. Similar program, Tropical Forest Conservation Act (TFCA), trust fund from collaboration between Indonesia and US government, WWF, YKAN, and KEHATI Foundation also have partnered with local groups, such as JALA, YAKOBI, Menapak.

Apart from Derawan, there are Sangalaki Island Marine Park and Semama Island Wildlife Reserve. This area was also designated as Derawan-Sangalaki National Strategic Tourism Zone (*Kawasan Strategis Pariwisata Nasional/KSPN*) by the Ministry of Tourism and Creative Economy in the National Tourism Masterplan (*RIPPARNAS*) 2010-2025. Unlike the Derawan Islands and its surroundings managed under the Ministry of Marine Affairs and Fisheries, Sangalaki Island Marine Park and Semama Island Wildlife Reserve are managed under the Ministry of Environment and Forestry, through the East Kalimantan UPT BKSDA. Regarding the implementation of the Sangalaki Island Marine Park and Semama Island Wildlife Reserve, it was identified that there was a collaboration between the Ministry of Tourism and Creative Economy and Ministry of Marine and Fisheries, Ministry of Environment and Forestry, Ministry of Transportation, Ministry of Public Works and Housing, East Kalimantan Tourism Agency, East Kalimantan DKP, and East Kalimantan Public Works and Housing Agency.

Economic activities in the mining and plantation sectors are one of the biggest labor absorbers in Berau Regency. However, there are indications that these two activities have caused negative impacts and even some environmental conflicts in Berau Regency. Several news reports indicate coal mining activities of PT. Berau Coal has polluted water and soil in the Lati River which flows directly into Berau Sea close to KKP3K KDPS. Related to PT. Berau Coal, no conflicts were found based on information sources on the internet. Some information actually describes the initiation of PT. Berau Coal to carry out environmentally responsible mining practices and collaborate with several agencies, namely the Dipterocarp Forest Ecosystem Research and Development Center (B2P2EHP) and the Nusa Bahari Foundation[43].

In addition, there are indications that land clearing for oil palm plantations causes high sedimentation which damages the coral reef ecosystem on the Berau coast. It was found that water pollution from oil palm plantation activities enters the river directly and affects the pH of the water which can have fatal consequences to the aquatic ecosystem of Berau Regency. The identified oil palm plantation companies are under the Kuala Lumpur Kepong (KLK) Group[44]. The Regent of Berau and DKLH Berau filed a protest to the Ministry of Environment and Forestry so that the private sector was followed up.

In the stakeholder map for Berau Regency, Distractors were identified, namely coal mining (PT. Berau Coal) and oil palm plantations (Kuala Lumpur Kepong Group). Many provincial and central government agencies have been identified in disaster management and environmental conservation activities in Berau Regency.

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[43] Reported in "*Melalui PKS, B2P2EHD Dukung PT. Nusantara Berau Coal dengan Riset Restorasi Lahan Pasca Tambang Batubara* (MoU on B2P2EHD Support for PT. Nusantara Berau Coal with Post Coal Mining Land Restoration Research)" https://www.forda-mof.org/berita/post/3976

[44] Tribun Kaltim: "*KLK Group Bantah Tudingan Cemari Sungai Segah, Bupati Muharram Ingin Buktikan Melalui Kajian Ilmiah* (KLK Group Denies Accusation of Polluting Sungai Segah, Regent Muharram Wants to Prove It Through Scientific Studies)" https://kaltim.tribunnews.com/2019/12/02/klk-group-bantah-tudingan-cemari-sungai-segah-bupati-muharram-ingin-buktikan-melalui-kajian-ilmiah

Figure 96 Berau Regency Stakeholder Map (Analysis, 2021).

The stakeholder social network in Berau Regency in Figure 97 includes 57 actors and 216 relationships. Among them, there are 2 conflict relationship regarding water pollution which caused fish kill in the river and delta.

In the network, it is shown that actors with the highest degree scores are central government institutions (KKP3K KDPS Task Team) and the province (East Kalimantan Governor and the East Kalimantan Marine and Fisheries Agency), and YKAN. Unlike other regencies, in Berau Regency, the provincial government of East Kalimantan has a more dominant role in the network because the management role of KKP3K KDPS (Derawan Islands conservation area) is mostly coordinated by central and provincial agencies.

In addition, there are only 2 relationships that are categorized as negative and conflicting, namely between oil palm plantation developers (Kuala Lumpur Kepong Group) and KLHK and the Regent of Berau. The issue of water and soil pollution due to coal mining by PT. Berau Coal is not widely mentioned as an environmental issue in online news media, except in one 2009 study (Marganingrum and Noviardi, 2009). In fact, there are indications of cooperation between PT. Berau Coal with B2P2EHD and the Nusa Bahari Foundation in the mining company's Corporate Social Responsibility (CSR) program.

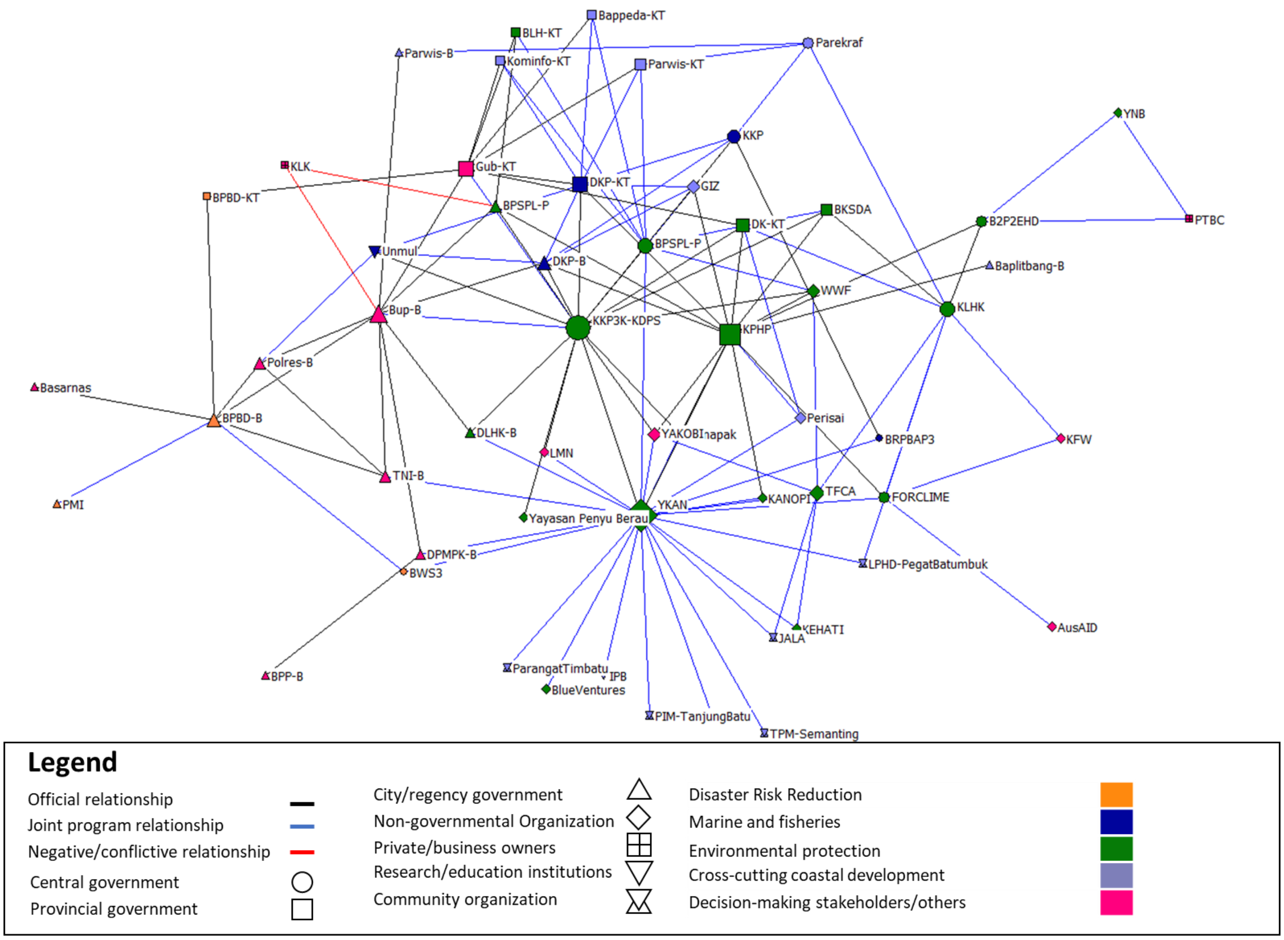


Figure 97 Stakeholder Network Diagraph in Berau Regency (Analysis, 2021).

Furthermore, the table below shows the institutions with the highest degree of centrality and betweenness centrality in Berau Regency, as an initial proxy for the identification of key actors at the location. The value of Degree centrality shows the number of relationships. Meanwhile, the value of Betweenness centrality shows the frequency of one actor between two or more other actors, thus indicating a proxy role as a coordinator.

Table 57 Degree and betweenness centrality values of stakeholders in Berau Regency

Stakeholder	Degree
KKP3K KDPS Task Team	34
West Berau KPHP	29
The Nature Conservancy	27
Berau Regent	22
East Kalimantan Governor	17

Stakeholder	Betweenness
The Nature Conservancy	711.46
West Berau KPHP	298.21
KKP3K KDPS Task Team	243.17
Berau Regent	185.05
Berau LDMO	130.43

East Kalimantan Marine and Fisheries Agency	13	BPSPL Pontianak	115.84

Source: Analysis, 2021

There is very limited information which can be found from secondary sources and internet search for SPDAB capacity assessment in Berau Regency. The available formal plan in Berau are the 2012-2032 Berau Regency Spatial Plan and 2016-2021 Berau Mid-term Development Plan.

There is a type A Disaster Management Office in Berau Regency. According to the latest information found, the Disaster Risk Map was under preparation process in June 2019. There is no further information on whether it is done. There are still no Disaster Management Plan available. Consequently, the spatial and development plans which was established several years before the map was available have not explicitly use the consideration of disaster risk level in the planning process. The National Disaster Management Office (BNPB) have started two pilot Disaster Resilient Villages (Destana) in Berau Regency, Kampung Tumbit Melayu and Sambaliung Village. For further assessment, this study will need primary data and information from local sources.

By using the SPDAB Tool developed by CARI! Team, the final score for Berau Regency is **22.6%** as shown in spiderweb diagram in Figure 98. The 26 measure indicators are divided into 4 pillars, namely: (1) Governance, Policy, and Planning Standard, (2) Preparedness and Socio-Economic Strengthening Service Standard, (3) Critical Infrastructure Protection and Recovery Preparedness Standard, and (4) Disaster Emergency Service Standard. The strongest pillar in Berau Regency is Critical Infrastructure Protection and Recovery Preparedness Standard (3rd Pillar), while the weakest is Governance, Policy, and Planning Standard (1st Pillar). Average score of each Pillar is shown in Table 58.

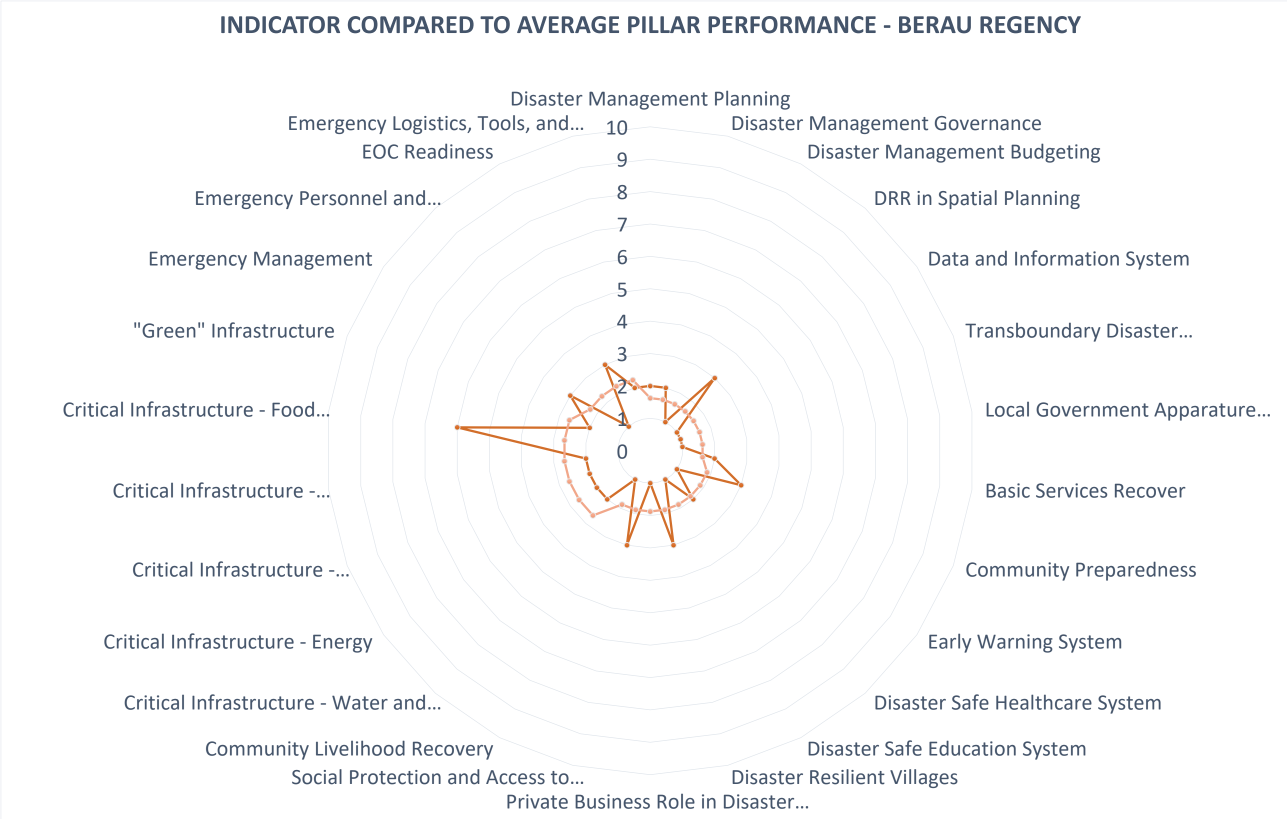


Figure 98 CARI! SPDAB Tool Output Spiderweb Capacity Diagram for Berau Regency (Analysis, 2021).

Table 58 SPDAB Pillar Average Indicator and Final Score in Berau Regency.

SPDAB Pillar	**Average Indicator Score**
PILLAR 1: Governance, Policy, and Planning Standard	1.63
PILLAR 2: Preparedness and Socio-Economic Strengthening Service Standard	1.88
PILLAR 3: Critical Infrastructure Protection and Recovery Preparedness Standard	2.67
PILLAR 4: Disaster Emergency Service Standard	2.25
	Final SPDAB Score = **0.226**

7.4 Risk Profile, Valuation, and Scenario of Berau Regency

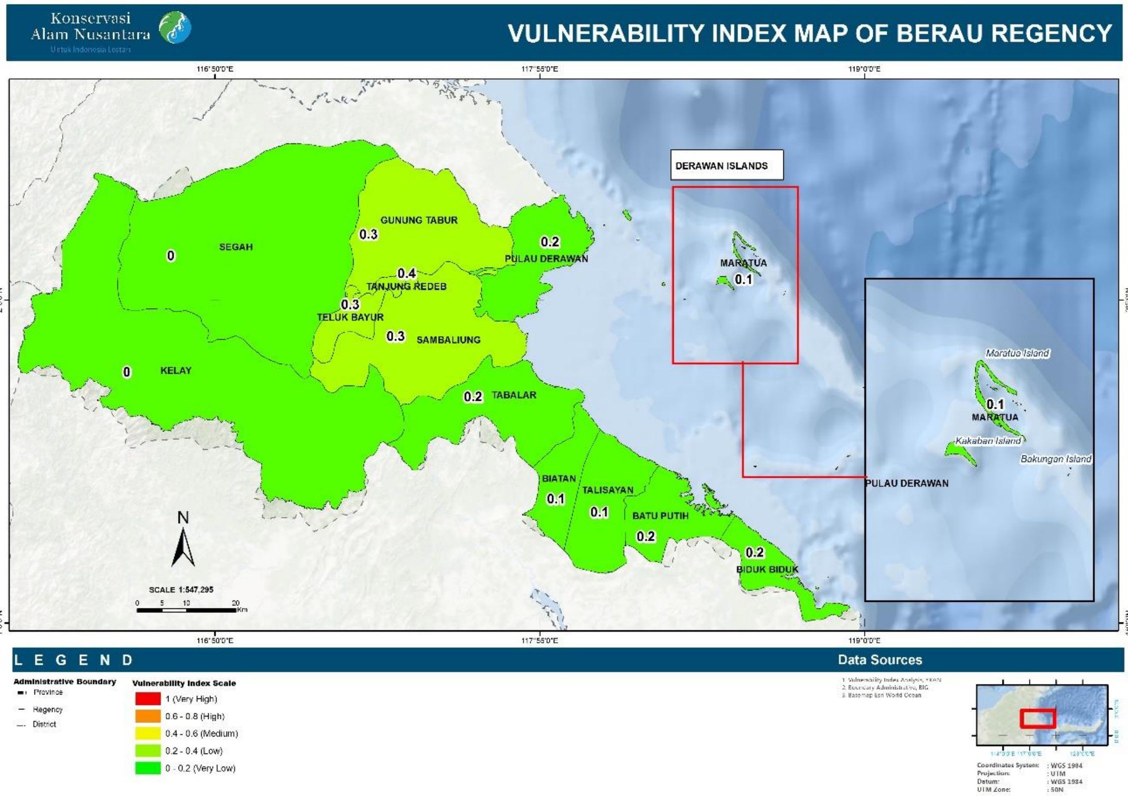


Figure 99 Vulnerability Map of Berau Regency (Analaysis, 2021)

The risk profile is explained based on the risk index which comes from Hazard and Vulnerability. The Vulnerability itself is generated from Exposure, Sensitivity, and Adaptive Capacity.

The vulnerability index in Tanjung Redeb is the highest, 0.435 because this district is the center of the regency.This district has the highest number of population as well as population density, thus it made the sensitivity index higher than the other districts. The population is 69,730 people. The vulnerable age in this district is 20,905 people with a dependency factor of 42.83 %. Even though social factor not the highest one, Tanjung Redeb district has the most physical assets such as houses, education facilities, medical facilities, and critical facilities such as ship port airport and municipal waterworks.

This study adapts the exposure index from Bappenas (2018). The exposure in all districts in Berau Regency are low with the value is 0.2. The reason behind is because this regency placed on the relatively stable coastal area with a sea-level rise under 0.73 mm/ year. The tide rang was >4 m and the mean significant wave height still under 0.75 m.

Table 59 Risk Profile of Berau Regency.

District	Index Hazard	Index Exposure	Index Sensitivity	Adaptive Capacity Index	Index Vulnerability	Risk Index
Tanjung Redeb	0.28	0.20	0.49	0.23	0.43	0.35
Sambaliung	0.20	0.20	0.42	0.23	0.37	0.27
Biduk-Biduk	0.28	0.20	0.24	0.23	0.21	0.24
Gunung Tabur	0.20	0.20	0.37	0.23	0.33	0.26
Pulau Derawan	0.20	0.20	0.23	0.23	0.21	0.20
Teluk Bayur	0.20	0.20	0.35	0.23	0.31	0.25
Maratua	0.20	0.20	0.17	0.23	0.15	0.18
Tabalar	0.20	0.20	0.31	0.23	0.28	0.24
Biatan	0.20	0.20	0.16	0.23	0.14	0.17
Talisayan	0.20	0.20	0.20	0.23	0.18	0.19
Batu Putih	0.20	0.20	0.23	0.23	0.20	0.20

Source: Analysis, 2021.

Risk Index (Table 59) in District Tanjung Redeb and Sambaliung is the highest which are 0.35 and 0.27. Those two districts have relatively higher vulnerability index value event though the hazard index values are not that high. On the other hand the lowest is Biatan 0.17.

The Index value of Berau Regency based on Indonesia Risk Disaster Index (IRBI) for multi-hazard in 2019 is 202.4 which classified as High (BNPB, 2018). This value makes Berau Regency in the first rank and it sit as the highest disaster risk in East Kalimantan Province and rank 34th in Indonesia. There is a contradictive statement between this study and IRBI (BNPB, 2020). The reson is because this study only record the events from the last 20 year (2000-2020). So, there is possibilities there were a lot of events occurred in outside this study period.

Since Kalimantas Island classified as aseismic area, hence it makes this island has the least number of earthquakes events. However, the fault can be triggered any earthquake hazard. There was an earthquake in 2015. Based on this data, this event needs extra attention. The fault movement from north Kalimantan can affect this regency. One of the earthquake sources is the movement of the Tarakan Fault. This regency has potential of tsunami with the 1-2 m height based on Probabilistic Tsunami Hazard Analysis in 500 years return period.

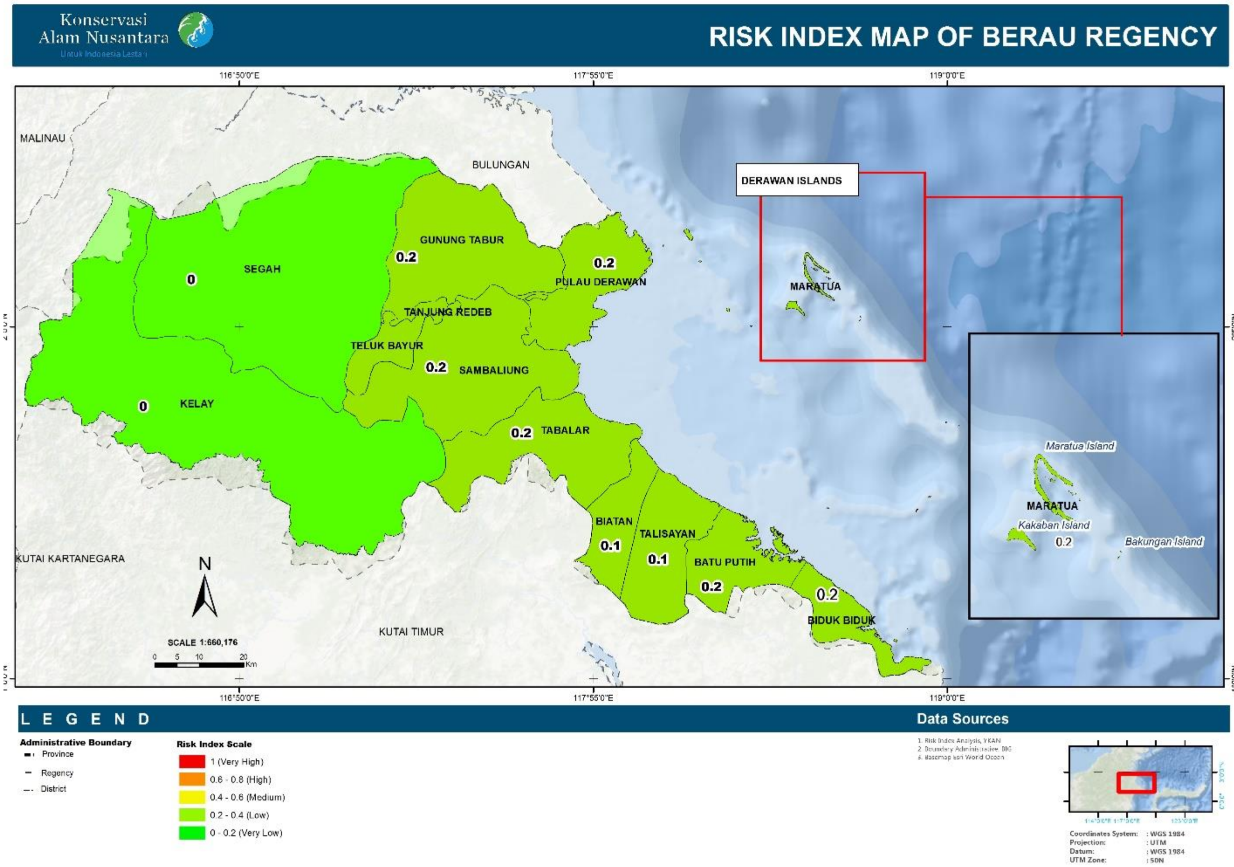


Figure 100 Risk Index Map of Berau Regency (Analysis, 2021)

Tanjung Redeb and Biduk-Biduk have the highest hazard index 0.35, since two hydrometeorological hazards, flood, and strong wind, has occurred in these districts. The strong wind in Biduk-Biduk and floods in Tanjung Redeb impacted 60 houses. However generally, most of districts are classified as low risk (Figure 100).

The anthropogenic hazard comes from destructive fishing in the offshore area. However, the ship grounding not so many compared to the destructive fishing. During the last two decades, there were 13 destructive fishing and 4 ship grounding events. Those even took a place in Pulau Derawan district and Maratua District. For the details please see sub-section 7.2.2.

Approximately 60% of coral reefs in Marine Conservation Zone of Berau Regency have damaged. It happened because of not only from the nature hazard factors but also the fish bombing and fish poisoning (Wihardandi, 2012). In Maratua island the average of dead coral coverage reached 22% because of strong wave and the fish bombing in the past time (Syafrie, 2017). The other problem causing the death pf the coral is the flood. This excessive run-off happens due to the bad practice of land use and it brings excessive sediment as well. The combination of flood and fish bombing gave contribution to 41.6% death o f corals in Derawan Island, Berau Agency (Voogd, Becking, E., & Cleary, 2009); (Turak, 2003). Based on the previous research (Turak, 2003) the bomb craters can be spotted in every 30-50, stretch of the reefs. Another problem is coming from the storm and the problem of climate change. The climate change makes the increasing of se level at the rate of 10 mm/ years while the growth rate of the coral reefs is only 2-4 mm/years. This event make a changes in ecosystem, the solid corals will replace the branch corals since the more deeper habitat, the harder sunlight can infiltrate, and the harder branch coral can life. The less diverse coral type the more harmful to the ecosystem since it breaks the balance which should keep the balance with the erosion and sedimentation (Hantoro, et al., 2009). Generally the damage of the corals in Berau Regency is categorized into three areas. The corals in nearshore area posses threat from the sedimentation. The midshore area is threaten by the blasting, and storm also another factors causing corals bleaching. Moreover, the more off shore area suffers from the threat of oil spills. On the other hand, the sinking ship has the minor role in corals damage (Voogd, Becking, E., & Cleary, 2009)

Accordingly, the risk scenario of Berau Regency in monetary terms is presented in the following figure. The calculations were done using the Blue Guide with inputs from the recorded disaster events and risk profiles of the regency. The approaching scenario forecasts the total damages and losses for the next 20 years with 5% discount rate to reveal a summary figure based on present currency value.

SCENARIOS

Basic approach (simplified)	
Timeframe (years into the future)	20
Discount rate	5%

In the basic approach, the three scenarios are automatically generated based on the data you entered above. Scenario A assumes that the level of damages and losses will remain the same as it was over the past 10 years. Scenario B assumes an increase by 10% (progressive increase by 2.5% every 5 years). Scenario C assumes an increase by 20% (progressive increase by 5.0% every five years). The discount rate of 5% is applied across all three scenarios to reveal a summary figure based on **present currency values**.

	SCENARIO A	SCENARIO B	SCENARIO C
Assumption for this scenario	The level of damages and losses will not change, compared to the past ten years: 0%	The level of damages and losses will progressively increase by*: 10%	The level of damages and losses will progressively increase by*: 20%
Year 1	2,701,500,000	2,769,037,500	2,836,575,000
Year 2	2,566,425,000	2,630,585,625	2,694,746,250
Year 3	2,438,103,750	2,499,056,344	2,560,008,938
Year 4	2,316,198,563	2,374,103,527	2,432,008,491
Year 5	2,200,388,634	2,255,398,350	2,310,408,066
Year 6	2,090,369,203	2,194,887,663	2,299,406,123
Year 7	1,985,850,743	2,085,143,280	2,184,435,817
Year 8	1,886,558,205	1,980,886,116	2,075,214,026
Year 9	1,792,230,295	1,881,841,810	1,971,453,325
Year 10	1,702,618,780	1,787,749,719	1,872,880,658
Year 11	1,617,487,841	1,738,799,429	1,860,111,018
Year 12	1,536,613,449	1,651,859,458	1,767,105,467
Year 13	1,459,782,777	1,569,266,485	1,678,750,193
Year 14	1,386,793,638	1,490,803,161	1,594,812,684
Year 15	1,317,453,956	1,416,263,003	1,515,072,049
Year 16	1,251,581,258	1,376,739,384	1,501,897,510
Year 17	1,189,002,195	1,307,902,415	1,426,802,634
Year 18	1,129,552,086	1,242,507,294	1,355,462,503
Year 19	1,073,074,481	1,180,381,929	1,287,689,378
Year 20	1,019,420,757	1,121,362,833	1,223,304,909
Total damages and losses over 20 years	34,661,005,612	36,554,575,325	38,448,145,037
Annualised average	1,733,050,281	1,827,728,766	1,922,407,252

Scenario B: *In 2.5% increments every 5 years
Scenario C: *In 5.0% increments every 5 years

Figure 101 Risk Scenario of Berau Regency in Monetary terms (Analysis, 2021).

The summary in Figure 101 shows the damages and losses forecast in three scenarios A, B, and C. Following the recent monetary values calculation for the past ten years (Section 7.2.1), the forecasted monetary values for the next 20 years counts as IDR 34.66 billion with an annual average of IDR 1.73 billion (Scenario A). Scenario B takes into account the increasing level of damages and losses by 10% and by that, the total value elevates to IDR 36.55 billion. The forecasted annual average for Scenario B is IDR 1.83 billion, which takes into account a 2.5% of increments every 5 years. The most extreme scenario, Scenario C, have a 20% increase of damages and losses from Scenario A, which leads to a higher value of IDR 38.45 billion in total and an annual average of IDR 1.92 billion, with a 5% increments every 5 years.

8. Risk and Disaster Management Profile of Raja Ampat Regency

8.1 Overview of Raja Ampat Regency

Raja Ampat Regency is an archipelago district consisting of 10 Districts. The area is now divided into 24 Districts into 4 major islands namely Waigeo Island, Batanta, Salawati, and Misool, as well as more than 600 small islands. The center of government is located in Waisai City District, about 70 km from Sorong City. This archipelago has a responsibility an important role as an area directly adjacent to the foreign territories where Fani Island is located at the northernmost tip of the Raja Ampat Islands chain, directly adjacent to the Republic of Palau.

The area of Raja Ampat is 67,379.6 km2, with a total land area of only 7,559.6 km2. The largest area is West Waigeo District with an area of 12.98% of the total area of Raja Ampat and the smallest area is the Tiplol Mayalibit District with only 0.44%.

Table 60 Area, number of islands and the number of Villages / Sub-districts in the Coastal Delineation of Raja Ampat Regency

No	District	Area (Km^2)	Percentage of Regency Area	Number of Island	Number of Sub-district
1	South Misool	170.937	2.29	131	5
2	West Misool	663.001	8.89	109	5
3	Misool	716.036	9.60	60	5
4	Kofiau	210.336	2.82	51	5
5	East Misool	655.531	8.79	373	6
6	Sembilan Islands	17.0148	0.23	22	4
7	North Salawati	500.741	6.72	7	6
8	Central Salawati	250.578	3.36	40	7
9	West Salawati	300.519	4.03	13	4
10	South Batanta	258.608	3.47	3	4
11	North Batanta	216.068	2.90	15	4
12	South Waigeo	183.416	2.46	54	5
13	Teluk Mayalibit	493.305	6.62	32	4
14	Meos Mansar	203.682	2.73	71	4
15	Kota Waisai	109.851	1.47	1	6
16	Tiplol Mayalibit	484.627	6.50	21	9
17	West Waigeo	476.177	6.39	234	5
18	West Waigeo Islands	118.634	1.59	40	6
19	North Waigeo	326.732	4.38	21	6
20	Warwarbomi	388.251	5.21	2	4
21	Supnin	281.392	3.77	11	4
22	Ayau Islands	11.8779	0.16	11	4
23	Ayau	6.3911	0.09	1	5
24	East Waigeo	411.574	5.52	2	4
TOTAL		**7,455.28**	**100**	**1,325**	**121**

Source: Raja Ampat Regency in Figures 2020, BPS, 2020

Most of the population in Raja Ampat Regency live in coastal areas, and most of the villages are coastal villages, as many as 107 villages out of 121 total villages in Raja Ampat Regency. The entire district is a coastal district that has a coastline and is included in the study delineation area. The population of Raja Ampat Regency continues to develop every year. Based on population projection data for 2019, the population of Raja Ampat Regency reaches 93,918 people. Raja Ampat has a population density of around 12.42 people / km2. Ayau District has the largest population density, namely 219.55 people / km2 because Ayau District has the smallest land area of only 5.83 km2 but has a fairly large population of around 1,796 people.

Table 61 Demographic Conditions in the Coastal Delineation of Raja Ampat Regency.

No.	District	Amount of Population	Percentage of Population	Population Density per km^2	Sex Ratio
1	South Misool	6,201	6.59	36.28	110.99
2	West Misool	2,008	2.13	3.03	105.74
3	Misool	3,223	3.43	4.50	116.45
4	Kofiau	3,713	3.95	17.65	114.13
5	East Misool	4,359	4.63	6.65	112.95
6	Sembilan Islands	2,078	2.21	122.13	102.14
7	North Salawati	3,954	4.20	7.90	111.67
8	Central Salawati	3,116	3.31	12.44	117.45
9	West Salawati	1,463	1.56	4.87	109.30
10	South Batanta	2,284	2.43	8.83	117.94
11	North Batanta	2,155	2.29	9.97	120.80
12	South Waigeo	2,814	2.99	15.34	110.16
13	Teluk Mayalibit	1,772	1.88	3.59	112.22
14	Meos Mansar	2,893	3.08	14.20	114.61
15	Kota Waisai	32,499	34.55	295.85	119.38
16	Tiplol Mayalibit	1,491	1.58	3.08	108.24
17	West Waigeo	2,597	2.76	5.45	117.87
18	West Waigeo Islands	3,263	3.47	27.50	110.79
19	North Waigeo	2,554	2.71	7.82	112.30
20	Warwarbomi	2,099	2.23	5.41	121.88
21	Supnin	1,658	1.76	5.89	141.69
22	Ayau Islands	1,796	1.91	151.21	92.54
23	Ayau	1,796	1.91	281.02	106.20
24	East Waigeo	2,288	2.43	5.56	116.46
TOTAL		**94,074**	**100**	**1,056.16**	**115.18**

Source: Raja Ampat Regency in Figures 2020, BPS, 2020

By following the direction of the Papua Island RTR[45], the stipulation of marine conservation areas includes water reserves, marine reserves, wildlife reserves, marine wildlife reserves, marine nature reserves, national parks, marine national parks, nature tourism parks, and marine nature tourism parks. located in Raja Ampat Regency include: a) Nature Reserve of the Raja Ampat Islands and the surrounding sea; b) The Waigeo Islands Nature Reserve in the west and the surrounding sea; c) East Weigo Island Nature Reserve; d) Misool Island Nature Reserve; e) Kofiau Island Nature Reserve.

The waters of Raja Ampat Regency are included in the WPPNRI 715. The direction of the fisheries management plan of the WPPNRI 715[46] covers the waters of Tomini Bay, Maluku Sea, Halmahera Sea, Seram Sea, and Berau Bay. This area includes the Raja Ampat Islands which is the center of the world's biodiversity and the center of the world's coral triangle. The condition of coral reefs in these waters is as much as 60% in good and very good condition. Based on the results of a survey conducted by CI (Conservation International) in collaboration with Cenderawasih University and LIPI in the MRAP (Marine-Rapid Assessment Program) activity in Raja Ampat in 2001, 2,000 species of biota were identified at 45 dive points, 450 species of coral, where 7 species of which have never been found in the world, 950 species of reef fish, 4 species that are new to the world, namely Eviota (a type of gobi), Apogon (2 species of cardinalfish), Hemiscylium (a type of shark), and 600 species of mollusks. In general, the types of seagrass found in Papua are Enhalus acroides, Halodule sp, Halophila sp. Thalassia hemprichi, Cymodoce sp (Hutomo, 1985 in Dahuri et al, 2001).

The results of Manta Tow CI in 2010 around the small islands of Raja Ampat revealed that the types of coral reefs found consisted of fringing reefs and scorched corals (broken reefs with sloping contours to steep (drop off). These islands are white sand beaches, rocky beaches, karst islands, and mangrove beaches. Some have seagrass ecosystems. The percentage of live coral cover ranges from 0-70% with an average cover percentage of 30.97%. dead coral was 15.06%, broken coral was 18.50%, sand was 19.66% and the cover of other biota was 15.80%.

[45] Presidential Regulation No. 57 of 2014 concerning the Papua Island Spatial Plan

[46] Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 82 / KEPMEN-KP / 2016 concerning the Fishery Management Plan for the State Fisheries Management Area of the Republic of Indonesia 715

The waters around the Raja Ampat islands are a place for foraging green turtles (Chelonie mydas) and hawksbill turtles (Eratmachelys imbricata). The waters on several islands are thought to be the spawning areas for groupers. In general, around the islands, it is easy to find giant clams (Tridacna gigas), trumpet snails (Cherania thtonis), goat's head snails (Cassis cornuta), lola (Trocus niioticus), coconut crab (Birgus latro) and dugongs (Dugong dugor). These waters are a crossing place for several types of whales and dolphins.

Several marine conservation areas contained in the WPPNRI 715 are as follows: 1) The Raja Ampat Watershed and Surrounding Seas covering an area of 60,000 ha which is managed by the Ministry of Marine Affairs and Fisheries; 2) Mayalibit Bay Area Water Conservation Area of 53,100 ha managed by the Raja Ampat Regency Government; 3) Dampier Strait Area Water Conservation Area of 303,200 ha which is managed by the Raja Ampat Regency Government; 4) Water Conservation Area of the Kofiau-Boo Islands, covering an area of 170,000 ha which is managed by the Raja Ampat Regency Government; 5) Water Conservation Area of South East Misool, covering an area of 343,200 ha which is managed by the Raja Ampat Regency Government;

Based on the West Papua Province RZWP3K Directives[47], the development directions for the Raja Ampat Regency are:

1. The Raja Ampat Islands Marine Protected Area which is divided into zoning includes:
   a. Core Zone, hereinafter referred to as KKP-ZI-01 to KKP-ZI-05;
   b. Use Zone, hereinafter referred to as KKP-ZP-01 to KKP-ZP-73;
   c. Sustainable Fishery Zone, hereinafter referred to as KKPZPB-01 to KKP-ZPB-79; and
   d. Other Zones, hereinafter referred to as KKP-ZL-01 to KKP-ZL-04.
2. The Nature Reserve of the Raja Ampat Islands and the surrounding sea which is divided into zoning includes:
   a. Core Zone, hereinafter referred to as KKP-ZI-06;
   b. Use Zones, hereinafter referred to as KKP-ZP-74 to KKP-ZP-81; and
   c. Sustainable Fishery Zone, hereinafter referred to as KKPZPB-80 to KKP-ZPB-81;

[47] West Papua Provincial Regulation Number 13 of 2019 concerning the Zoning Plan for Coastal Areas and Small Islands of West Papua Province for 2019-2039

3. The Nature Reserve of the Waigeo Islands in the west and the surrounding sea which is divided into zoning includes;
   a. Core Zone, hereinafter referred to as KKP-ZI-07;
   b. Utilization Zone, hereinafter referred to as KKP-ZP-82 to KKP-ZP-83; and
   c. The Sasi Zone, hereinafter referred to as KKP-S-08.
4. Marine Protected Area in North Misool Area, hereinafter referred to as KKP-12;
5. Certain National Strategic Areas, covering the outermost small islands in West Papua Province, namely Moff Island hereinafter referred to as KSNT-01 in Raja Ampat Regency, and Fani Island hereinafter referred to as KSNT-02 in Raja Ampat Regency

In the economic aspect, the sectors driving the regional economy can be seen from the contribution of these sectors to the Gross Regional Domestic Product (GRDP). Based on data from Raja Ampat Regency in Figures 2020 (BPS, 2020), the value of GRDP in Raja Ampat Regency reached IDR 2.9 trillion in 2019, with the most contributing sectors being Agriculture, Forestry, and Fisheries. Meanwhile, seeing the GRDP growth in the last few years based on constant prices, the densest growth of GDRP in Raja Ampat Regency was 3.92% in 2019, with the sectors has the highest growth rates, namely sectors 1) Electricity and Gas Procurement; 2) Financial Services and Insurance; 3) Information and Communication.

8.2 Summary of Past Disaster Events in Raja Ampat Regency

8.2.1 Past disaster events due to natural hazards and sudden onset in nature

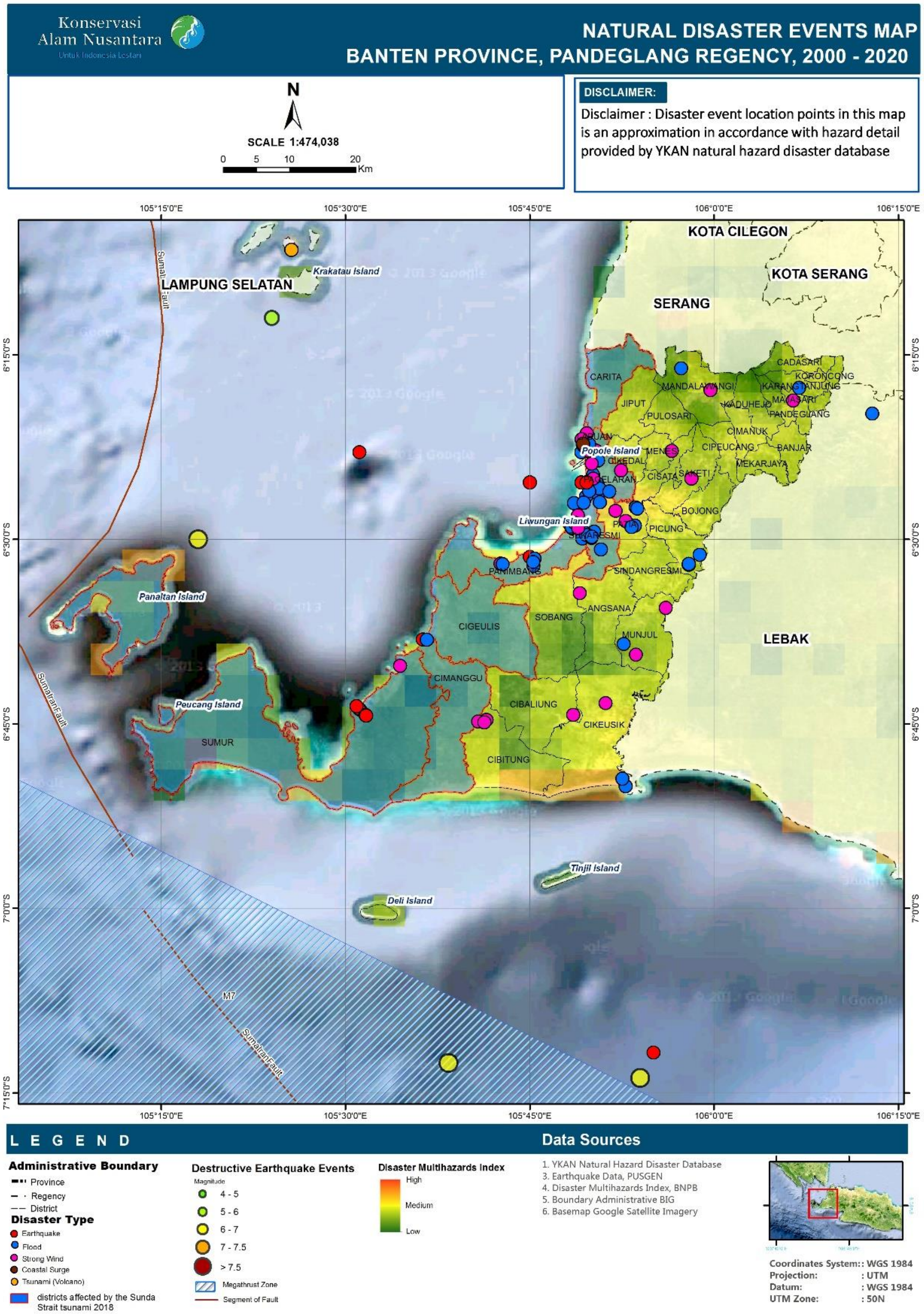


Figure 102 Map of Natural Disaster Events in Raja Ampat Regency 2000-2020 (Analysis, 2021).

The islands of Raja Ampat are generally dominated by hilly areas which are still filled with natural forests. Meanwhile, the coastal areas have various characteristics such as sloping black sand beaches, sloping white sandy beaches with damaged coral reefs that are still virgin, deep beaches and mangrove forests. Waigeo Island, Salawati Island, Batanta Island and Misool Island are non-volcanic islands which are hilly and mostly still covered by dense tropical rainforest. On Waigeo Island, there is Mount Nokh with an altitude of 715 masl. While the small islands scattered among the four islands are in the form of coral islands and non-volcanic islands, these small islands are generally overgrown with coconut plants, shrubs and small trees.

Raja Ampat Regency is threatened by several natural disasters such as tidal waves, tsunamis, land movements, and landslides. Based on this study's, record the disasters are mainly occurred in the middle area and south area of Raja Ampat Regency Figure 102.

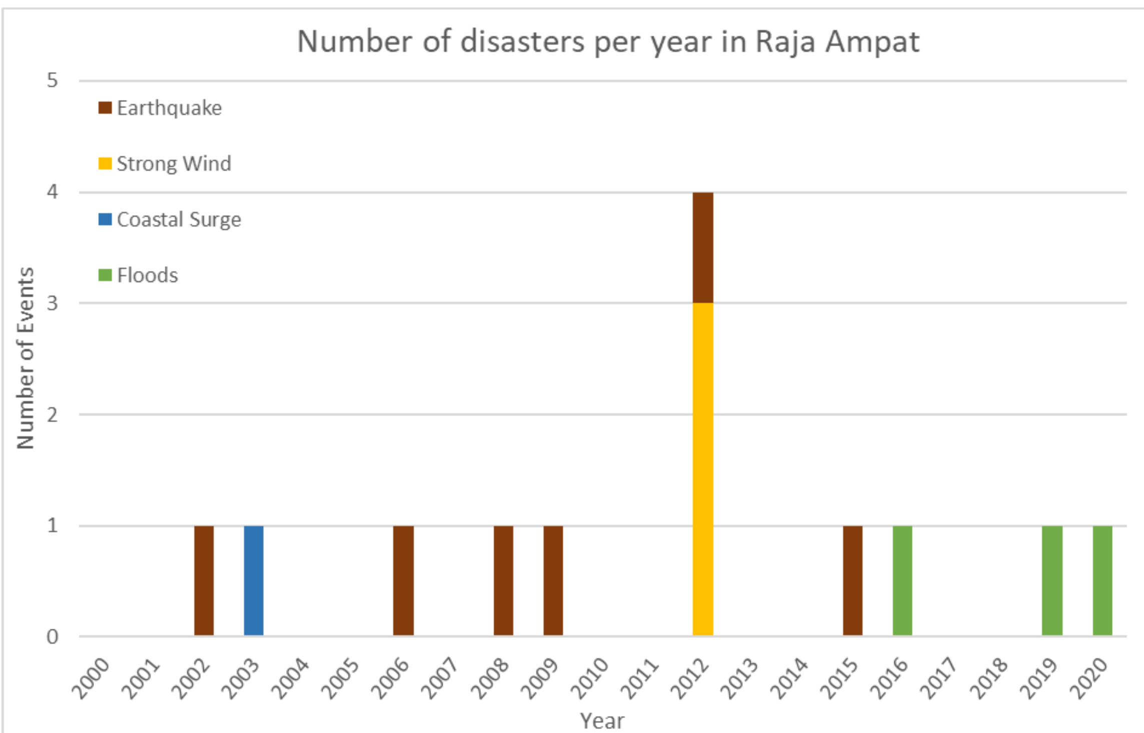


Figure 103 Graphic of natural hazard events in the last 20 years in Raja Ampat Regency (Analysis, 2021).

From tracing disaster events in the past 20 years, the number of recorded disasters is 12 events dominated by hydrometeorological disasters such as floods and hurricanes and tropical cyclones and earthquakes.

During the last 20 years, the most incidence periods were found in the 2009-2013 time period. Other disaster events that can occur in this area are earthquakes that occurred around these islands, totaling 6 events.

Table 62 Hazard index of Raja Ampat Regency

District Name	Frequency Index	Severity Index	Hazard Index
Misool Utara	0.40	0.00	0.00
Kep. Sembilan	0.40	0.00	0.00
Salawati Barat	0.40	0.00	0.00
Salawati Tengah	0.40	0.00	0.00
Bantata Selatan	0.40	0.00	0.00
Waigeo Barat Kepulauan	0.40	0.00	0.00
Meos Mansur	0.40	0.00	0.00
Waigeo Selatan	0.40	0.00	0.00
Waigeo Barat	0.40	0.00	0.00
Tiplol Mayalibit	0.40	0.00	0.00
Waigeo Timur	0.40	0.00	0.00
Warwar Bumi	0.40	0.00	0.00
Waigeo Utara	0.40	0.00	0.00
Supnin	0.40	0.00	0.00
Kepulauan Ayau	0.40	0.00	0.00
Ayau	0.40	0.00	0.00
Teluk Mayalibit	0.40	0.00	0.00
Bantata Utara	0.40	0.60	0.49
Kofiau	0.40	0.00	0.00
Kota Waisai	0.40	1.00	0.63
Misool Barat	0.40	0.00	0.00
Misool Selatan	0.40	0.80	0.57
Misool Timur	0.40	0.60	0.49
Salawati Utara	0.40	0.00	0.00

Source: Analysis, 2021

Based on the hazard index analysis (Table 62). Over all the frequency index value in the whole districts in this regency is the same, 0.40. Hence the severity index has the great role in classifying hazard index value. Kota Waisai possess the highest hazard index, 0.63, due to the highest severity index, 1.00. The severity in this district comes from the high affected people, 6 fatalities and missing, 20 displaced people, and relatively high economic loss, and 230 impacted infrastructures. Hence, Kota Wasai has the highest value of the Hazard Index

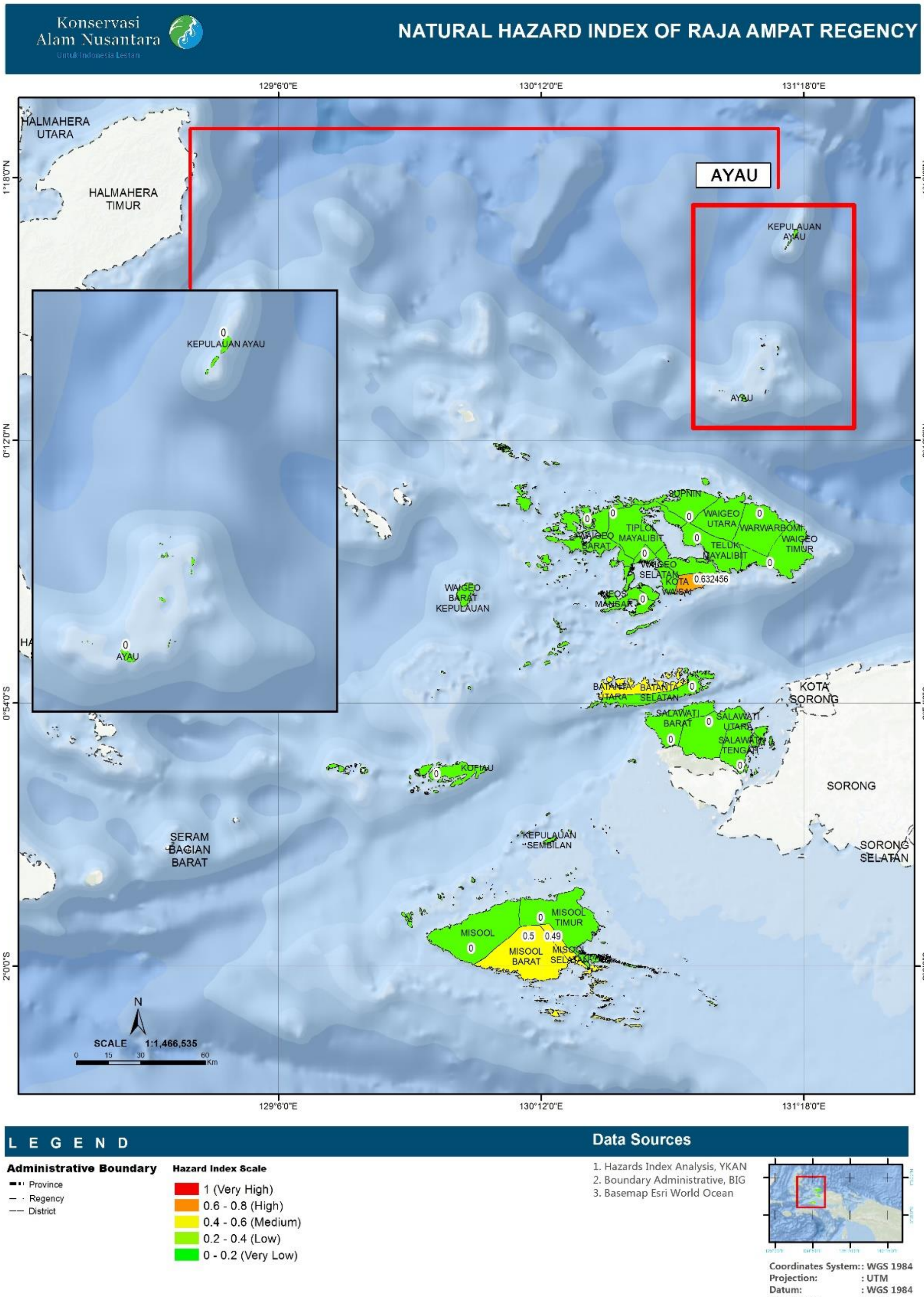
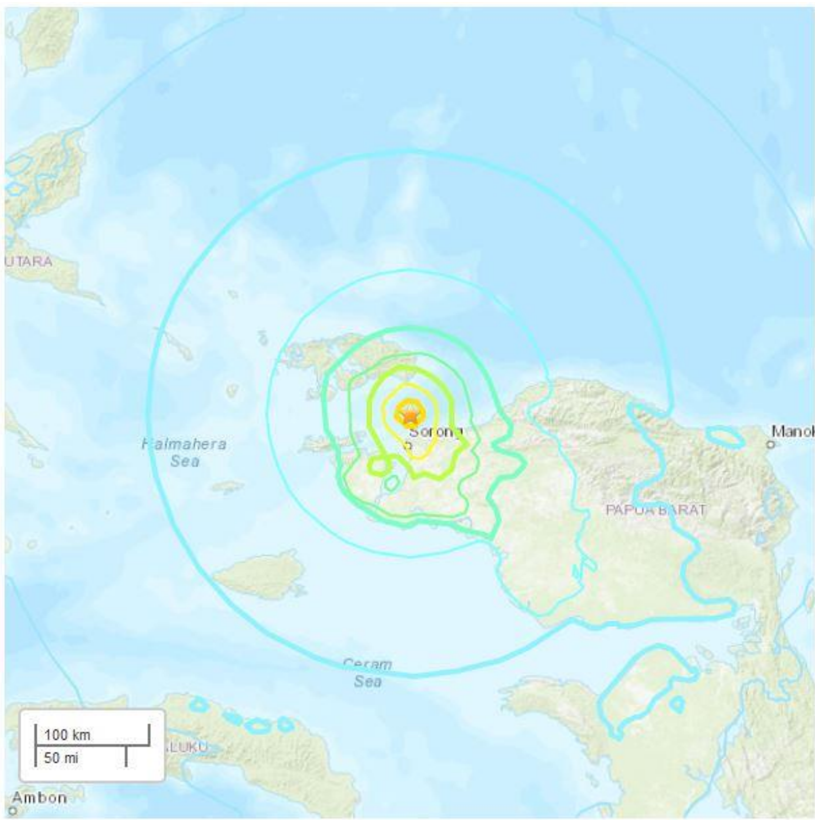


Figure 104 Hazard Index Map of Raja Ampat Regency (Analysis, 2021)

Based on the map above (Figure 104) Kota Waisai district and Misool Barat district are classified as Medium hazard index, while the others are low hazard index.

Among all disaster events due to natural hazard, the worst impact is earthquake which causes the most casualties, displaced people, affected people, and impacted infrastructure and public facilities. Furthermore, Raja Ampat Regency is located in earthquake-prone area, mainly because this area is traversed by the Sorong fault system which protrudes from the northern part of Papua mainland. This fault system placed along the coastline and it crosses Sele Strait and towards the northern part of Salawati Island. This fault has a width abround 10 km. Thus, the occurrence of the earthquakes around these islands causes a significant loss and damages instead of hydrometeorological hazard. As an example the 2015 Sorong's earthquake causing a lot of damages and losses is explained in Figure 105 and Box 4.



SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.0464	0.297	2.76	6.2	11.5	21.5	40.1	74.7	>139
PGV(cm/s)	<0.0215	0.135	1.41	4.65	9.64	20	41.4	85.8	>178
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Worden et al. (2012) Version 1: Processed 2020-06-06T19:40:31Z
△ Seismic Instrument ○ Reported Intensity ★ Epicenter

Figure 105 Seismic Intensity (MMI) during the 2015 Sorong Earthquake (USGS, 2015).

The Sorong's earthquake was occurred due to strike-slip fault activity of Sorong fault. The magnitude was 6.6 SR with the MMI scale of IV – VI in Raja Ampat regency area.

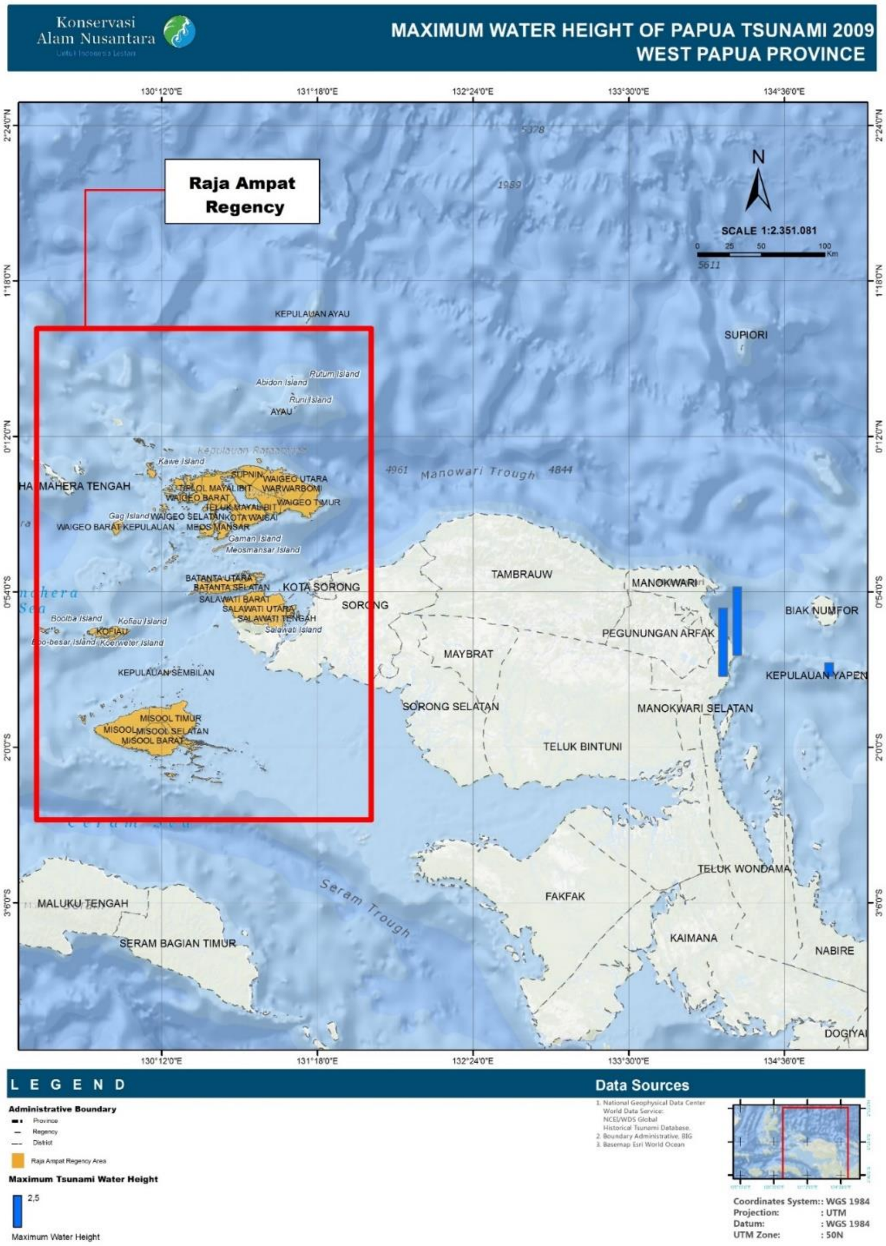


Figure 106 Tsunami in Manokwari, West Papua (Analysis, 2021).

Besides the earthquake Papua still has a threat from tsunami. The proof from the threat occurred in 2009. The earthquake due to thrust fault activity in the northeast of Manokwari. The earthquake generated tsunami with 1-2.5 m wave height.

Unfortunately, based on the records of the impact of the existing disaster events, the valuation value of the damages and losses is not properly recorded. Hence, The damages and losses estimation from past hazards/stressors was done using the Blue Guide Calculator (The Nature Conservation, 2020) (Figure 107).

Collect and add data on damages and losses from past hazards/stressors over the past ten years.			
HAZARD/STRESSOR 1 (Most damaging)		**HAZARD/STRESSOR 2**	
List the most damaging hazard/stressor	Earthquake	List the second-most damaging hazard/stressor	Flood
How many times has this occurred over the past ten years?	6.0	How many times has this occurred over the past ten years?	2.0
The annual probability rate (APR) for this hazard is:	0.6	The annual probability rate (APR) for this hazard is:	0.2
What currency will you use for monetary figures?	IDR	What currency will you use for monetary figures?	IDR
Damages (monetary values)		**Damages (monetary values)**	
Damages to homes	134,400,000,000	Damages to homes	1,950,000,000
Damages to business assets	1,500,000,000	Damages to business assets	0
Damages to public infrastructure	0	Damages to public infrastructure	0
Other damages (e.g. loss of land from erosion)	0	Other damages (e.g. loss of land from erosion)	0
Total damages	135,900,000,000	Total damages	1,950,000,000
Direct losses (monetary values)		**Direct losses (monetary values)**	
Losses in produce	0	Losses in produce	0
Losses in income	0	Losses in income	0
Other direct losses	4,350,000,000	Other direct losses	0
Total direct losses	4,350,000,000	Total direct losses	0
Indirect losses (monetary values)		**Indirect losses (monetary values)**	
Prolonged losses from produce sales	0	Prolonged losses from produce sales	0
Prolonged income losses	0	Prolonged income losses	0
Other indirect losses	39,495,000,000	Other indirect losses	300,000,000
Total indirect losses	39,495,000,000	Total indirect losses	300,000,000
Hazard 1: Total damages and losses	179,745,000,000	Hazard 2: Total damages and losses	2,250,000,000
Hazard 1: Annualised damages and losses	107,847,000,000	Hazard 2: Annualised damages and losses	450,000,000
The combined damages and losses from all four hazards/stressors over ten years have been:			181,995,000,000
On an annual basis, the combined damages and losses over ten years have been:			108,297,000,000

Figure 107 Past Damages and Loss Estimation Raja Ampat Regency (Analysis, 2021).

The damages and losses estimation from past hazards/stressors was done using the Blue Guide Calculator (The Nature Conservation, 2020) and the results were showed in Figure 107. In brief, the most frequent and damaging natural hazards in Raja Ampat Regency are earthquake, followed by flood. Over ten years, earthquakes give damages and losses estimation of approximately IDR 179.75 billion in total with the annualised value reaches IDR 107.85 billion, while floods were estimated to possess damages and losses of approximately IDR 2.25 billion in total with annualised value of about IDR 450 million. Further, the combined damages and losses monetary value from all the hazards/stressors over ten years was calculated to be around IDR 181.99 billion with IDR 108.3 billion calculated in an annual basis.

Box 4: Sorong's Earthquake 2015

A 6.6 SR magnitude earthquake struck Sorong and surrounding area on 24 September 2015. The source of this earthquake was at 31km NE Sorong or 68 km NE Raja Ampat West Papua at depth of 10km. The intensity was IV-V MMI scale and there was no tsunami potential. This earthquake struck Manokwari and Raja Ampat as well. In Raja Ampat the shake effect occurred in 15 seconds. It caused 62 injured, 12,247 affected people, and it impacted 200 houses in Raja Ampat. Everybody in this area felt the shake effect and the houses were damaged, the windows and wall were broken[48, 49,50].

Damages from Sorong's Earthquake September 2015[51,52]

[48]Gempa Sorong Bersifat Merusak https://nasional.tempo.co/read/703885/gempa-sorong-bersifat-merusak
[49] Dozens Injured as Earthquake Jolts Sorong https://jakartaglobe.id/opinion/dozens-injured-earthquake-jolts-sorong/
[50] Gempa 6,8 SR Terasa Kuat 15 Detik di Sorong https://bnpb.go.id/berita/gempa-6-8-sr-terasa-kuat-15-detik-di-sorong
[51] 2015-09-24 Mw 6.6 NEAR N COAST OF PAPUA, INDONESIA https://www.emsc-csem.org/Earthquake/Gallery/?id=461267
[52] Gempa Sorong: Inilah Foto-foto Kerusakan dan Korban https://www.tribunnews.com/regional/2015/09/25/gempa-sorong-inilah-foto-foto-kerusakan-dan-korban

8.2.2 Past disaster events due to anthropogenic hazards

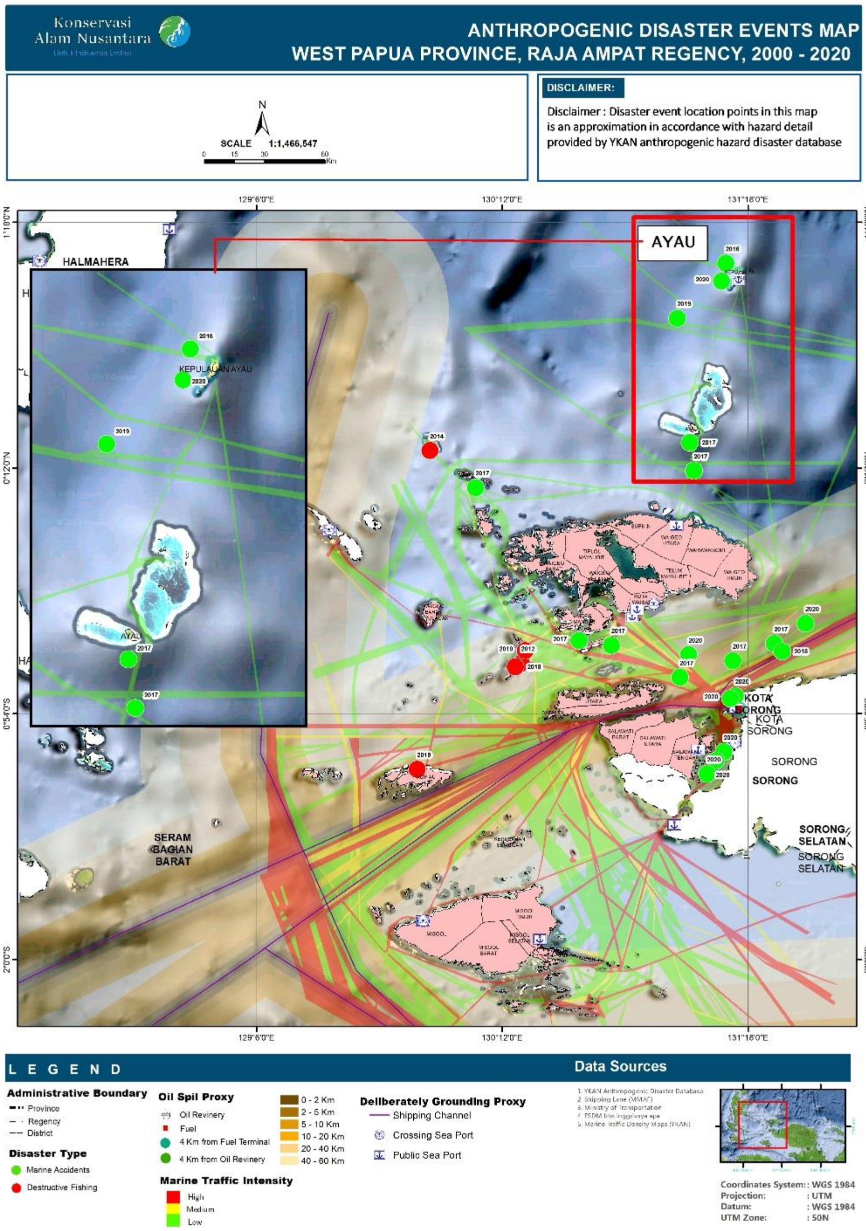


Figure 108 Map of Anthropogenic Disaster Events in Raja Ampat Regency 2000-2020 (Analysis, 2021).

Based on Figure 108, the distribution of anthropogenic disaster events mainly spreading between in Dampier strait. The figure shows that the marine traffic intensity is high. In this place the marine accident is dominating the events. The marine accident spreads to the north part as well. On the other hand, the destructive fishing distributaion spreads in the north-west , middle and south-west area of Raja Ampat regency.

In general, the incidence of disasters due to anthropogenic hazards that occurred in Raja Ampat Regency, West Papua Province was dominated by events related to marine accidents. From the results of tracing the collected data over the last 20 years, the number of destructive fisheries incidents is 24% that in details are 7 events which all of it relating to fish blasting. On the other hand, the number of marine accidents was 76% that in details are 22 events consisting of 4 cases of ship grounding, 2 cases of ship collisions, and 2 cases of ship overturning, 13 cases of damaged ships, and 1 case of mooring.

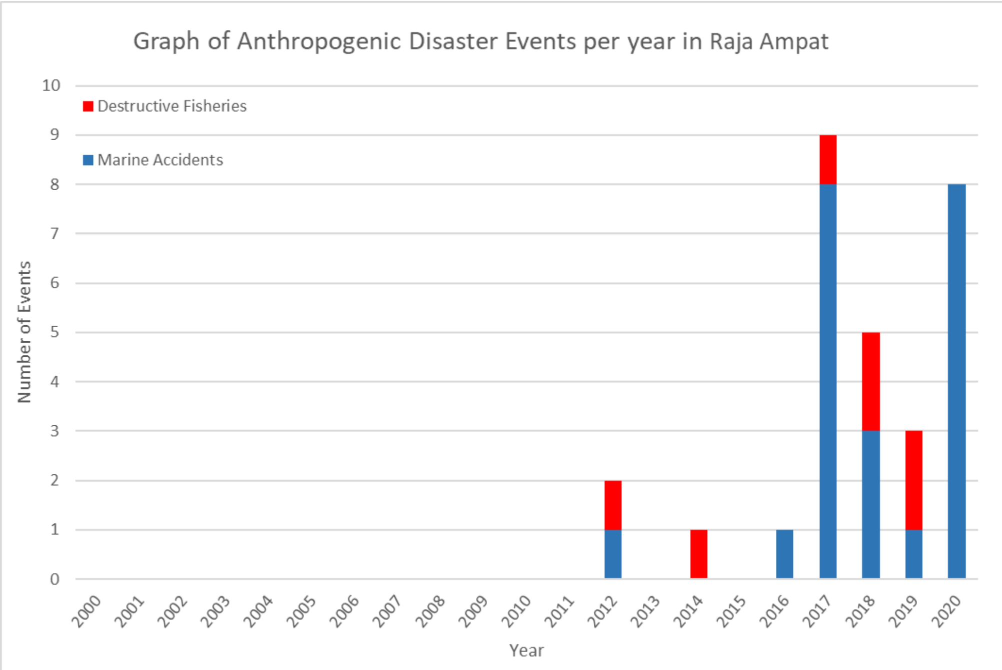


Figure 109 Number of Disaster Antrhropogenic in Coastal RajaAmpat Regency period Last 20 Years (Analysis, 2021).

From the last two decades, the disasters events due to anthropogenic hazards recorded in Raja Ampat mainly were occurred in the second decade of the study period (2011-2020). From 2000 to 2010, there was no record of events. In contrary, in the period 2011 - 2020 it increased to 29 events. The pattern of the number of disasters due to anthropogenic hazards that occurred in Raja Ampat, West Papua Province is shown in Figure 109.

among 29 events, they have a direct impact on people. Generally, it causes threats to human safety or damage and loss of the livelihoods. Apart from directly affecting livelihoods, disasters due to anthropological hazards also have the potential or have an impact on the health of the surrounding environment especially marine ecosystem. Based on this study's records, during the last 20 years, there are still some destructive fishing activity in Raja Ampat Regency. In details, seven cases of fish blasting activities were found. As a result of these activities, Raja Ampat Regency Marine Fisheries Service arrested the perpetrators of the fish blasting with 250 kg of fish as the obtained evidence from the bombing on 14 September 2012. In addition, on 10 December 2017 the police managed to catch a fishing boat carrying 500 ready-to-use fish bomb bottles in Raja Ampat waters.

Apart from destructive fishing activities, there were also sea accidents, which during the period 2000 - 2020 have been found as many as 22 cases. Sea accidents certainly cause loss of important livelihood assets for coastal communities, namely two cases of ship collisions, 2 cases of ship overturning, four cases of drowning, 1 case of mooring and 13 cases of ship damage. The number of records of ship accidents that have been found indicates that the Raja Ampat waters have a threat that is quite dangerous to the environment due to the large number of shipping activities. In addition, there is also a record of the loss of seven people due to sea accidents.

Table 63 Anthropogenic hazard index of Raja Ampat Regency.

District	Destructive Fishing	Marine Accident	Oil Spill	Anthropogenic Hazard Index
Misool Utara	0	0	0	0.00
Kep. Sembilan	0	0	0	0.00
Salawati Barat	0	0	0	0.00
Salawati Tengah	0	0	0	0.00
Bantata Selatan	0	0	0	0.00
Waigeo Barat Kepulauan	0	0	0	0.00
Meosmansar	0	2	0	0.36
Waigeo Selatan	0	1	0	0.18
Waigeo Barat	4	3	0	1.00
Tiplol Mayalibit	0	0	0	0.00
Waigeo Timur	0	5	0	0.90
Warwar Bumi	0	0	0	0.00
Waigeo Utara	0	1	0	0.18
Supnin	0	0	0	0.00
Kepulauan Ayau	0	3	0	0.54
Ayau	0	0	0	0.00
Teluk Mayalibit	0	1	0	0.18
Bantata Utara	0	0	0	0.00
Kofiau	1	0	0	0.11
Kota Waisai	0	0	0	0.00
Misool Barat	1	0	0	0.11
Misool Selatan	0	0	0	0.00
Misool Timur	0	0	0	0.00
Salawati Utara	0	1	0	0.18

Source: Analysis, 2021.

Waigeo Barat district possess the highest index. The highest number of events has occurred in this district. The 2nd highest with 0.9 index is placed on Waigeo Timur due to a lot of ships grounding has been occurred in those districts water.

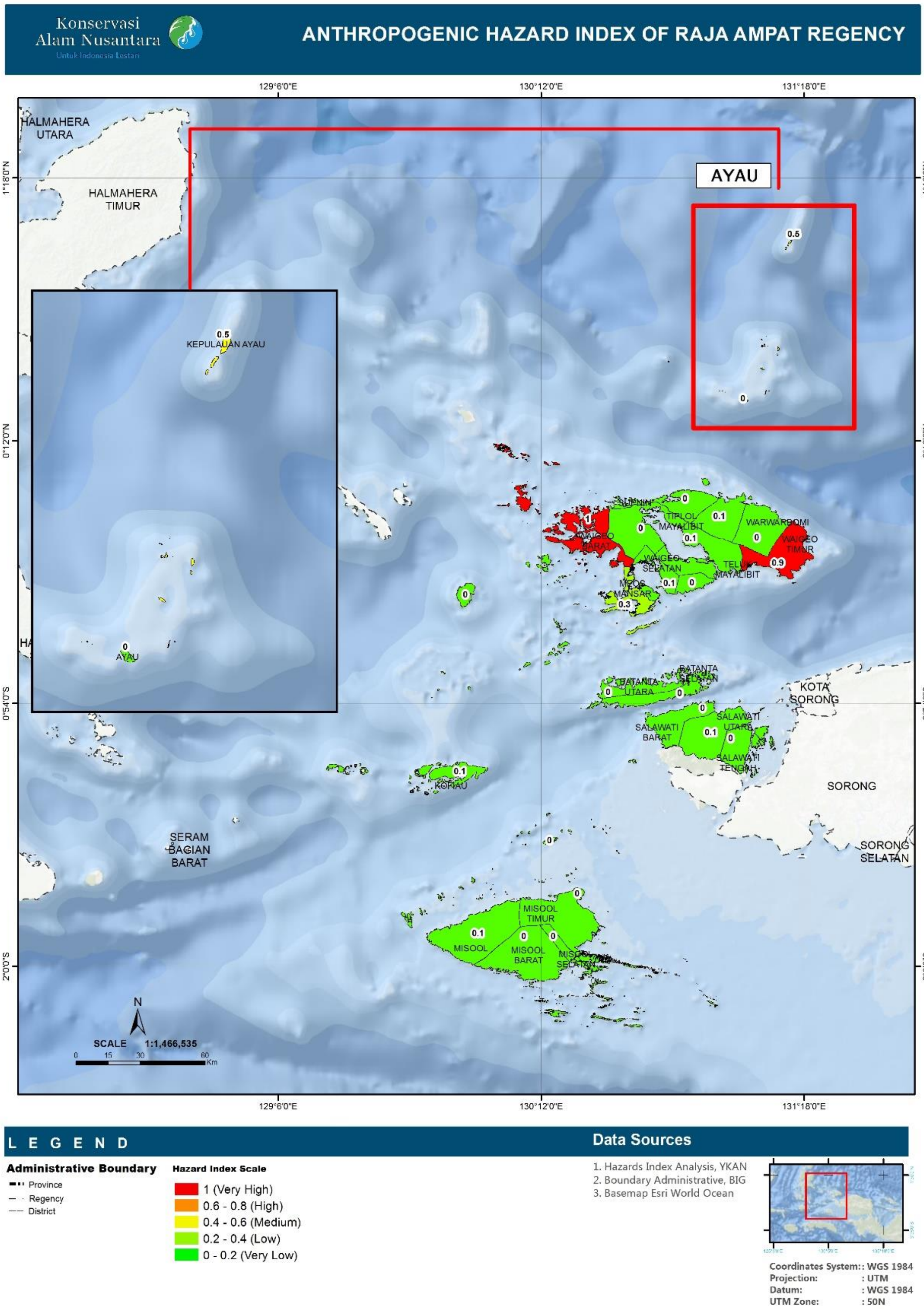


Figure 110 Map of Anthropogenic Hazard Index of Raja Ampat Regency (Analysis, 2021).

Based on the map of Anthropogenic Hazard Index (Figure 110), Waigeo Barat district and Waigeo Timur District are categorized as very high anthropogenic hazard index. Kepulauan Ayau is classified as medium index scale, and Waigeo Barat Kepulauan district is classified as low index. Furthermore, the other area are very low anthropogenic hazard index.

Box 5: Caledonian Sky MV Smashed The Coral Reefs in Raja Ampat

On Saturday, 4 March 2017, British cruise ship, Caledonian Sky Motor Vessel (MV), smashed into the coral reefs in Raja Ampat Island. This ship is 4,200 ton heavy cruise ship carrying 102 passengers and 79 crew members. It happened because the captain did not aware of the low tide. This ship made it's freedom to the deeper sea with the help of the tug boat which made more damage into the reefs even though it got the helps from the nature due to the higher tide[53][54][55].

The ship was grounded in the 5 m sea depth area exactly at 0^{0} 30.992' S and 130^{0} 40.283 E Pulau Kri sea area, Meosmansar district, Dampier Strait. This area is classified as the regional conservation zone of Raja Ampat Islands[56].

The crash destructed around 1,600 ha of coral reefs with the length of 300-400m and 100 m width. The evaluation team said that the company should pay compensation of $1.28 million to $1.92 million for the damages of the marine park [1 2 3 57]. Unfortunately, the researcher (Witomo, et al., 2017) state that the coral reefs will only be able to make its recovery in around 25 years. After the more detail calculation the Witomo et al (2017) conclude that the damage area is 1,8882 ha with the estimated loss around $ 23 million.

[53] https://www.indonesia-investments.com/id/news/todays-headlines/cruise-ship-damages-coral-reef-in-indonesia-s-raja-ampat/item7683

[54] https://www.thejakartapost.com/news/2017/03/13/cruise-ship-smashes-into-coral-in-raja-ampat.html

[55] https://www.independent.co.uk/news/world/asia/british-cruise-ship-crashes-coral-reef-indonesia-papua-raja-ampat-a7629061.html

[56] https://ekonomi.bisnis.com/read/20170315/99/637409/ini-kronologi-mv-caledonian-sky-tabrak-terumbu-karang-di-raja-ampat

[57] https://www.mongabay.co.id/2017/03/15/begini-penampakan-kapal-pesiar-mv-caledonian-sky-yang-merusak-terumbu-karang-raja-ampat/

8.2.3 Past disaster events due to natural and anthropogenic hazards and slow onset in nature

Climate change occurs in all regions evenly in all locations, including in archipelagic areas consisting of scattered islands such as the Raja Ampat Islands. In the waters of the Raja Ampat Regency, coral reefs are generally scattered throughout the Raja Ampat Islands. The largest coral reefs are in the Districts of West Waigeo, South Waigeo, Ayau, Samate and South Misool.

With the influence of the quite large waters of the Pacific Ocean, the Raja Ampat islands have a fairly warm water profile and have a sea surface temperature rise rate of 0.2 - 0.3^{0}C per decade, as can be seen in Figure 10. With the rate of increase in sea surface temperature Thus, the occurrence of coral bleaching at the Raja Ampat location could occur in a fairly large and massive area.

The incidents observed by TNC in 2010, 2011, 2013 and 2015. TNC indicated an alarming rate of coral bleaching in the Raja Ampat area (Donner et al., 2017). Meanwhile, according to an assessment of the status of coral reefs by LIPI, coral reefs in the Raja Ampat islands are generally in fairly good condition. From the observations made by LIPI, coral reefs in the Salawati and Batanta areas have relatively bad conditions, considering that 5 out of 12 observation points have bad conditions. Thus, overall, although there is no indication of cause and effect from the reporting of the condition of the coral reefs and the location of the observation points, the condition of the coral reefs of the Raja Ampat Islands indicates a decrease in environmental quality for the coral reef ecosystem.

Table 64 Status of Coral Reef in Raja Ampat.

Location	Num of Station	Very Good	Good	Fair	Bad
Misool Raja Ampat (Papua Barat)	7	0	1	5	1
KKPN Kab. Raja Ampat (Papua Barat)*	9	0	2	4	3
Selatan Waigeo Kab Raja Ampat (Papua Barat)	7	0	1	4	2
Batang Pele, Kab Raja Ampat (Papua Barat)	5	0	2	3	0
Salawati & Batanta, Kab Raja Ampat (Papua Barat)*	12	0	0	7	5

Source: Hadi, et al., 2019.

As this study examined threat from anthropogenic factor as seen in Table 17 in section 2.3.5. Threats from anthropogenic factor which could potentially risk coastal ecosystem especially coral reefs are marine activities. With Coastal Population of 94,074 people which mainly reside adjacent to the sea, requires Raja Ampat Regency to support the community with 94 ports, in detail 4 main port (PU) and 90 domestic ports intended for whether fisheries activity or transport activity. The Raja Ampat uniqueness as archipelago regency force this area for having a lot of ports. Hence simultaneously this area has high shipping intensity as well. With those ports the fishing and shipping intensity would be high. This regency has small domestic airports which meets the coastal line thus, the threat becomes medium. This regency has no oil infrastructure. However the existence of oil terminal should be consider since it placed near the coastline. So, it has potential to become as a threat as well. Another anthropogenic threat which could harm the coral reefs is from tourism activity, there are around 99 known hotels in Berau Regency.

8.3 Stakeholder Mapping and Local Institutional Capacity of Raja Ampat Regency

Based on the Ministry of Maritime Affairs and Fisheries Decree No. 63/2014 and Raja Ampat Regent Regulation No. 5/2009, there are 8 Marine Protected Areas in Raja Ampat Regency. The areas designated as National Marine Protected Areas (National MPA) are the Raja Ampat Marine Nature Reserve and the surrounding sea, and the West Waigeo Islands and the surrounding sea. Meanwhile, 6 others are Regional Marine Protected Areas (Regional MPA) namely the Ayau-Asia Islands, Sayang-Wayag, Teluk Mayalibit, Dampier Strait, Kofiau-Boo Islands, and South East Misool. The Raja Ampat Work Unit of the National Marine Conservation Area Agency (*Balai Kawasan Konservasi Perairan Nasional/BKKPN*) in Kupang is an agency under the Ministry of Marine Affairs and Fisheries which coordinates the implementation of National MPA supervision in Raja Ampat. In the supervision of marine protection affairs involving law enforcement (for example shipwreck), BKKPN is assisted by Ministry of Environment and Forestry and National Police.

Meanwhile, as the main actor in implementing Regional MPA functions, the Raja Ampat Regency Government established the Regional Technical Implementation Unit for Raja Ampat MPA (*Unit Pelaksana Teknis Daerah-Kawasan Konservasi Perairan/UPTD-KKP*) in Regent Regulation no. 7 of 2011. In this Regent Regulation, there are seven tasks of the UPTD-KKP, namely (1) formulating technical policies, (2) executing, and (3) coordinating relevant agencies in MPA Management, Supervision and Control, (4) preparation of community economic empowerment programs, (5) human resource development, (6) research collaboration, and (7) other tasks assigned by the Regent in accordance with the other 6 tasks.

Since before the formation of the Raja Ampat UPTD-KKP, the Raja Ampat Regency Government has worked closely with several NGOs, namely Conservation International and TNC since 2004, and with Starling Resources since 2010. This collaboration was strengthened in 2017 with the signing of a partnership agreement between BKKPN and CI.

In addition to the establishment of the 2 National MPA and 6 Regional MPA, the Raja Ampat Islands have also been designated by the Ministry of Tourism as a priority National Tourism Strategic Area (*Kawasan Strategis Pariwisata Nasional/KSPN*). The determination of the KSPN was followed up by the development of land and sea transportation structures and other infrastructure, jointly by the Regional Infrastructure Development

Agency of the Ministry of Public Works and Housing and the development of tourist destinations by the Ministry of Creative Economy.

Raja Ampat Regency depends on the marine tourism sector as their main source of income. Therefore, to preserve the marine ecosystem and the sustainability of tourism in Raja Ampat Regency, the Regional Government also imposes Environmental Service and Maintenance Fee to domestic and foreign visitors before entering the Raja Ampat tourist area which is valid for one year. These funds are managed by the Local Public Service Agency for the Local Technical Implementation Unit of Raja Ampat MPA (*Badan Layanan Usaha Daerah/BLUD UPTD*) which was formed in 2015.

In addition, various programs have also been launched by the Central Government related to environmental conservation in Raja Ampat Regency. The national Coral Reef Rehabilitation and Management Program (COREMAP) is a program that has been running since 1998 in Indonesia, supported by funding from the World Bank and the Asian Development Bank. The three phases of the program are rescue efforts in several priority areas for coral reef management, especially in East Nusa Tenggara and West Papua. This program penetrated into Raja Ampat Regency in phase II which began in 2004 and phase III which was just released in 2020. In COREMAP phase II, LIPI became the main implementation agency using a data-based approach. COREMAP Phase III has just been inaugurated to start on November 13, 2020.

In COREMAP phase III, also known as the COREMAP-CTI program, BAPPENAS became the main implementing agency with a grant donor of US $ 6.2 million from the Global Environmental Facility (GEF) managed by the World Bank implemented through the Indonesia Climate Change Trust Fund (ICCTF). The program, which consists of six activity packages, collaborates with various partners in the implementation of each activity package carried out in Raja Ampat and the Savu Sea. The partners involved in the activity packages in Raja Ampat Regency are as follows:

1. Sustainable Use of Marine Protected Areas (MPAs) by Communities in Raja Ampat (Implementing Partner: Indonesian Coral Reef Foundation (*Yayasan Terumbu Karang Indonesia/Terangi*)
2. Implementation of the National Plan of Action (NPOA) for Threatened Species in Raja Ampat and Savu Sea (Implementing Partner: Reef Check Indonesia)
3. Implementation Support for Integrated Coastal Zone Management (ICZM) in Raja Ampat (Implementing Partner: Center for Coastal and Ocean Resources Studies-Bogor Agricultural University (*Pusat Kajian Sumberdaya Pesisir dan Kelautan Institut Pertanian Bandung/PKSPL-IPB*)
4. Support for Community Monitoring Groups in Raja Ampat and the Savu Sea (Implementing Partners: Terangi)

5. Access to Fisheries Resources Management Areas for Local Communities in Raja Ampat and Savu Sea (Implementing Partners: Indonesian Environmental Information Center (*Pusat Informasi Lingkungan Indonesia/PILI*)

Before the existence of various interventions from government and other non-governmental organizations, efforts to conserve aquatic ecosystems have been a hereditary culture in indigenous communities in Maluku and Papua, including Raja Ampat. Sasi is an activity to close and open marine resource extraction activities at certain times that have been mutually determined. Sasi is currently run under village heads, the Maya Tribal Council, and the Raja Ampat Klasis of the Evangelical Christian Church. In recent years, government agencies such as UPTD-KKP and NGOs such as TNC have collaborated with the community in conducting sasi, such as by providing information on research results to increase the effectiveness of opening and closing times.

In addition, there are many NGOs with conservation goals in Raja Ampat Regency. Bird's Head Seascape Initiative (BHS) is an NGO that was founded from the synergy of several international NGOs (CI, TNC, and the World Wildlife Fund/WWF) with a focus on protecting marine and fisheries ecosystems in the Marine Protected Area network in West Papua. BHS collaborates with many agencies, including 30 NGOs, local governments, research agencies, and local communities to carry out integrated marine resource management. Various other NGOs were also found to have various conservation programs in Raja Ampat Regency, namely the Raja Ampat Research and Conservation Center (RARCC), Kayak4Conservation, Papua Diving, Raja Ampat Dive Resort Association (RADRA), Conservation Footprint Foundation, and the Raja Ampat Sea Center.

The number of tourism activities such as diving cruises and liveaboard in Raja Ampat Regency creates the risk of damage to the coral reef ecosystem. Several foreign-owned cruise ships reportedly sank in the Raja Ampat sea (Aqua Blu, MV Caledonian Sky), particularly in the National MPAs which caused significant damage to coral reefs in protected areas. The shipwreck was strictly processed by the Ministry of Environment and Forestry. Regarding the MV Caledonian Sky shipwreck, the government is reported to have arranged for compensation to the ship insurance company SPICA Service Indonesia in 2017.

Disaster management is a sector that has not been given much attention in Raja Ampat Regency. Although a Type A Raja Ampat Local Disaster Management Office (BPBD) has been established in Raja Ampat Regency, disaster management institutions are not very integrated with other sectors. In addition, there was a case of corruption in Raja Ampat BPBD funds by 8 individuals in 2014, which process took up to 6 years. Several agencies collaborating in disaster management in Raja Ampat Regency are the Raja Ampat Civil Service Police Unit (*Satpol PP*), the Raja Ampat Army, a Class III Geophysical Station in Sorong, and the Raja Ampat Police.

The table below is a summary of stakeholders in disaster management and environmental and coastal management in Raja Ampat Regency.

In the stakeholder matrix of Raja Ampat Regency in Figure 111 below, the Raja Ampat Regent is categorized as a veto actor. Based on information sources obtained online, the Raja Ampat Regent's participation rarely appears in news related to disaster management and environmental conservation. This indicates both the lack of interest and inactivity of the Raja Ampat Regent on these two issues. The driving actors who are active in initiating various important environmental conservation programs in Raja Ampat Regency are government agencies at the national level (BKKPN, BAPPENAS, LIPI, and KLHK), while partner and supporting actors are foreign and international NGOs involved in various programs.

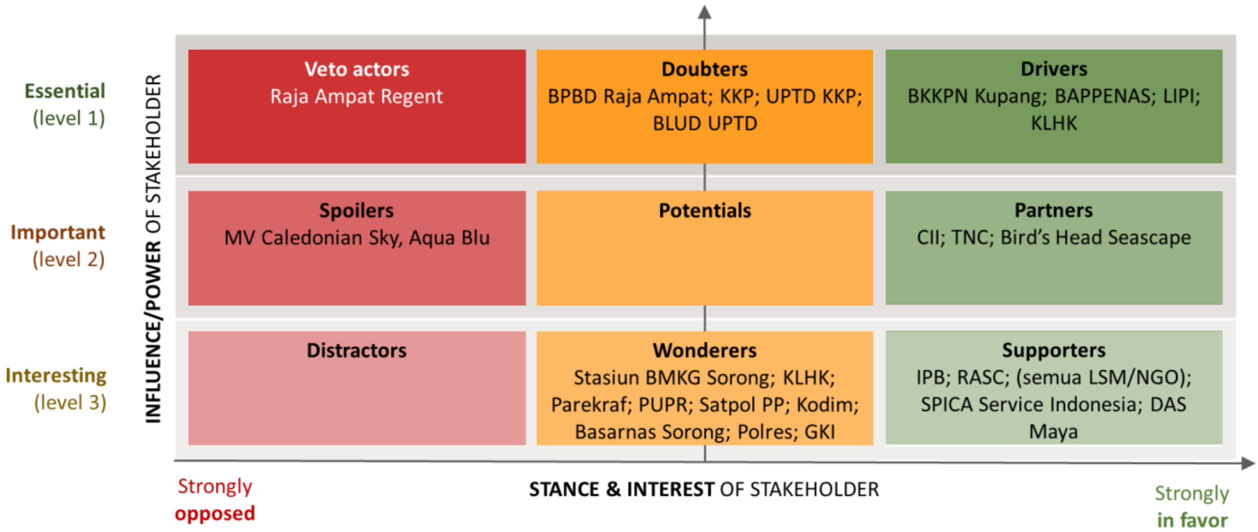


Figure 111 Raja Ampat Regency Stakeholder Map (Analysis, 2021).

In the stakeholder network of Raja Ampat Regency, which can be found in Figure 112, there are 53 actors and 174 identified relationships, including formal coordination based on regulations, availability of joint programs within the past 5 years, and conflict relationships.

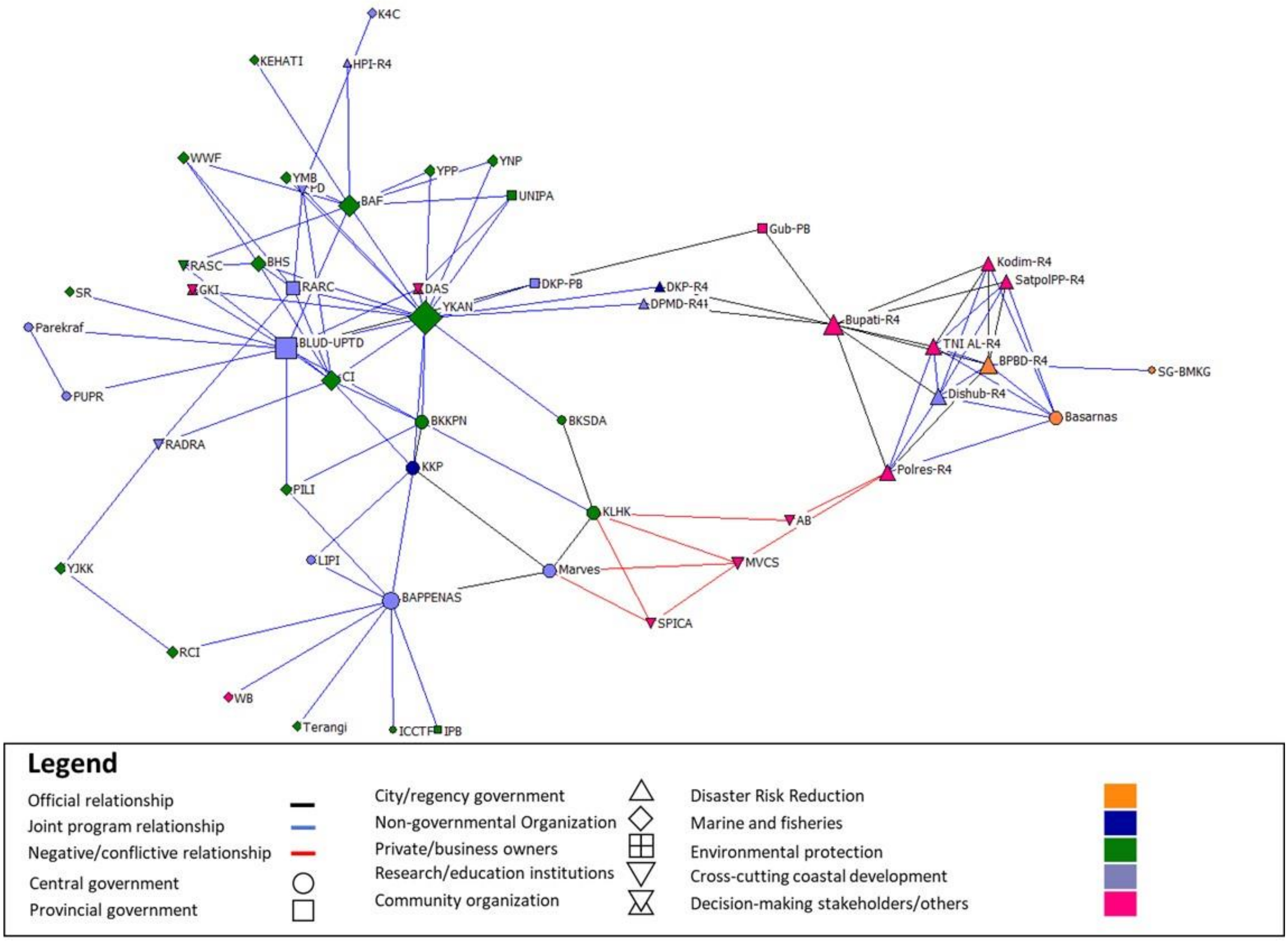


Figure 112 Social Network Analysis Diagraph between stakeholders in Raja Ampat Regency (Analysis, 2021).

In the network diagraph above, the Raja Ampat stakeholder network is divided into two clusters for disaster management (right) and a sub-network for environmental conservation (left). In the middle are actors involved in conflicts with stakeholders related to law enforcement in matters of conservation and disaster management. The table below shows the institutions with the largest provisional degree and betweenness scores on the network for Raja Ampat Regency.

Furthermore, the table below shows the institutions with the highest degree of centrality and betweenness centrality in Raja Ampat Regency, as an initial proxy for the identification of key actors at the location. The value of degree centrality shows the number of relationships; Meanwhile, the betweenness centrality value shows the frequency with which one actor is between two or more other actors, thus indicating the proxy role as coordinator. However, due to the limited data input at secondary sources, albeit with additional information and clarification with YKAN field officer, this finding needs further validation.

Table 65 Degree and betweenness centrality values of stakeholders in Raja Ampat Regency.

Stakeholder	Degree	Stakeholder	Betweenness
Raja Ampat Regent	20	TNC (YKAN)	634.33
TNC (YKAN)	19	Raja Ampat Regent	265.63
Ministry of Environment and Forestry	14	BAPPENAS	257.90
Raja Ampat Resort Police	13	BLUD UPTD Raja Ampat	219.34
Raja Ampat LDMO	12	Ministry of Maritime Affairs and Fisheries	200.99
BLUD UPTD Raja Ampat	12	Blue Action Fund	145.29

Source: Analysis, 2021.

In the 2nd Interrim Report, the actor "Raja Ampat Regent Office" was not identified as a part of the network. However, following the validation interview with TNC field officer in Waigeo, strong coordination with Raja Ampat Regent Office and other regency level agencies were identified. However, since the enactment of Law no. 23 2014 about Local Government, marine conservation area authority is mandated to West Papua Provincial government, thus strong collaboration was identified between NGOs and Papua Barat government (through BLUD UPTD Raja Ampat). The relationship between most actors with Raja Ampat Regent Office and West Papua Governor Office in marine conservation and disaster management issues are mostly formal relationships (related to project permit, etc.).

In addition, the disaster management sub-network is quite vulnerable due to indications of corruption cases in the Regency budget for BPBD in 2014 which just finished the process in 2020. As a result of this case, reports related to the Raja Ampat BPBD were dominated by corruption cases, and there was no news regarding collaboration in disaster management, leading to indications of poor performance and collaboration.

There are two central actors in collaboration in matters of environmental conservation, namely Raja Ampat UPTD KKP and BAPPENAS. Various sources indicate good active collaboration between Raja Ampat UPTD KKP and BKKPN with various other parties such as NGOs, namely TNC and CI. Besides, the COREMAP-CTI program also adds new actors involved in the conservation of the Raja Ampat MPA.

The SPDAB assessment for Raja Ampat Regency was very challenging due to absence of critical document availability online. Neither spatial nor development plan of Raja Ampat was available. This assessment relied on Raja Ampat in Figures 2020, National Disaster Management Office (BNPB) Accountability and Performance Report 2019.

Raja Ampat Local Disaster Management Office (BPBD) had been created but have not shown significant work. There was also a corruption case on the local regency budget for BPBD which went under investigation from

2013 to 2019. This might indicate a bad track record for fund management for disaster risk reduction in Raja Ampat Regency.

According to the BNPB Report, Disaster Risk Map was available in Raja Ampat Regency since 2018 but have not been adopted into a Disster Management Plan. Unfortunately, no further information could be found from Raja Ampat Regency for assessment. For further assessment, this study will need primary data and information from local sources.

By using the SPDAB Tool developed by CARI! Team, the final score for Raja Ampat Regency is **15.4%** as shown in spiderweb diagram in Figure 113. The 26 measure indicators are divided into 4 pillars, namely: (1) Governance, Policy, and Planning Standard, (2) Preparedness and Socio-Economic Strengthening Service Standard, (3) Critical Infrastructure Protection and Recovery Preparedness Standard, and (4) Disaster Emergency Service Standard. Generally, all pillar scores in this SPDAB assessment are very weak in Raja Ampat Regency. The 1st and 2nd pillar has the largest score, while the 3rd Pillar has the smallest average score. Average score of each Pillar is shown in Table 66.

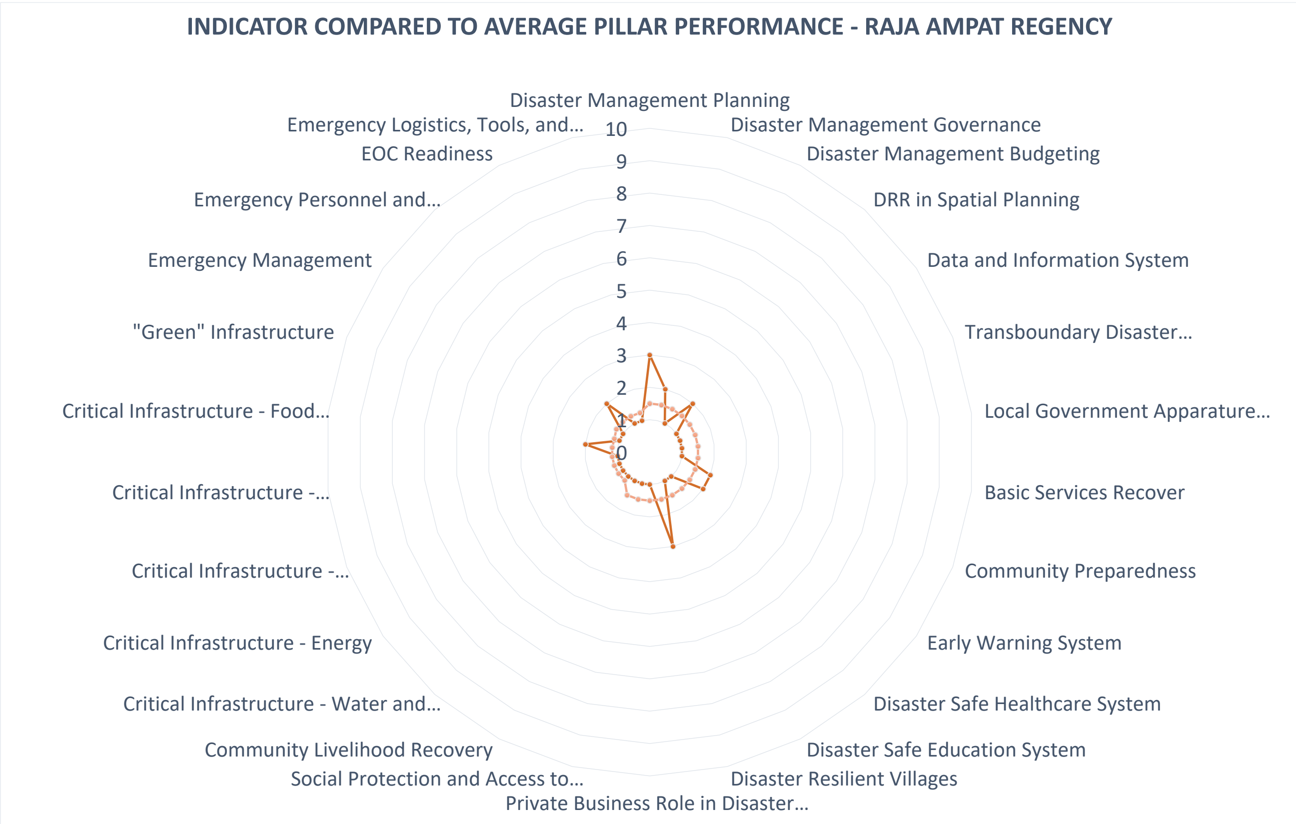


Figure 113 CARI! SPDAB Tool Output Spiderweb Capacity Diagram for Raja Ampat Regency (Analysis, 2021).

Table 66 SPDAB Pillar Average Indicator and Final Score in Raja Ampat Regency.

SPDAB Pillar	Average Indicator Score
PILLAR 1: Governance, Policy, and Planning Standard	1.50
PILLAR 2: Preparedness and Socio-Economic Strengthening Service Standard	1.50
PILLAR 3: Critical Infrastructure Protection and Recovery Preparedness Standard	1.17
PILLAR 4: Disaster Emergency Service Standard	1.25
	Final SPDAB Score = **0.154**

Source: Analysis, 2021.

8.4 Risk Profile, Valuation, and Scenario of Raja Ampat Regency

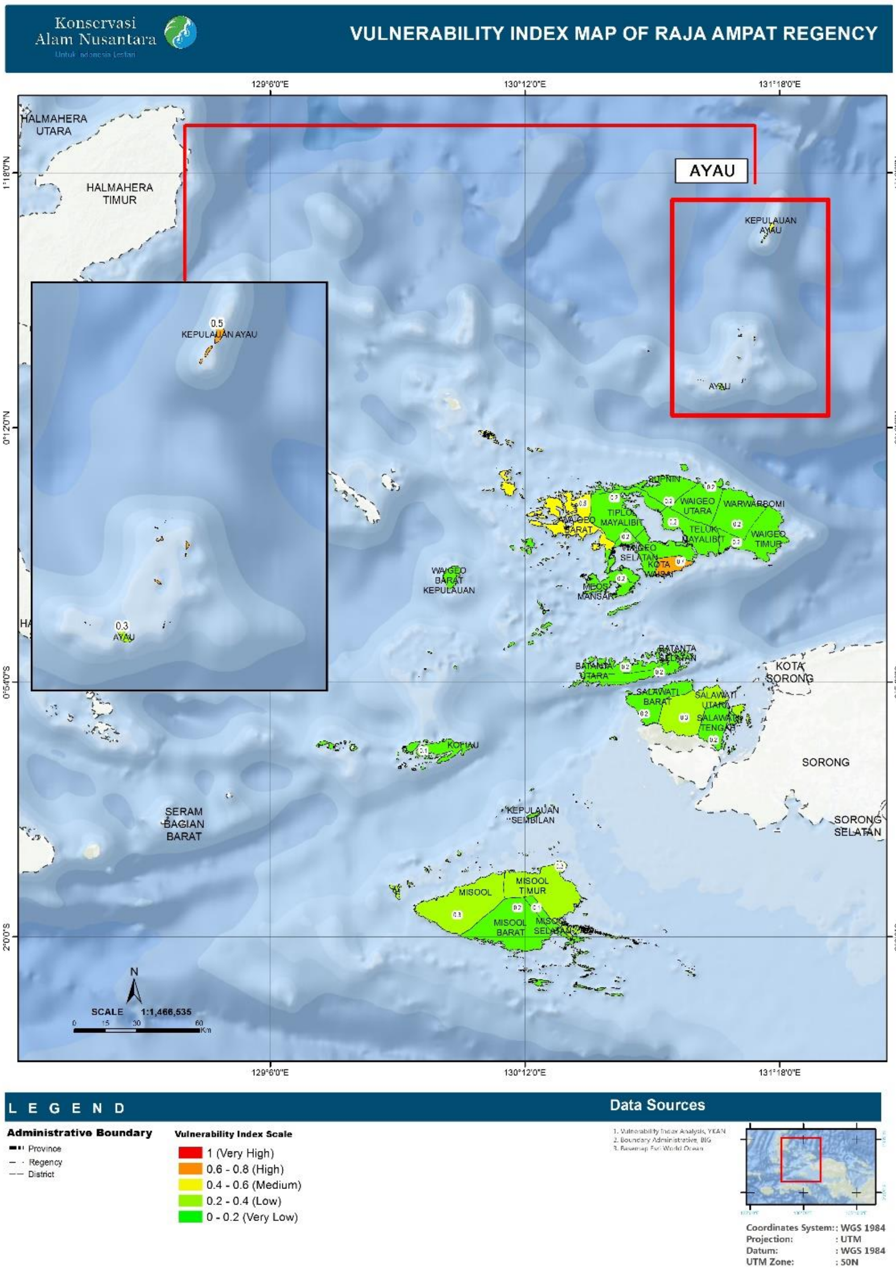


Figure 114 Vulnerability Indax Map of Raja Ampat Regency (Analysis, 2021).

The risk profile is explained based on the risk index which comes from Hazard and Vulnerability. The Vulnerability itself is generated from Exposure, Sensitivity, and Adaptive Capacity.

Vulnerability index in Kota Wasai is the highest with 0.739. The reason behind is the sensitivity index in this district is the highest as well. This district has the most number of population in Raja Ampat Regency. Furthermore this district is the centre of the regency hence it is the largest urban area in the regency. The most significant hazard to this district is an earthquake since it affected a lot of people and a lot of physical aspects.

Kota Waisai has a 32,449 population with a population density of 2.9 people/ha. The number of vulnerable age population is 8,393 with a 34.8% dependency factor. Since Kota Waisai is the centre, it has critical facilities such as municipal waterworks, power plants, port and airport. Moreover, the number of medical facilities and educational facilities is also the highest among the rest of the districts. Due to the high number of population, this district has a lot of building for housing. Those assets are the most valuable in this district.

The highest exposure index is 0.6 which placed on Kepulauan Ayau since this archipelago consists of loose of coarse soil. It has sea-level rise between 0.74 and 0.75 mm/year with the tide range 1.5 – 2.0 m and the mean significant wave height between 1.00 and 1.25 m.

Table 67 Risk Index of Raja Ampat Regency.

District	Index Hazard	Index Exposure	Index Sensitivity	Adaptive Capacity Index	Index Vulnerability	Risk Index
Ayau	0.28	0.20	0.25	0.15	0.33	0.30
Batanta Selatan	0.28	0.20	0.17	0.15	0.22	0.25
Batanta Utara	0.49	0.20	0.19	0.15	0.25	0.35
Kepulauan Sembilan	0.28	0.20	0.15	0.15	0.20	0.24
Kepulauan Ayau	0.28	0.60	0.15	0.15	0.60	0.41
Kofiau	0.28	0.20	0.15	0.15	0.19	0.23
Kota Waisai	0.63	0.20	0.57	0.15	0.74	0.68
Meos Mansar	0.28	0.20	0.21	0.15	0.27	0.28
Misool	0.28	0.20	0.25	0.15	0.32	0.30
Misool Barat	0.57	0.20	0.20	0.15	0.26	0.38
Misool Selatan	0.49	0.20	0.15	0.15	0.20	0.31
Misool Timur	0.57	0.20	0.23	0.15	0.30	0.41
Salawati Barat	0.28	0.20	0.16	0.15	0.21	0.24
Salawati Tengah	0.28	0.20	0.23	0.15	0.29	0.29
Salawati Utara	0.28	0.20	0.25	0.15	0.33	0.31
Supnin	0.28	0.20	0.19	0.15	0.25	0.27

Teluk Mayalibit	0.28	0.20	0.22	0.15	0.28	0.28
Tiplol Mayalibit	0.28	0.20	0.22	0.15	0.28	0.28
Waigeo Barat	0.28	0.40	0.22	0.15	0.58	0.41
Waigeo Barat Kepulauan	0.28	0.20	0.21	0.15	0.27	0.28
Waigeo Selatan	0.28	0.20	0.22	0.15	0.28	0.28
Waigeo Timur	0.28	0.20	0.21	0.15	0.27	0.28
Waigeo Utara	0.28	0.20	0.21	0.15	0.27	0.28
Warwarbomi	0.28	0.20	0.19	0.15	0.25	0.27

Source: Analysis, 2021.

The highest risk index is 0.68 which is possessed by Kota Waisai. Kota Waisai has the highest hazard index as well as the vulnerability index. Based on the BNPB report (BNPB, 2018), the value of the Raja Ampat Disaster Risk Index (IRBI) for multi-threats in 2018 is 135.74 with a risk class including Medium and ranks 321 in Indonesia.

The source of hazard which needs big attention is Sorong Fault. This fault activity has affected a whole Raja Ampat Regency, Kota Waisai in particular. The previous event has affected people and it made around 200 suffering from damage. This fault type is a strike-slip fault that rarely triggering a tsunami. However, based on Probabilistic Tsunami Hazard Analysis in 500 years return period, this regency has a potential inundated from 1-2 m tsunami wave height.

Based on the Risk Index map in Figure 115, Kota Waisai district is classified as medium risk, while the others are low and very low risk.

Raja Ampat besides the main island Papua, also consists of several large islands and a lot of small islands. Raja Ampat is a part of the Coral Triangle area which contributes the highest marine diversity on earth. The coral condition in this regency is categorized as relatively healthy. However, the signs of destruction are existed due o fish bombing and fish poisoning (Subhan, et al., 2020). Moreover, other threats are also coming from the cyclone effect. The rising and declining of water temperature in sudden condition for some period indeed affect the coral to possess a disease even bleaching (Santosa, 2020); (Subhan, et al., 2020). This problem makes the prevalence of Atramentous Necrosis disease which makes corals bleach. This disease commonly infects *Montipora*, *Favites*, *Pectinia*, *Echinopora, Turbinaria, and Merulina.* Indeed this disease relates to the problem of extreme weather which relates to the cyclone. When the temperature decreasing it will disappear while the temperature is increasing it will start to appear (Subhan, 2020). The corals bleaching is happened in Waigeo island and Waisai precisely in the area of marine conservation due to temperature changing (Santosa, 2020). The sedimentation due to run-off mainly damages *Goniastrea, Acropora, Porites, Diploastrea,* *Montipora, Pachyseris,* and *Echinopora.* The sediment makes the coral tissue loss. it cannot be avoided that sediment is the main causes of turbid water thus, the sunlight cannot penetrate to the seawater (Subhan, et al., 2020).

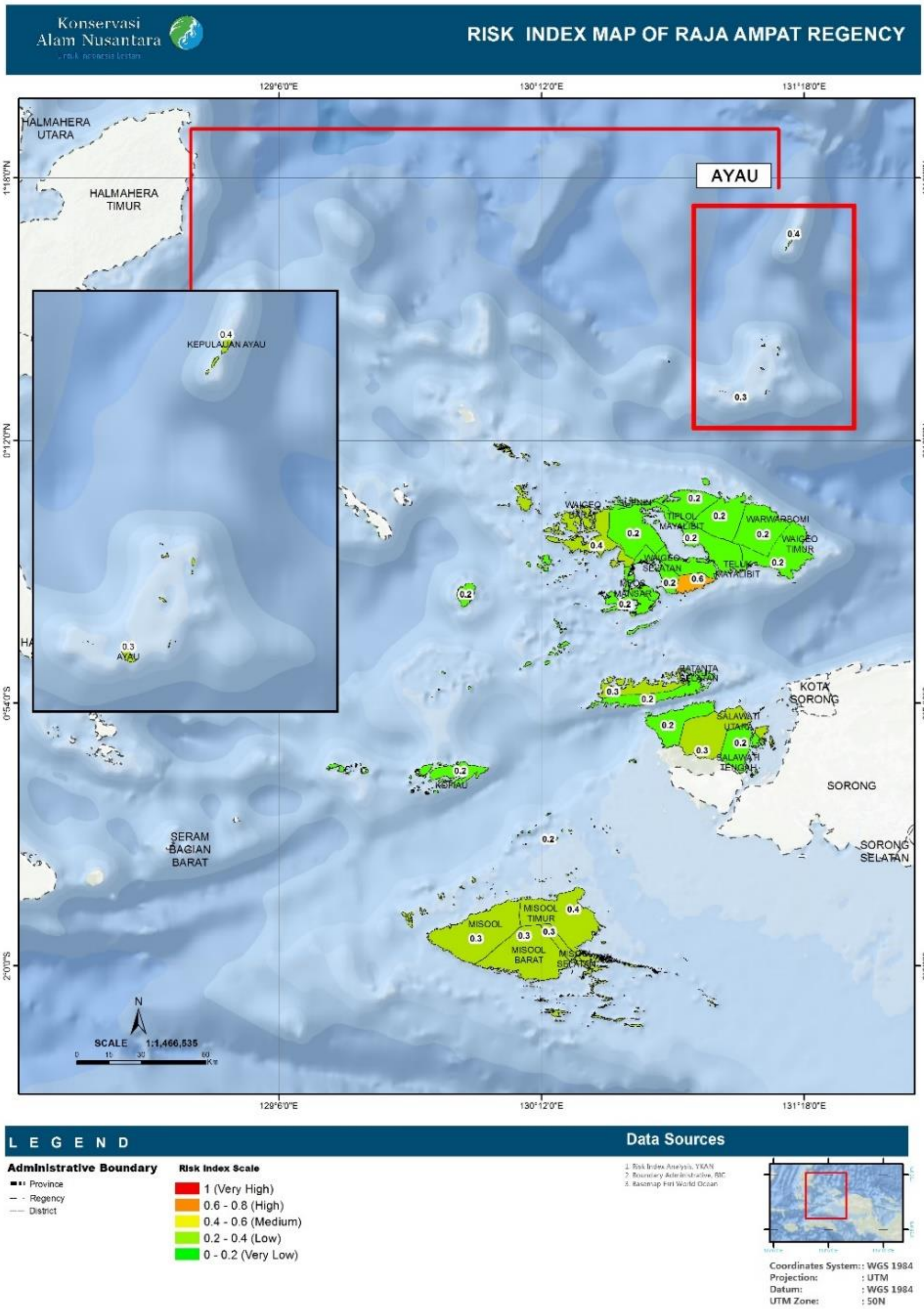


Figure 115 Risk Index Map of Raja Ampat Regency (Analysis, 2021).

The anthropogenic cause is also a threat in Raja Ampat regency, besides the fish bombing and fish poisoning, tourism activities contribute to the coral damage. In Waisai more than 10 diving sites showed the bleaching of the branch soft, and table corals. The major issue from tourism is the accident of the big ship called

Caledonian Sky with UK flag crashed the coral reefs and wreck. This accident destroys 18,882 m^2 coral reefs with an estimated loss of around USD 23 Million. The area with 90% damage was 13,270 m^2 and 5,612 m^2 suffered 50% damage. This damaged area will only 100% restored in 25 years (Witomo, et al., 2017)

Accordingly, the risk scenario of Raja Ampat Regency in monetary terms is presented in the following figure. The calculations were done using the Blue Guide with inputs from the recorded disaster events and risk profiles of the regency. The approaching scenario forecasts the total damages and losses for the next 20 years with 5% discount rate to reveal a summary figure based on present currency value.

SCENARIOS

Basic approach (simplified)	
Timeframe (years into the future)	20
Discount rate	5%

In the basic approach, the three scenarios are automatically generated based on the data you entered above. Scenario A assumes that the level of damages and losses will remain the same as it was over the past 10 years. Scenario B assumes an increase by 10% (progressive increase by 2.5% every 5 years). Scenario C assumes an increase by 20% (progressive increase by 5.0% every five years). The discount rate of 5% is applied across all three scenarios to reveal a summary figure based on **present currency values**.

SCENARIO A		SCENARIO B		SCENARIO C	
Assumption for this scenario		Assumption for this scenario		Assumption for this scenario	
The level of damages and losses will not change, compared to the past ten years	0%	The level of damages and losses will progressively increase by*:	10%	The level of damages and losses will progressively increase by*:	20%
Year 1	108,297,000,000	Year 1	111,004,425,000	Year 1	113,711,850,000
Year 2	102,882,150,000	Year 2	105,454,203,750	Year 2	108,026,257,500
Year 3	97,738,042,500	Year 3	100,181,493,563	Year 3	102,624,944,625
Year 4	92,851,140,375	Year 4	95,172,418,884	Year 4	97,493,697,394
Year 5	88,208,583,356	Year 5	90,413,797,940	Year 5	92,619,012,524
Year 6	83,798,154,188	Year 6	87,988,061,898	Year 6	92,177,969,607
Year 7	79,608,246,479	Year 7	83,588,658,803	Year 7	87,569,071,127
Year 8	75,627,834,155	Year 8	79,409,225,863	Year 8	83,190,617,571
Year 9	71,846,442,447	Year 9	75,438,764,570	Year 9	79,031,086,692
Year 10	68,254,120,325	Year 10	71,666,826,341	Year 10	75,079,532,357
Year 11	64,841,414,309	Year 11	69,704,520,382	Year 11	74,567,626,455
Year 12	61,599,343,593	Year 12	66,219,294,363	Year 12	70,839,245,132
Year 13	58,519,376,414	Year 13	62,908,329,645	Year 13	67,297,282,876
Year 14	55,593,407,593	Year 14	59,762,913,162	Year 14	63,932,418,732
Year 15	52,813,737,213	Year 15	56,774,767,504	Year 15	60,735,797,795
Year 16	50,173,050,353	Year 16	55,190,355,388	Year 16	60,207,660,423
Year 17	47,664,397,835	Year 17	52,430,837,618	Year 17	57,197,277,402
Year 18	45,281,177,943	Year 18	49,809,295,738	Year 18	54,337,413,532
Year 19	43,017,119,046	Year 19	47,318,830,951	Year 19	51,620,542,855
Year 20	40,866,263,094	Year 20	44,952,889,403	Year 20	49,039,515,713
Total damages and losses over 20 years	1,389,481,001,218	Total damages and losses over 20 years	1,465,389,910,765	Total damages and losses over 20 years	1,541,298,820,312
Annualised average	69,474,050,061	Annualised average	73,269,495,538	Annualised average	77,064,941,016
		*In 2.5% increments every 5 years		*In 5.0% increments every 5 years	

Figure 116 Risk Scenarios of Raja Ampat Regency in Monetary Terms (Analysis, 2021).

The summary in Figure 116 shows the damages and losses forecast in three scenarios A, B, and C. Following the recent monetary values calculation for the past ten years (Section 7.2.1), the forecasted monetary values for the next 20 years counts as IDR 1.39 trillion with an annual average of IDR 69.47 billion (Scenario A). Scenario B takes into account the increasing level of damages and losses by 10% and by that, the total value elevates to IDR 1.46 trillion. The forecasted annual average for Scenario B is IDR 73.27 billion, which takes into account a 2.5% of increments every 5 years. The most extreme scenario, Scenario C, have a 20% increase of damages and losses from Scenario A, which leads to a higher value of IDR 1.54 trillion in total and an annual average of IDR 77.06 billion, with a 5% increments every 5 years.

9. Risk and Disaster Management Profile of Rote Ndao Regency

9.1 Overview of Rote Ndao Regency

Rote Ndao is one of the archipelagic regencies in Indonesia. There are 96 islands in the Rote Ndao Regency, 7 of which are inhabited islands while 89 other islands are uninhabited. The total land area of the Rote Ndao Regency is 1,280.10 km^2. Rote Ndao is the southernmost regency of a cluster of islands in the archipelago.

Table 68 Area, number of islands and the number of Villages / Sub-districts in the Coastal Delineation of Rote Ndao Regency.

No	District	Area (Km^2)	Percentage of Regency Area	Amount of Island
1	Southwest Rote	139.38	10.46	**19**
2	Northwest Rote	182.03	13.66	**22**
3	Lobalain	152.22	11.42	**18**
4	Central Rote	181.04	13.59	**8**
5	South Rote	73.54	5.52	**7**
6	Pantai Baru	174.99	13.13	**15**
7	East Rote	121.39	9.11	**11**
8	Landu Leko	187.25	14.05	**7**
9	West Rote	103.47	7.76	**7**
10	Ndao Nuse	17.26	1.29	**5**
TOTAL		**1,332.57**	**100.00**	**119.00**

Source: Rote Ndao Regency in Figures 2020, BPS, 2020

The population of Rote Ndao Regency based on the projection results in 2018 will reach 165,807 people. This number increased by 3.88 percent of the projected population in 2017. With the land area of Rote Ndao Regency of 1,280.10 km2, each km2 in Rote Ndao Regency is occupied by around 129 to 130 residents. The highest population density is in Ndao Nuse District, which is 278 people per km2, while Landu Leko District is the district with the lowest population density of 31 inhabitants per km2.

Table 69 Demographic Conditions in the Coastal Delineation of Rote Ndao Regency

No.	District	Amount of Population	Rate of Population Growth	Percentage of Population
1	Southwest Rote	24,957	3.88	16.81
2	Northwest Rote	27,835	3.89	18.74
3	Lobalain	31,108	3.87	20.95
4	Central Rote	9,508	3.89	6.40
5	South Rote	6,352	3.88	4.28
6	Pantai Baru	14,945	3.87	10.06
7	East Rote	14,959	3.88	10.07
8	Landu Leko	5,57	3.89	3.75
9	West Rote	9,438	3.87	6.36
10	Ndao Nuse	3,834	3.92	2.58
TOTAL		**148.506**	**3.88**	**100**

Source: Rote Ndao Regency in Figures 2020, BPS, 2020

The directions for the RTRW of East Nusa Tenggara Province[58] and RTRW of Rote Ndao Regency[59] stipulate that there is a development of a local activity center (PKL), namely the Ba'a city in Lobalain District and the establishment of a Local Promotion Activity Center (PKLp) which includes Busalangga Urban in North West Rote District and Olafulihaa City in Pantai Baru District.

Determination of protected areas in the form of marine reserves covering the Savu Sea National Marine Protected Area (KKPN) with an area of 3.5 million hectares, as well as mangrove forested coastal areas covering an area of approximately 7,157 hectares, covering along the coast in all districts. In addition, other protected areas were also stipulated, including:

a. hunting park area, namely on Ndana Island, Southwest Rote District, covering an area of approximately 1,562.5 hectares.
b. animal refugee areas, including: a. Savu Sea Waters Area; and b. Indian Ocean Waters.
c. coral reef area, including: a. The coral reef area of Tesabela Village, Pantai Baru District; b. Onatali Village coral reef area, Rote Tengah District; and c. The coral reef area of Do'o Island, Ndao Nuse District.
d. Protected marine animal/biota corridor areas include: a. Rote Strait Waters; b. The waters area of Rote Island, the Savu Sea; and c. Waters of Rote Island, Indian Ocean.

There are several strategic areas in Rote Ndao Regency, such as the National Strategic Area, namely the Indonesian Sea Border Area with the State of Australia, including Ndana Island in Southwest Rote District; The Provincial Strategic Area which includes: 1) the strategic area from the point of view of the function and carrying capacity of the environment is the Integrated Coastal and Marine Area Unit of the Savu Sea III; and 2) another strategic area in the form of a border strategic supporting area to support the National Strategic Area for land and sea borders with the States of Timor Leste and Australia is the Ndana Region. As well as regency strategic areas with an interest in the function and carrying capacity of the environment, including: a. Ndana Island wildlife reserve in Southwest Rote District; b. Mangrove forested coastal areas on the southern and eastern coasts of the regency; and c. The springs area in Lobalain District and Rote Tengah District.

[58] East Nusa Tenggara Provincial Regulation Number 1 of 2011 concerning the 2010-2030 East Nusa Tenggara Provincial Spatial Plan
[59] Regional Regulation of Rote Ndao Regency Number 7 of 2013 concerning the Regional Spatial Plan of Rote Ndao Regency in 2013-2033

In the distribution of the National Fisheries Management Area, the waters of Rote Ndao Regency are included in the WPPNRI 573. At the direction of the WPPNRI 573 fisheries management plan[60], there is a marine conservation area in the area of Rote Ndao Regency in the form of the Savu Sea National Park (TNP), East Nusa Tenggara Province. Savu Sea TNP, which is a management planning area located in the waters of the Sumba Strait and the waters of East Rote-Sabu-Betek. TNP Sawu Sea is located in the Lesser Sunda Ecoregion. The waters of the Savu Sea are located in the Lesser Sunda Shelf which is surrounded by a series of islands, namely Timor, Sabu, Sumba, Flores, and Alor Islands, the Savu Sea TNP area is reserved based on the Decree of the Minister of Marine Affairs and Fisheries Number KEP.38 / MEN / 2009 concerning Reserves The Savu Sea National Marine Protected Area and its Surroundings in East Nusa Tenggara Province with an area of 3,355,352.82 hectares consisting of 2 regions, namely the waters of the Sumba Strait and its surroundings and the waters of Sabu-Rote Island Timor-Batek and its surroundings.

Administratively, the Savu Sea TNP area is located in Kupang Regency, Rote Ndao Regency, South Central Timor Regency, Sabu Rajua Regency, Manggarai Regency, West Manggarai Regency, East Sumba Regency, Central Sumba Regency, West Sumba Regency, and Southwest Sumba Regency.

In the economic aspect, the sectors that drive the regional economy can be seen from the contribution of these sectors to the Gross Regional Domestic Product (GRDP). Based on data from Rote Ndao Regency in 2020 Figures (BPS, 2020), the value of Rote Ndao Regency's GRDP reached IDR 3,136,404 billion in 2019, with the most contributing sectors being Agriculture, Forestry, and Fisheries. Meanwhile, looking at the GRDP growth in the last few years based on constant prices, the densest growth of Rote Ndao Regency's GRDP was 5.32% in 2019, with the sectors has the highest growth rates, namely sectors 1) Government Administration, Defense and Compulsory Social Security; 2) Processing Industry; 3) Other Services. The economy in terms of capture fisheries in Rote Ndao Regency, based on data from Rote Ndao Regency in 2020 Figures (BPS, 2020), in 2019 the fish cultivation production of Rote Ndao Regency reached 3,529 tons. The number of fisherman households consisting of full-time fishermen (2,435), main taking (320), and additional taking (236). Catching units commonly used are Jukung (1,782), Outboard motorboat (542), Motorboat (360), and non-motorized boat (59).

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[60] Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 77 / KEPMEN-KP / 2016 concerning the Fishery Management Plan for the State Fisheries Management Area of the Republic of Indonesia 573

9.2 Summary of Past Disaster Events in Rote Ndao Regency

9.2.1 Past disaster events due to natural hazards and sudden onset in nature

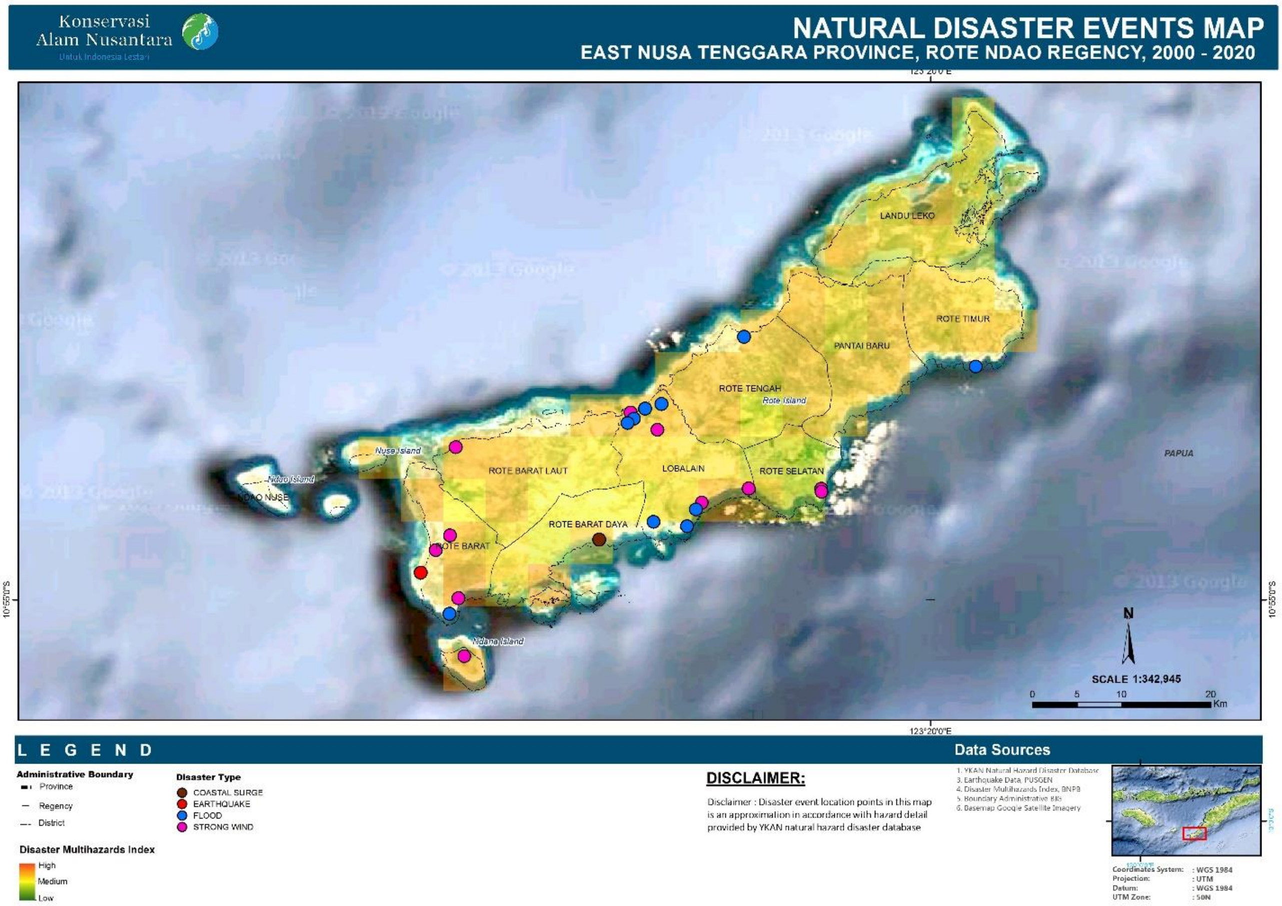


Figure 117 Map of Natural Disaster Events in Rote Ndao Regency 2000-2020 (Analysis, 2021).

Based on the map of past disaster event of Rote Ndao Regency (Figure 117) shows that generally, the events are distributed mostly in the middle of the island (Lobalain District), and the south west of the island (Rote Barat District).

Geographically, the entire territory of Rote Ndao Regency is limited by waters which include the Rote Strait, Savu Sea, Timor Sea and Indian Ocean. With a dry climate, the rainy season is short from December to March, while the dry season is very long from April to the first weeks of November each year. With such geographical conditions, Rote Ndao area is vulnerable to natural disasters, including strong wind and flood hazards.

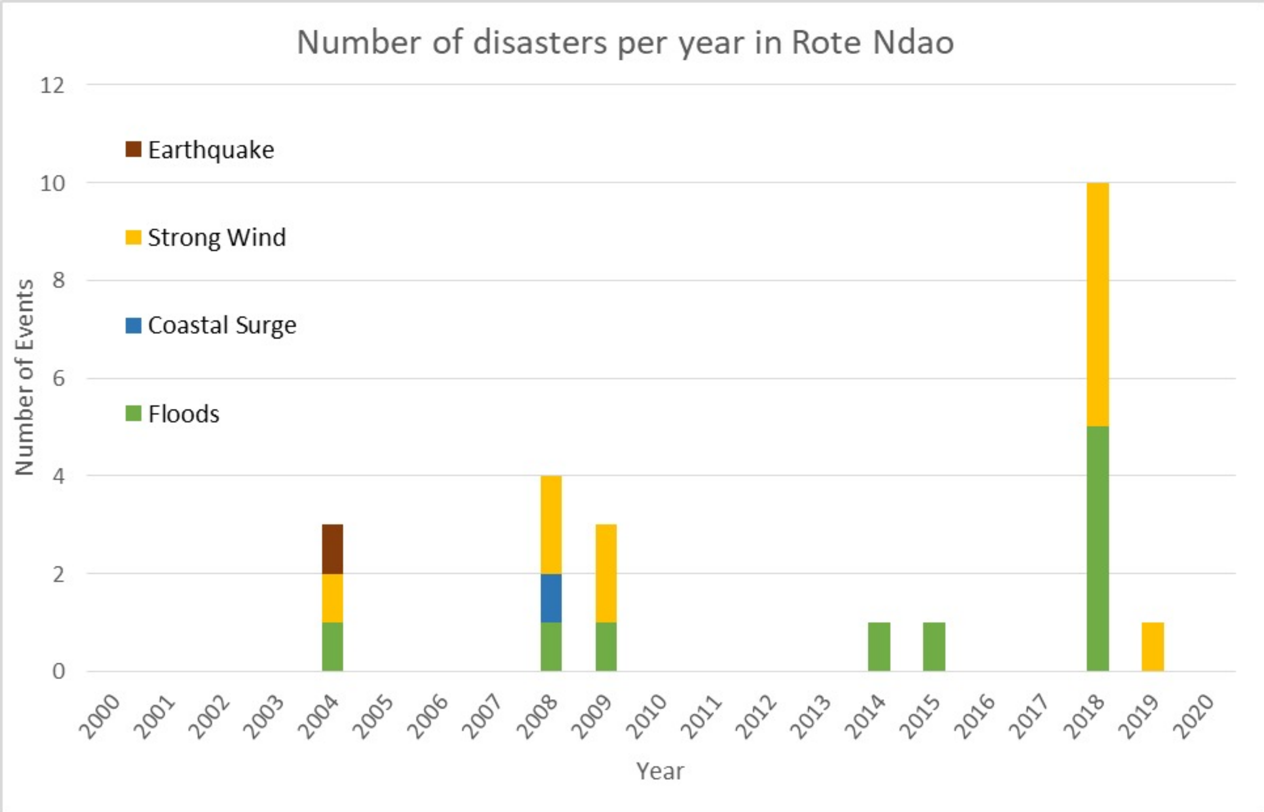


Figure 118 Number of Disaster Events due to Natural Hazards in Rote Ndao District (Analysis, 2021).

From the records of disaster events that were previously collected, Rote Ndao Regency had 23 natural disaster events over the past 20 years. The most active time period for natural disasters in Rote was during the period 2004-2009 and 2014-2019. The most incidents were experienced in 2018 where strong wind and floods dominating the chart in Figure 118 while year 2008 accounts for the most variable events namely strong winds, flood, and coastal surge. During the previous decade, only strong winds and floods recorded in Rote Ndao.

The natural disasters in Rote Ndao were dominated by hydrometeorological disasters. Being surrounded by water and adjacent to Australia to the south, the tail of a tropical cyclone often hits the region and these proved to give indirect impacts to Rote Ndao for both the land and waters. A total of 25 tropical cyclones had been haunting the region for the past 20 years. The link between the tropical cyclone and strong wind or flood had been elaborated in Chapter 2.3.4, and it is found out that the flood occurrences, especially ones in Rote Ndao can be related to the cyclone occurrences. A closer look to the effect of Tropical Cyclone Joyce in 2018, there were two flooding in Lobalain during the time of the event in Rote Ndao. Those damaged 12 houses but no people affected. Another evidence was also presented by Tropical Cyclone Riley in 2018 where it causes flooding in Lobalain. Only two houses damaged and no people affected in this event.

Table 70 Hazard Index of Rote Ndao.

District Name	Frequency Index	Severity Index	Hazard Index
Lobalain	0.80	0.80	0.80
Rote Barat	0.60	0.60	0.60
Rote Barat Daya	0.20	0.40	0.28
Rote Tengah	0.40	0.40	0.40
Rote Timur	0.40	0.60	0.49
Rote Barat Laut	0.40	0.60	0.49
Ndao Nuse	0.20	0.20	0.20
Rote Selatan	0.40	0.60	0.49
Pantai Baru	0.40	0.40	0.40
Landu Leko	0.20	0.00	0.00

Source: Analysis, 2021

Based on the analysis in Table 70, the hazard index in Lobalain district is the highest index among the whole district followed by Rote Barat, 0.80 and 0.60. Lobalain possess the highest hazard index because of the highest frequency and highest severity as well. Rote Barat district also follows in the second position the high hazard index and severity index after Lobalain district. On the other hand, the lowest Hazard index goes to Landu Leko, because there is no severity.

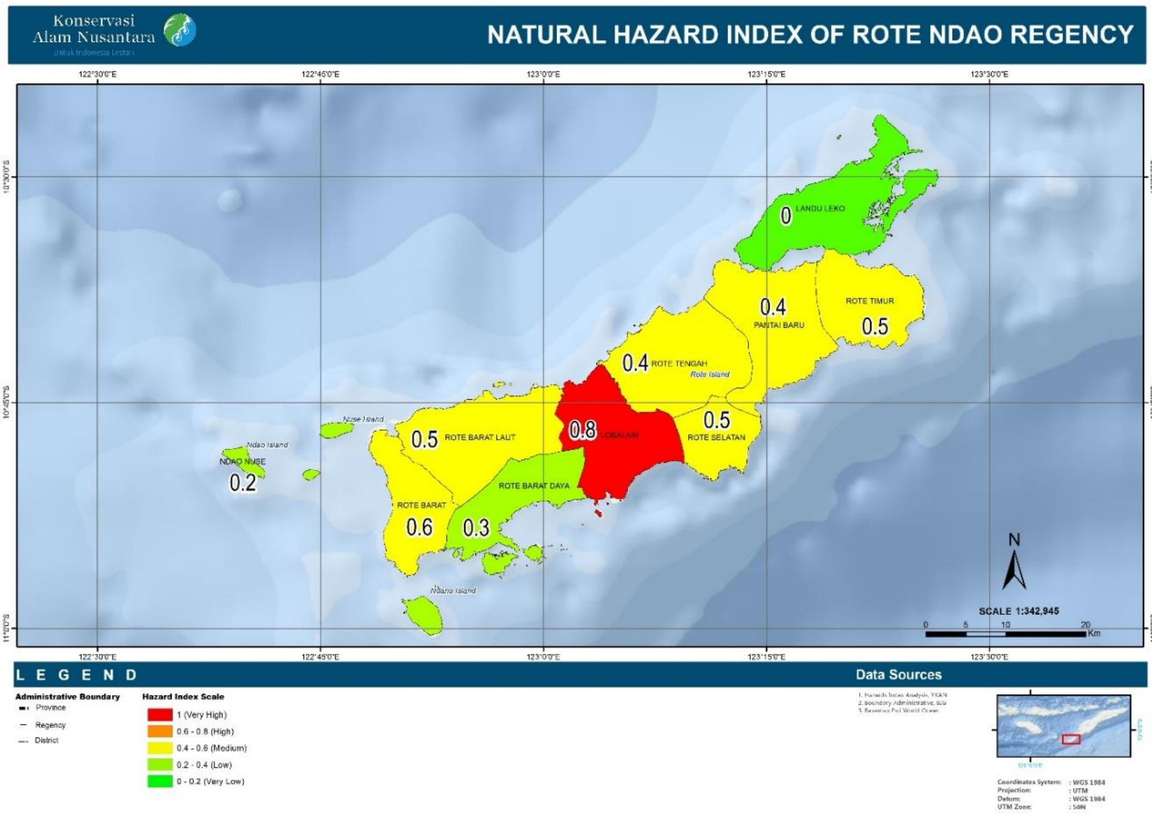


Figure 119 Map of Natural Hazard Index in Rote Ndao Regency (Analysis, 2021).

Figure 119 shows the hazard index served as spatial feature. Loalain district is classified as very high hazard index while the Rote Barat daya is categorized as low hazard index. Since Lando Leko district has the lowest value so, it is categorized as very low hazard index. On the other hand, the medium hazard index scale goes to the rest of unmentioned districts.

Within the study of the tropical cyclone tracks, there were several among them that have tracks exactly above Rote Ndao such as Tropical Cyclone Bonnie in 2002, Errol in 2002, Ilsa in 2009, Magda in 2010, and Narelle in 2013 (Data compiled from the Australian Bureau of Meteorology[61], BMKG, and an article from Haryani & Zubaidah, (2012) Due to the low latitude location, the passing cyclone was still on the weak phase and not yet upgraded to a cyclone category (See the Cyclone Map in Figure 18), thus did not incur any damage over Rote islands. However, the sustained wind speed of the passing cyclone at the time was still above average (<63 km/h), therefore it is something that needs to be anticipated as well. Apart from the cyclone, strong winds usually presented as the whirlwind, although not always the case. The whirlwind may have wind speed comparable to a cyclone, and when the lower part of it reaches settlement, it starts to break anything it passes. Therefore, strong winds in Rote Ndao could cast several damages to people and the settlements.

Apart from the tropical cyclones, monsoon storms accompanied by strong winds in the rainy season and shifts that often occur together with high rainfall can also cause flood disasters. With the frequency of flood disasters that can occur almost every year and cause repeated damage, coupled with tropical cyclone disasters, the number of accumulated impacts on the coastal communities of Rote Island will cause enormous losses.

Unfortunately, based on the records of the impact of the existing disaster events, the valuation value of the damages and losses is not properly recorded. Hence, The damages and losses estimation from past hazards/stressors was done using the Blue Guide Calculator (The Nature Conservation, 2020) (Figure 120).

On that account, the damages and losses estimation from past hazards/stressors was done using the Blue Guide Calculator (The Nature Conservation, 2020) and the results were showed in Figure 120. In brief, the most frequent and damaging natural hazards in Rote Ndao Regency are flood, followed by strong wind. Over ten years, floods give damages and losses estimation of approximately IDR 18.06 billion in total with the annualised value reaches the same amount, while strong winds were estimated to possess damages and losses of approximately IDR 5.67 billion in total with annualised value of about IDR 6.24 billion. Further, the combined

[61] See http://www.bom.gov.au/ and http://meteo.bmkg.go.id/

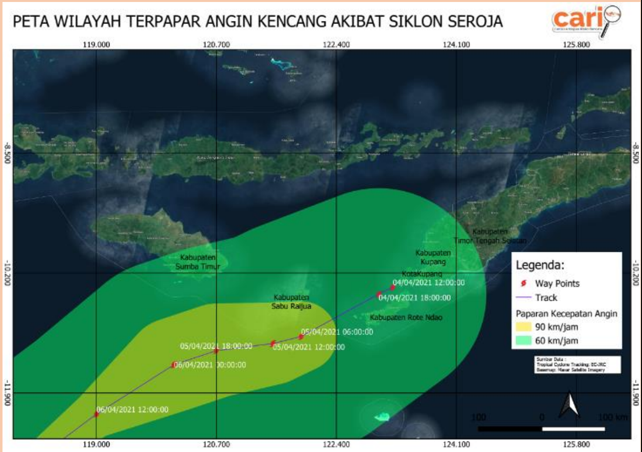
damages and losses monetary value from all the hazards/stressors over ten years was calculated to be around IDR 23.73 billion with IDR 24.3 billion calculated in an annual basis.

Collect and add data on damages and losses from past hazards/stressors over the past ten years.			
HAZARD/STRESSOR 1 (Most damaging)		**HAZARD/STRESSOR 2**	
List the most damaging hazard/stressor	Flood	List the second-most damaging hazard/stressor	Strong Wind
How many times has this occurred over the past ten years?	10.0	How many times has this occurred over the past ten years?	11.0
The annual probability rate (APR) for this hazard is:	1.0	The annual probability rate (APR) for this hazard is:	1.1
What currency will you use for monetary figures?	IDR	What currency will you use for monetary figures?	IDR
Damages (monetary values)		**Damages (monetary values)**	
Damages to homes	8,085,000,000	Damages to homes	1,530,000,000
Damages to business assets	8,700,000,000	Damages to business assets	2,000,000,000
Damages to public infrastructure	0	Damages to public infrastructure	750,000,000
Other damages (e.g. loss of land from erosion)	0	Other damages (e.g. loss of land from erosion)	0
Total damages	16,785,000,000	Total damages	4,280,000,000
Direct losses (monetary values)		**Direct losses (monetary values)**	
Losses in produce	0	Losses in produce	0
Losses in income	0	Losses in income	0
Other direct losses	0	Other direct losses	0
Total direct losses	0	Total direct losses	0
Indirect losses (monetary values)		**Indirect losses (monetary values)**	
Prolonged losses from produce sales	0	Prolonged losses from produce sales	0
Prolonged income losses	0	Prolonged income losses	0
Other indirect losses	1,275,000,000	Other indirect losses	1,395,000,000
Total indirect losses	1,275,000,000	Total indirect losses	1,395,000,000
Hazard 1: Total damages and losses	18,060,000,000	**Hazard 2: Total damages and losses**	5,675,000,000
Hazard 1: Annualised damages and losses	18,060,000,000	**Hazard 2: Annualised damages and losses**	6,242,500,000
The combined damages and losses from all four hazards/stressors over ten years have been:			23,735,000,000
On an annual basis, the combined damages and losses over ten years have been:			24,302,500,000

Figure 120 Past Damages and Loss Estimation Rote and Ndao Regency (Analysis, 2021).

Box 6: The Seroja Tropical Cyclone Hit NTT and Surrounding Area

On 4-7 April 2021 Seroja Tropical Cyclone hit NTT and surrounding area including Rote Ndao Regency[62]



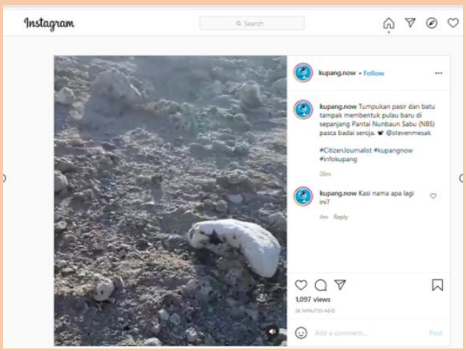
Collateral disaster such as:

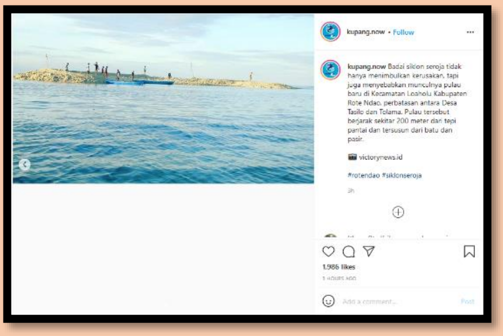
- Flood
- Flash flood
- Landslide
- Strong wind (approximately up to 75 km/h)
- Coastal Surge (approximately up to 2.5-4 m)

Impact:

- 112 village + 7 Sub-district affected (119 in total) with estimated losses IDR 112.38 billion
- 1190 houses with average 5-50 damaged houses/village(sub-district) with estimated losses IDR 11.9 billion
- 20,000 affected people with 1,000 displaced people spreading in 7 villages with total needs IDR 2 billion
- 1800 ha damaged paddy field with estimated losses IDR 71.83 billion
- 222 missing + broken boats with estimated losses IDR 3.65 billion
- 1 damaged harbor with estimated losses IDR 35 billion

A new "land" is formed near the shore of Kupang and Rote Island, due to sedimentation of extreme wave from Seroja TC. The newly form "land" consists of sand, boulder and rubble. It is likely these boulders and rubbles is a result of a broken/shattered nearby reefs, more information is needed.





[62] https://rotendaokab.go.id/dampak-badai-siklon-tropis-seroja-di-kabupaten-rote-ndao.php

9.2.2 Past disaster events due to anthropogenic hazards

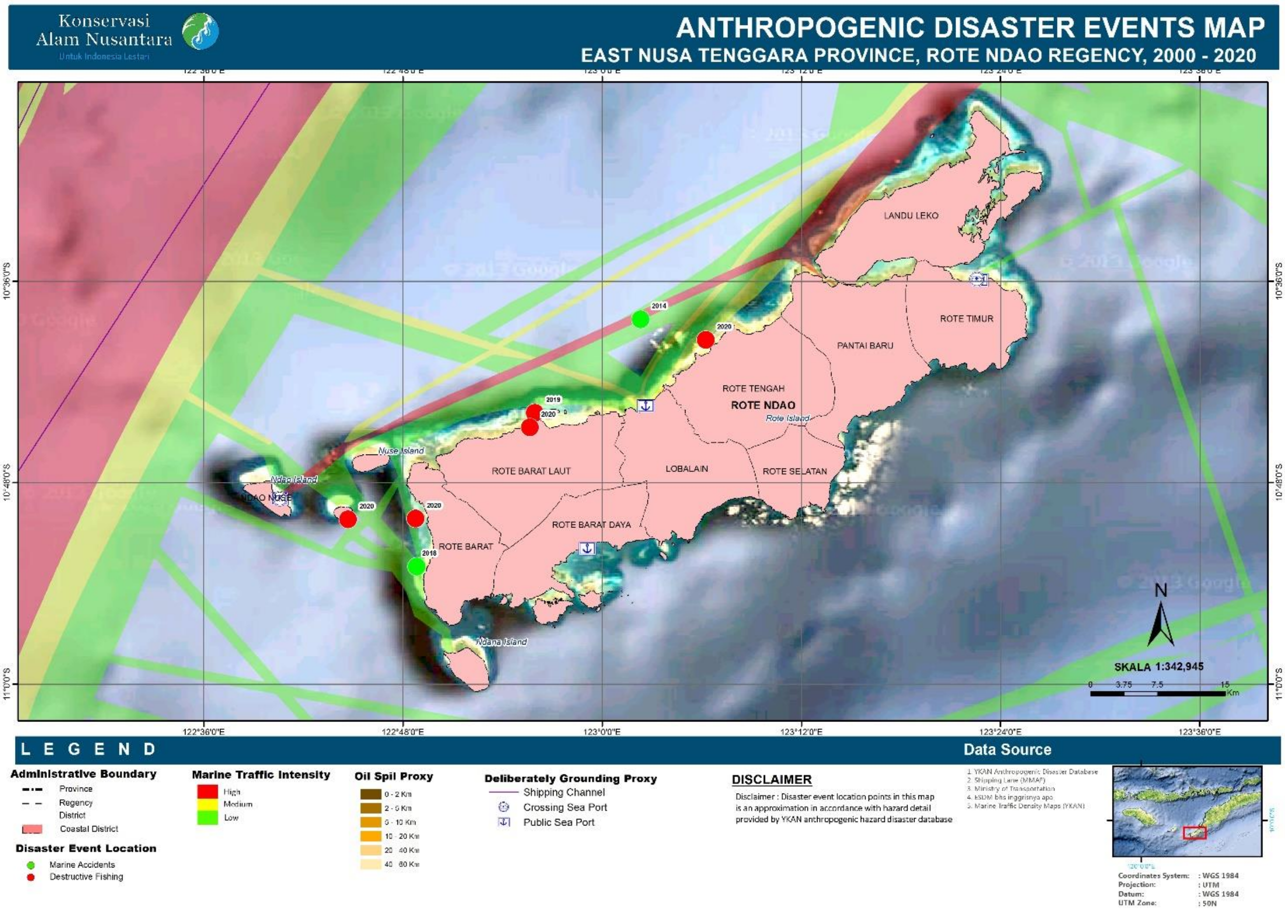


Figure 121 Map of Anthropogenic Hazard Index of Rote Ndao Regency (Analysis, 2021).

In general, disaster events due to anthropogenic hazards that occur in Rote Ndao, East Nusa Tenggara Province are dominated by events related to marine accidents spreading from the north part to the west pasrt of the island (Figure 121). From the data collected during the past 20 years, the number of disasters caused by anthropogenic hazards in Rote Ndao Regency was counted as 10, with a balanced proportion between destructive fisheries and marine accidents. Interestingly, most of the recorded events, excluding Montara Oil Spill in 2009, all happened frequently between 2017 and 2020. The pattern of the number of disasters due to anthropogenic hazards that occurred in Rote Ndao, East Nusa Tenggara Province is shown in Figure 122.

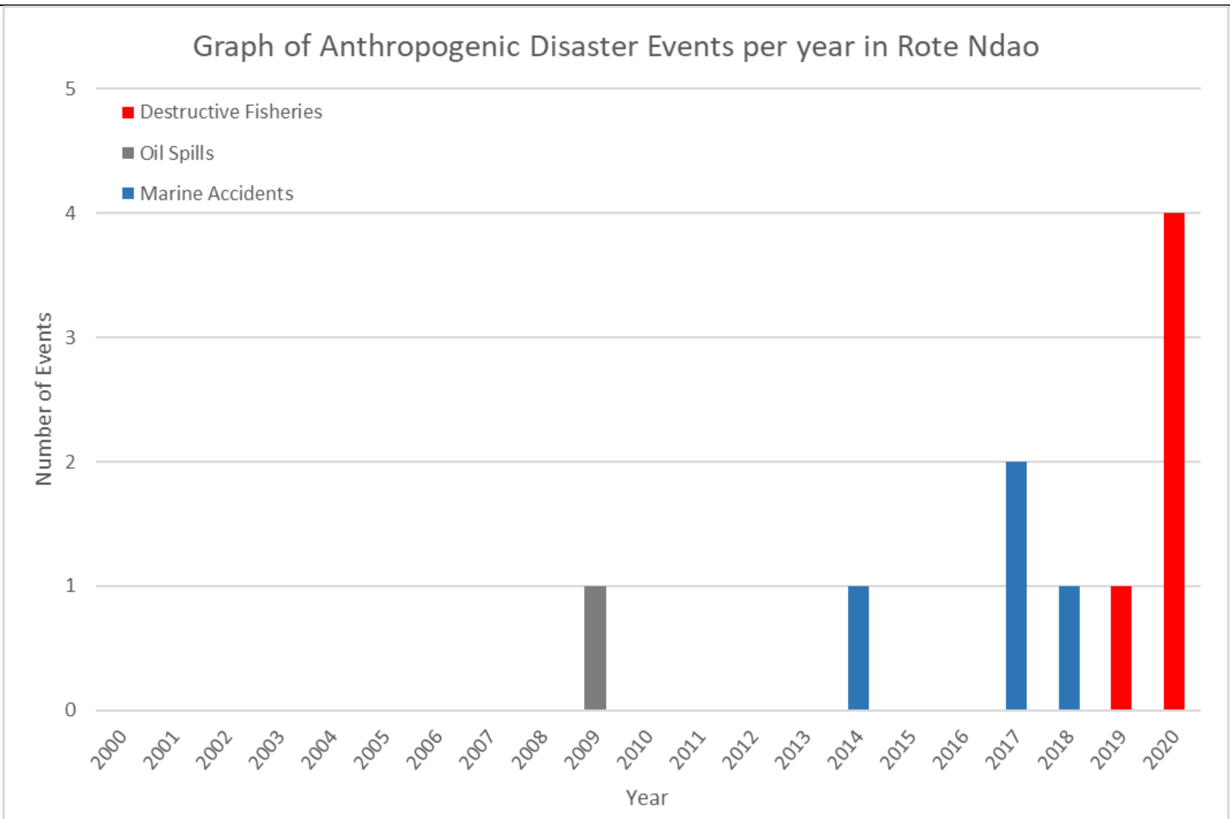


Figure 122 Number of Recorded Disaster Events due to Anthropogenic Hazards in Rote Ndao Regency during the Last 20 Years (Analysis, 2021).

Anthropogenic hazards recorded in this study were causing threats to human safety or damage and loss of livelihoods (Table 71). Apart from that, disasters due to anthropologenic hazards can also potentially impacting the health of the surrounding environment. Based on records over the past 20 years, there was more destructive fishing activities found in 2019 and 2020 (Figure 122). On November 12, 2020, three fishermen were caught by the police as having evidence of a fish bomb after coming from the sea. This shows that although blast fishing has gone from the records between 2000 and 2010, these activities have not disappeared completely and have the potential to reoccur if they are not strictly monitored. The destruction of environment and biota in the waters of Rote Ndao also threatened by oil pollution caused by the Montara oil spill which was impacting Indonesian waters years ago (See Box 6).

Table 71 Anthropogenic Hazard Index in Raja Ampat Regency (Analysis, 2021).

District	Destructive Fishing	Marine Accident	Oil Spill	Anthropogenic Hazard Index
Lobalain	0	0	0	0.00
Rote Barat	1	1	1	0.74
Rote Barat Daya	0	0	0	0.00
Rote Tengah	1	1	0	0.72
Rote Timur	0	1	1	0.46

District	Destructive Fishing	Marine Accident	Oil Spill	Anthropogenic Hazard Index
Rote Barat Laut	3	0	0	0.84
Ndao Nuse	0	0	0	0.00
Rote Selatan	0	1	1	0.46
Pantai Baru	0	0	0	0.00
Landu Leko	0	0	0	0.00

Source: Analysis, 2021.

With all the anthropogenic events recorded in Rote Ndao, the hazard index becomes relatively high in Northwest Rote by 0.84, while Rote Tengah and West Rote having quite similar index value of 0.7. Interestingly, Lobalain have 0 value despite being the capital city and located between Northwest Rote and Rote Tengah. As the northernmost and the southernmost district of Rote Ndao, Landu Leko and Southwest Rote gave 0 index value following 0 anthropogenic hazard occurrences in the region.

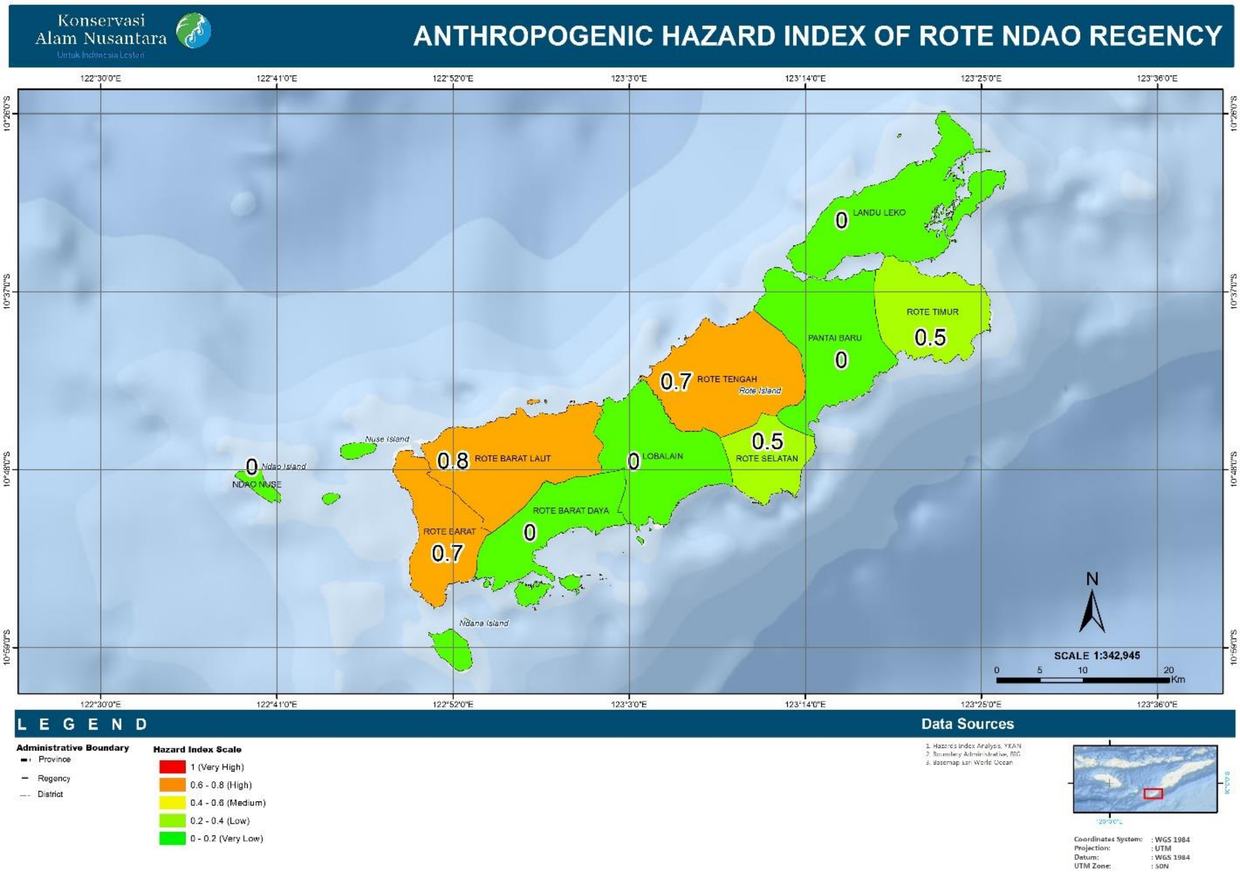
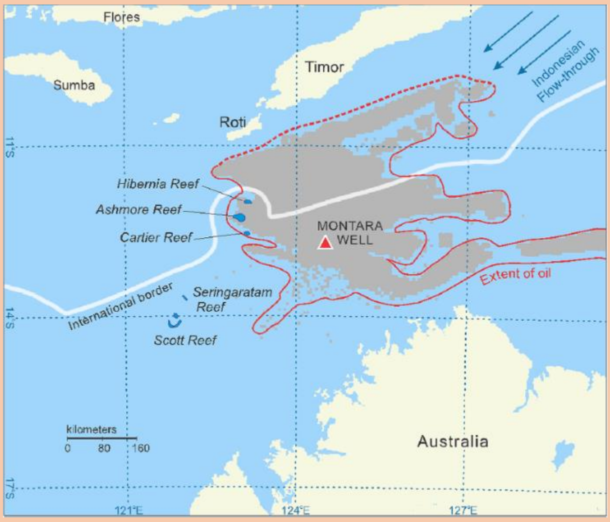


Figure 123 Map of Anthropogenic Hazard Index of Rote Ndao Regency (Analysis, 2021).

Based on the map of Anthropogenic Hazard Index (Figure 123), High classification of Hazard Index goes to Rote Tengah district, Rote Barat Laut and Rote Barat. Rote Timur district and Rote Selatan district have the low classification hazard index. Furthermore, the rest of the districts are classified as very low classification index.

Box 7: The 2009 Montara Oil Spill affecting Rote Ndao District, Nusa Tenggara Timur

The Montara well platform, located 260 km from the northwest coast of Australia (12°40'S, 124°32'E), released uncontrolled hydrocarbons from one of the platform wells on **21 August 2009.** This incident caused the oil to be spilled to the sea surface with temperature reaches more than 80°C and hydrocarbon gases enter the atmosphere. The initial statement issued by the bridge operator, namely **PTTEP Australia Ashmore Cartier (PTTEP AA) estimated that 400 barrels per day of crude oil was polluting the environment due to this incident**. The discovery of crude oil specks reached a radius of 35 km from the platform and in various directions affected by wind conditions, currents and varying temperatures. **The oil spill continued until 3 November 2009 (74 days)** and emergency response operations continued until the bridge was closed on 3 December 2009[63].



[**Top Left**] Map of Montara Oil Spill spreading in 2009, taken from Borthwick (2010) in Spies et al (2017) [**Top Righ**t] Oil slick escapes from Montara Well[64] [**Bottom**] Plumes of crude oil in the Timor Sea during the explosion of the Montara oil platform, 21 August 2009[65].

There are several estimates of the coverage area of the oil spill; Australian Maritime Safety Authority (AMSA) suggested an **area coverage of 6,000 km2**, while the coverage area may be wider considering WWF analysis which found the oil spill was found 70 nautical miles from the main platform. Another estimate based on satellite imagery **on September 24, 2009 indicates that the coverage area can reach 10,000 km2 to 25,000 km2** (Mustoe, 2009).

Furthermore, there are various evidence that Indonesian territorial waters, particularly in the Timor Sea, were also affected by this incident (Young et al., 2011). This includes maps from AMSA showing detected oil spills within a 57 km radius of the Indonesian coastline, as well as maps released by the Australian Lawyers Alliance showing the spill at a distance of 37 km from Rote Island on 13 September 2009 (day 24) from the time of the incident[66]. The negative impacts on Indonesian territory as a result of this incident include coral bleaching, economic losses for the seaweed farming industry, reduced fish catches, and decreased livelihoods for people in East Nusa Tenggara (NTT), particularly on Rote Island, for several years. **Mitchel (2016) estimates that economic losses in Indonesia are equivalent to AUD $ 1.5 billion / around 12.75 trillion rupiah in a year.**

[63] Australian Maritime Safety Authority (2010); Gilbert et al., (2010).
[64] https://www.maritimenz.govt.nz/public/environment/responding-to-spills/spill-response-case-studies/montara.asp
[65] https://kupang.antaranews.com/berita/21826/satu-dekade-kasus-tumpahan-minyak-montara
[66] See https://www.lawyersalliance.com.au/news/foi-maps-prove-montara-oil-spill-investigation-is-vital,

9.2.3 Past disaster events due to natural and anthropogenic hazards and slow onset in nature

With the influence of the Indian Ocean waters and as one of the Arlindo crossways, Rote water areas have a fairly warm water profile with high biodiversity of coral reefs. With a rate of increase in the sea surface temperature of around 0.2°C per decade, the incidence of coral bleaching at the location Rote Ndao can occur massively within a fairly large location.

In 2013, the percentages of live hard coral cover in the East Rote at three research locations were in a bad category. The corals in the western side have an average cover of 23.98%, while the ones in the Thousand Mouth Strait have a percentage of hard live coral cover of 15.8% and those in the eastern side has the lowest percentage with an average cover of 12.33% (Achmad, Munasik, & Wijayanti, 2013). These findings were in line with results from a survey conducted by TNC in 2016, showing that Rote waters were also experiencing coral bleaching at the time (Table 72). In 2019, LIPI analysts showed that over the 6 observation locations, 4 locations were in a bad condition. These results indicate that the coral reefs in Rote waters are now in an alarming condition and have experiencing more environmental quality degradation.

Table 72 Status of Coral Reefs in Rote Ndao Regency.

Location	Station Number	Very good	Good	Fair	Poor
Rote Ndao, KKPN Laut Sawu (NTT)*	6	0	2	0	4

Source: Hadi, et al., 2019.

The problems regarding slow-onset reef quality degradation was not caused by bleaching only. Human activities might also play an important role to threaten the ecosystem. Such infrastructures built for transportation and tourism purpose, although found to be beautiful by the people, can also have negatve impacts in the long term for the coastal and marine ecosystems in the vicinity. As previously shown Table 17 in section 2.3.5, threats from the anthropogenic factor in Rote Ndao Regency which could potentially threaten coastal ecosystem especially coral reefs are the ports/harbours activity. With coastal population of 148,506 people, which most of them are residing adjacent to the sea, there has been a relatively low threat to the surrounding coastal ecosystem. Apart from the coastal areas, human activities around the many rivers in the mainland could also contribute to the threat by supplying sediments and wastewater onto the river. Over the largest river in the regency, Batulilok River has a port around the mouth (Batutua Port) that could potentially threaten the coastal ecosystem. Other than that, the regency is also supported by three other main ports, one PPI and three docks which are intended for fisheries and allowing easier transportation back and forth to the surrounding Rote Islands and elsewhere. The inter-island shipping line around Rote Ndao is concentrated in Ba'a Port in Lobalain and Ndao Port in Ndao Nuse, thus making activities in these areas are prone to harm the surrounding ecosystem. Further, Rote Ndao has one airport within a distance from the coastal and reef ecosystem, giving it a medium threat since the presence of airport will boost tourism around the vicinity. Currently, there are 26 hotels built for the purpose which are located close to the shore. These hotels rely on the various marine tourism activities and thus could also potentially harm the surrounding reefs in the long term.

9.3 Stakeholder Mapping and Local Institutional Capacity of Rote Ndao Regency

In Rote Ndao Regency, the community consists of small tribes who live in a customary unit called Nusak. Based on the Law on the Establishment of Rote Ndao Regency, this regency consists of 10 districts and 119 villages. However, in addition, Rote Ndao Regency also recognizes the existence of 19 Nusak regions, or kingdoms, in the Rote Ndao custom, which are led by a Maneleo, the king. Aspects of customary norms in indigenous peoples still have a very strong role in the sustainability of life in Rote Ndao Regency, especially in environmental preservation.

Each Nusak has customary leaders (one or more) called Manaholo who serve as watchers of the papadak/hoholok, namely customary regulations regarding natural resource management. The monitoring function of Manaholo consists of 4 tasks, namely (1) determining and punishing papadak/hoholok violations, (2) supervising papadak/hoholok in the border area between Nusak, (3) conducting routine patrols on the use of land and sea natural resources, and (4) reporting problems that cannot be resolved alone to Manaleo so that they can be discussed at a meeting of the Communication Forum for Indigenous People who Care for Culture (Oktavia, Salim, & Perdanahardja, 2018).

The Communication Forum for Indigenous People who Care for Culture (*Forum Komunikasi Tokoh Adat Peduli Budaya/FKTAPB*) in Rote Ndao Regency is a forum consisting of 19 Manaleos in Rote Ndao Regency. FKTAPB has a very strong political role in Rote Ndao Regency. Chairman of FKTAPB, Manaleo Inahuk Leonard Haning is a former Regent who served for 2 terms from 2009 to 2019. Furthermore, since 2019 the Regent of Rote Ndao has been held by Paulina Haning-Bullu, the wife of Leonard Haning. This shows the harmonious implementation of government and customs.

In maintaining the preservation of waters in the Savu Sea TNP, Papadak and Hoholok regulates the management of marine resources and its implementation is supervised by Manaholo (the supervisory traditional leader) in each of the Nusak areas. The Manaholos from 19 Nusak joined the Rote Ndao Community Supervisory Group (*Kelompok Masyarakat Pengawas/Pokmaswas*). In terms of this supervision, FKTAPB and Pokmaswas have received various supports from local government agencies (Rote Ndao Marine and Fisheries Agency), and the central government, such as the Ministry of Marine and Fisheries through National Marine

Conservation Area Agency (*Balai Kawasan Konservasi Perairan Nasional/BKKPN*), and NGOs, namely TNC, through several capacity building and institutional programs. In addition, the collaboration between the central government and TNC also started before and after the establishment of the Savu Sea as KKPN Savu Sea TNP by the Ministry of Marine and Fisheries (*Kementerian Kelautan dan Perikanan/KKP*) in 2014, through the Savu Sea Project. Additionally, during the online meeting with TNC field officer for stakeholder network validation, collaborations with local universities and community groups were identified: Nusa Cendana University, Artha Wacana Christian University, Kupang Muhammadiyah University, Kupang Marine Polytechnics, Indonesia Fisherman Association (*Himpunan Nelayan Seluruh Indonesia/HNSI*), *Rumah Perempuan*, and *Sanggar Suara Perempuan* Foundation.

Currently, the national program in Rote Ndao Regency is the Coral Reef Rehabilitation and Management Program (COREMAP-CTI) which is being implemented simultaneously in Raja Ampat Regency and Rote Ndao Regency. In Rote Ndao District, the implementing agency, National Development Planning Agency (*Badan Perencanaan Pembangunan Nasional/BAPPENAS*), is collaborating with Global Environmental Facility (GEF), World Bank, Indonesia Climate Change Trust Fund (ICCTF), The Indonesian Institute of Sciences (*Lembaga Ilmu Pengetahuan Indonesia/LIPI*), and KKP, collaborating with several NGO agencies and research institutions in implementing program activities at Savu Sea MPA, namely the Community Empowerment and Nature Conservation Education Association (*Yayasan Pemberdayaan Masyarakat dan Pendidikan Konservasi Alam/Yayasan YAPEKA*), Reef Check Indonesia, the Indonesian Coral Reef Foundation (*Yayasan Terumbu Karang Indonesia/Terangi*), and the Indonesian Environmental Information Center (*Pusat Informasi Lingkungan Indonesia/PILI*). In information as of December 2019, the source of funding for COREMAP-CTI came from a GEF World Bank grant of US $ 6.2 million.

In addition, in 2016 the Ministry of Marine and Fisheries Decree No. 51/2016 designated 20 islands as the location for the development of the Integrated Marine and Fisheries Center (*Sentra Kelautan dan Perikanan Terpadu/SKPT*), including Rote Island. The development of SKPT in Rote Ndao Regency has been running effectively and encouraging the growth of the fisheries and marine economic sector in Rote Ndao Regency through the provision of facilities and infrastructure for fisheries and marine activities such as ships, Air Blast Freezer with a capacity of 3 tons, 2 units and Ice Flake Mechine with a capacity of 10 tons as much as 1 unit. The success of this program is thanks to the support of various parties in Rote Ndao Regency, including the East Nusa Tenggara Marine and Fishery Agency (*Dinas Kelautan dan Perikanan/DKP*), Rote Ndao DKP, to the Indonesian Public Fisheries Company (*Perusahaan Umum Perikanan Indonesia/Perum Perindo*). The benefits of SKPT are also felt by the fishing community of Rote Ndao through the assistance provided to the Fishermen Coop.

Eleven years after the Montara Oil Spill incident in the Timor Sea, many actors are still identified in solving this environmental problem. According to online news sources, coral reef fishermen in Rote Ndao are suing for $182 million US Dollar in damages. This amount cannot be paid by PTT Exploration and Production Public Company Limited (PTTEP) Australasia, the company whose offshore rig exploded in 2009. This dispute resulted in the involvement of many mediating parties, namely the Coordinating Ministry for Maritime Affairs and Investment (*Kementerian Koordinator Maritim dan Investasi/Kemenko Marves*), the Rote Ndao fishermen advocacy team from the West Timor Care Foundation, Bandung Institute of Technology (*Institut Teknologi Bandung/ITB*) experts as loss assessors, the Ministry of Environmental and Forestry, the Australian Department of Environment and Energy, and Maurice Blackburn law office in Singapore as mediator.

Stakeholders were identified in disaster management midwives, namely Type B Rote Ndao Local Disaster Management Office (BPBD), Marine Army Military Police, Rote Ndao Police, and Kupang SAR Agency, and Rote SAR Office. Rote Ndao Regency does not yet have specific regulations governing the disaster management system. Apart from that, there is not much information about disaster management in Rote Ndao Regency. In several villages, local wisdom is still used in earthquake preparedness. The community shouted "ami nai ia o (we are there)" when the earthquake occurred so people ran out of their houses. The sentence "we exist" is a dragon snake that is believed to balance the earth, feels that no human is feeding it, so it gives a reminder by shaking the earth (Thene, 2016). According to the information from TNC field officer, disaster early warning from BMKG is available through whatsapp groups, especially targeted to Indonesian National Shipping (*Pelayaran Nasional Indonesia/PELNI*).

The above stakeholders are mapped in a stakeholder matrix as shown below. The driving actors consist of district agencies (Rote Ndao BPBD, Rote Ndao DKP) and national government (BKKPN, BAPPENAS, LIPI, KLHK), as well as indigenous community groups (FKTAPB and Pokmaswas). Various sources of information online indicate the active involvement and initiation of these actors in environmental conservation, disaster management, and advocacy for communities who are victims of the PTTEP oil spill case. Several NGOs have also played a similar role, categorized as partner and supporting actors.

The Spoiler, namely PTTEP, appeared because he was unable to provide compensation. In this case, there were also many mediators between Rote Ndao and PTTEP who had neutral positions such as the Coordinating Ministry for Maritime Affairs and Investment, Maurice Blackburn, and the Australian Department of Environment and Energy.

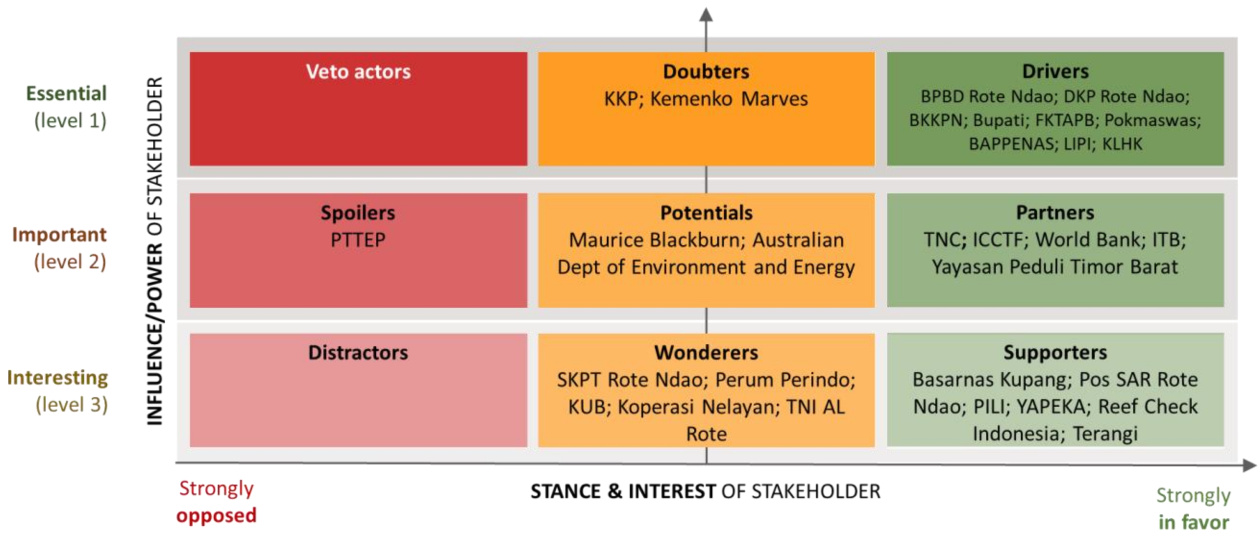


Figure 124 Rote Ndao Regency Stakeholder Map (Analysis, 2021).

In the stakeholder relations network of Rote Ndao Regency, 43 actors were found and 137 total ties.including relationships based on the existence of regulations or legal documents, the existence of a joint program, and conflict relationship due to the 2009 Montara Oil Spill incident.

The Montara oil spill incident in the Timor Sea was found to have enormous implications for the stakeholder network in Rote District. On the network, appear 11 red lines (conflict relationships) since the incident which occurred over 11 years ago.

In Figure 125 below, a cooperation between agencies in the district and central government seems very minimal due to a lack of sources of regulatory information and legal documents as well as popular media coverage. In terms of water resource management and environmental conservation, there are many relationships in joint programs between various parties (national government institutions, local governments, NGOs, and community groups).

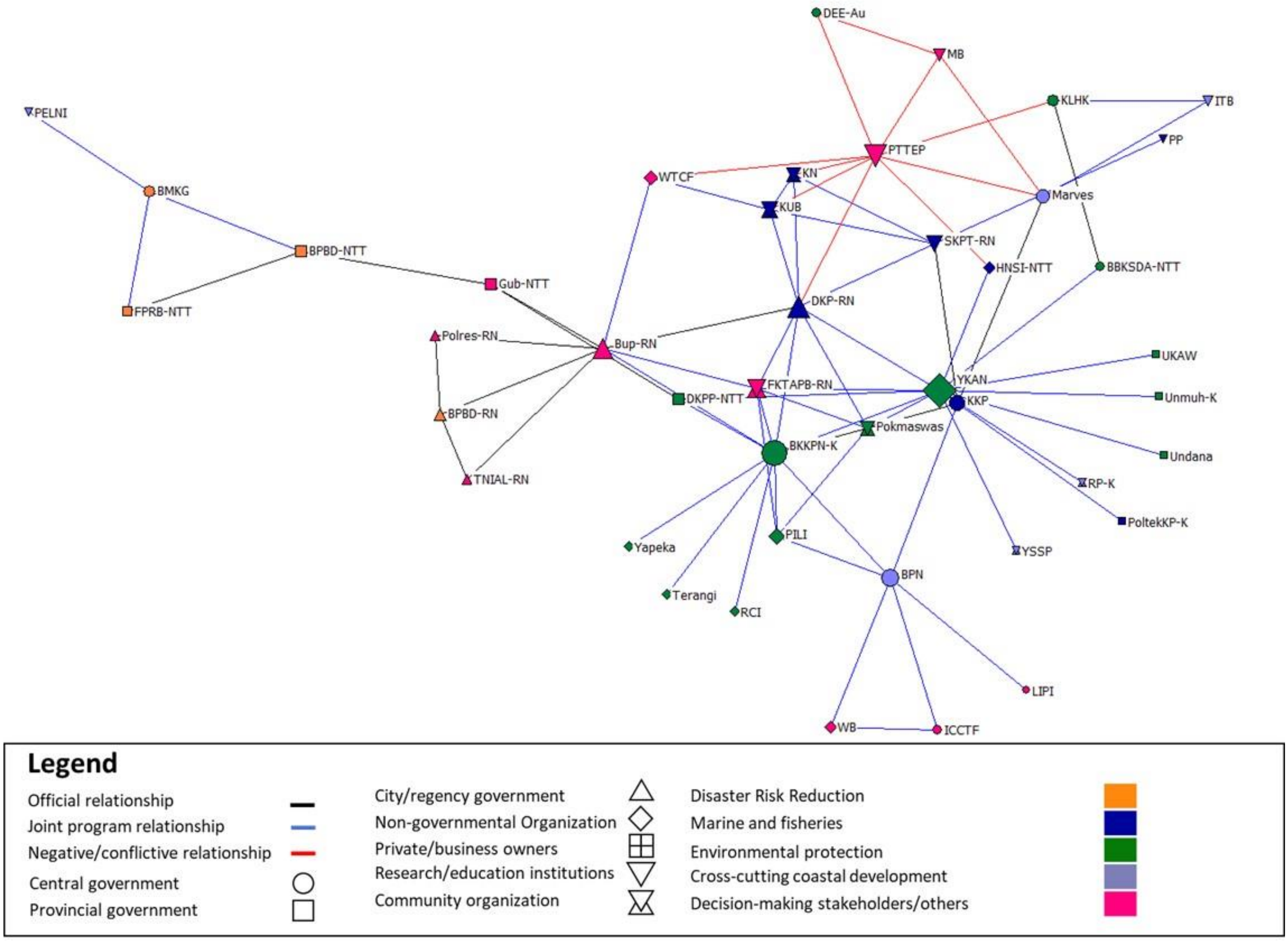


Figure 125 Social Network Analysis Diagraph between stakeholders in Rote Ndao Regency (Analysis, 2021).

The actors with the highest degree scores were PTTEP Australasia—due to Montara Oil spill conflict, followed by TNC, Rote Ndao Regenct, BKKPN, and Rote Ndao Marine and Fisheries Agency. The table of stakeholders with the high degree and betweenness can be seen in Table 30 below.

Table 73 Degree and betweenness centrality values of stakeholders in Rote Ndao Regency

Stakeholder	Degree
PTTEP Australasia	27
The Nature Conservancy	14
Rote Ndao Regent	13
BKKPN	12
Rote Ndao DKP	12

Stakeholder	Betweenness
The Nature Conservancy	305.88
BKKPN	246.42
Rote Ndao Regent	220.96
Rote Ndao DKP	170.57
NTT Governor	154.50

Source: Analysis, 2021

The capacity assessment using SPDAB in Rote Ndao relied on 2013-2033 Rote Ndao Spatial Plan, National Disaster Management Office (BNPB) Accountability and Performance Report 2019, and internet searches.

According to the sources found, Disaster Risk Assessment Map and Disaster Management Plan are not available yet in Rote Ndao Regency.

The primary DRR agency (LDMO) in Rote Ndao is a Type B BPBD. The BPBD is supported by Community Early Awareness Forum (FKDM) and traditional customs organization. However, disaster risk reduction is mentioned explicitly as one of the priorities in the 2013-2033 Rote Ndao Spatial Plan (RTRW Rote Ndao 2013-2033). This consequents in better consideration of DRR in some critical infrastructure and lifelines according to the spatial plan. For further assessment in this regency, the study will need primary data and information from local sources to validate assessment.

By using the SPDAB Tool developed by CARI! Team, the final score for Rote Ndao Regency is **23.9%** as shown in spiderweb diagram in Figure 126. The 26 measure indicators are divided into 4 pillars, namely: (1) Governance, Policy, and Planning Standard, (2) Preparedness and Socio-Economic Strengthening Service Standard, (3) Critical Infrastructure Protection and Recovery Preparedness Standard, and (4) Disaster Emergency Service Standard. The strongest pillar in Rote Ndao Regency is Disaster Critical Infrastructure Protection and Recovery Preparedness Standard (3rd Pillar), while the weakest is Disaster Emergency Service Standard (4th Pillar). Average score of each Pillar is shown in Table 74.

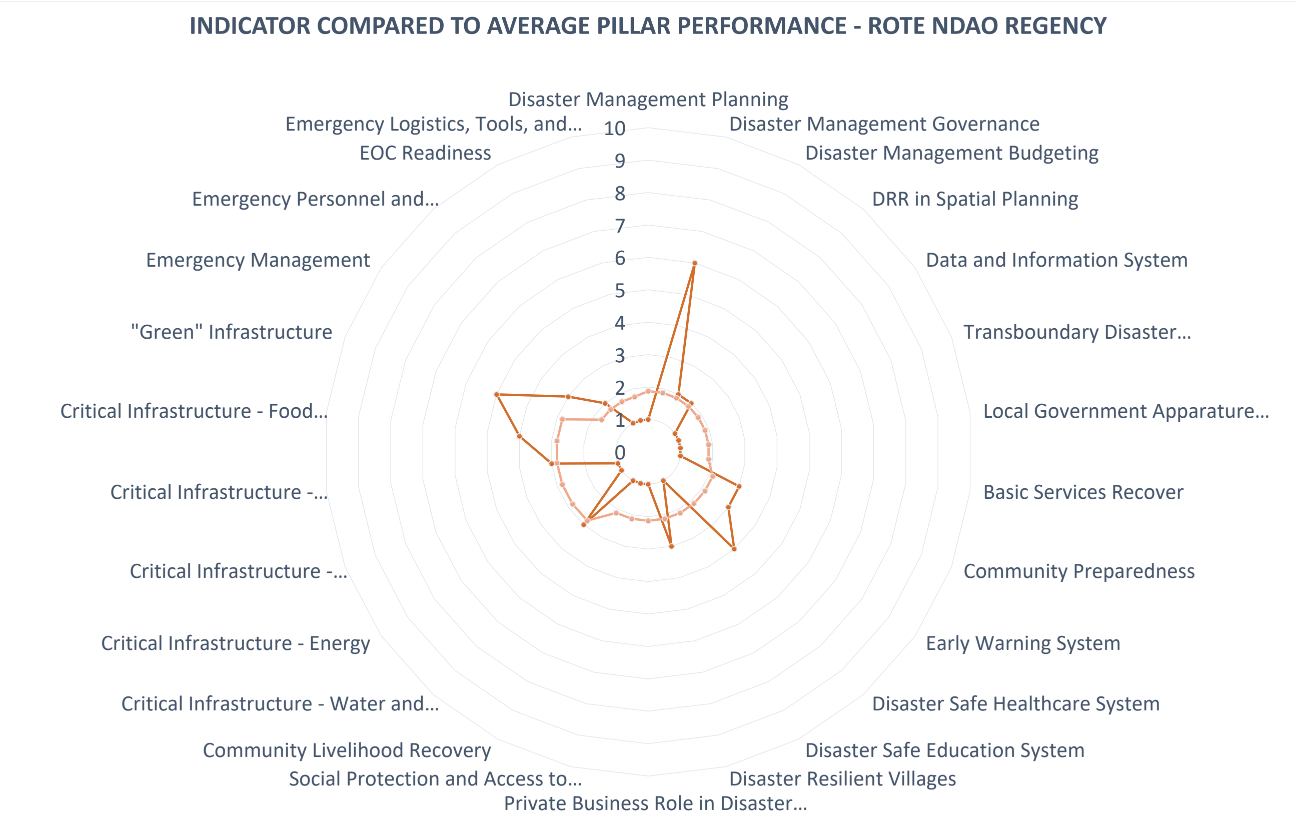


Figure 126 CARI! SPDAB Tool Output Spiderweb Capacity Diagram for Rote Ndao Regency (Analysis, 2021).

Table 74 SPDAB Pillar Average Indicator and Final Score in Rote Ndao Regency.

SPDAB Pillar	Average Indicator Score
PILLAR 1: Governance, Policy, and Planning Standard	1.88
PILLAR 2: Preparedness and Socio-Economic Strengthening Service Standard	2.13
PILLAR 3: Critical Infrastructure Protection and Recovery Preparedness Standard	2.83
PILLAR 4: Disaster Emergency Service Standard	1.75
	Final SPDAB Score = **0.239**

Source: Analysis, 2021.

9.4 Risk Profile, Valuation, and Scenario of Rote Ndao Regency

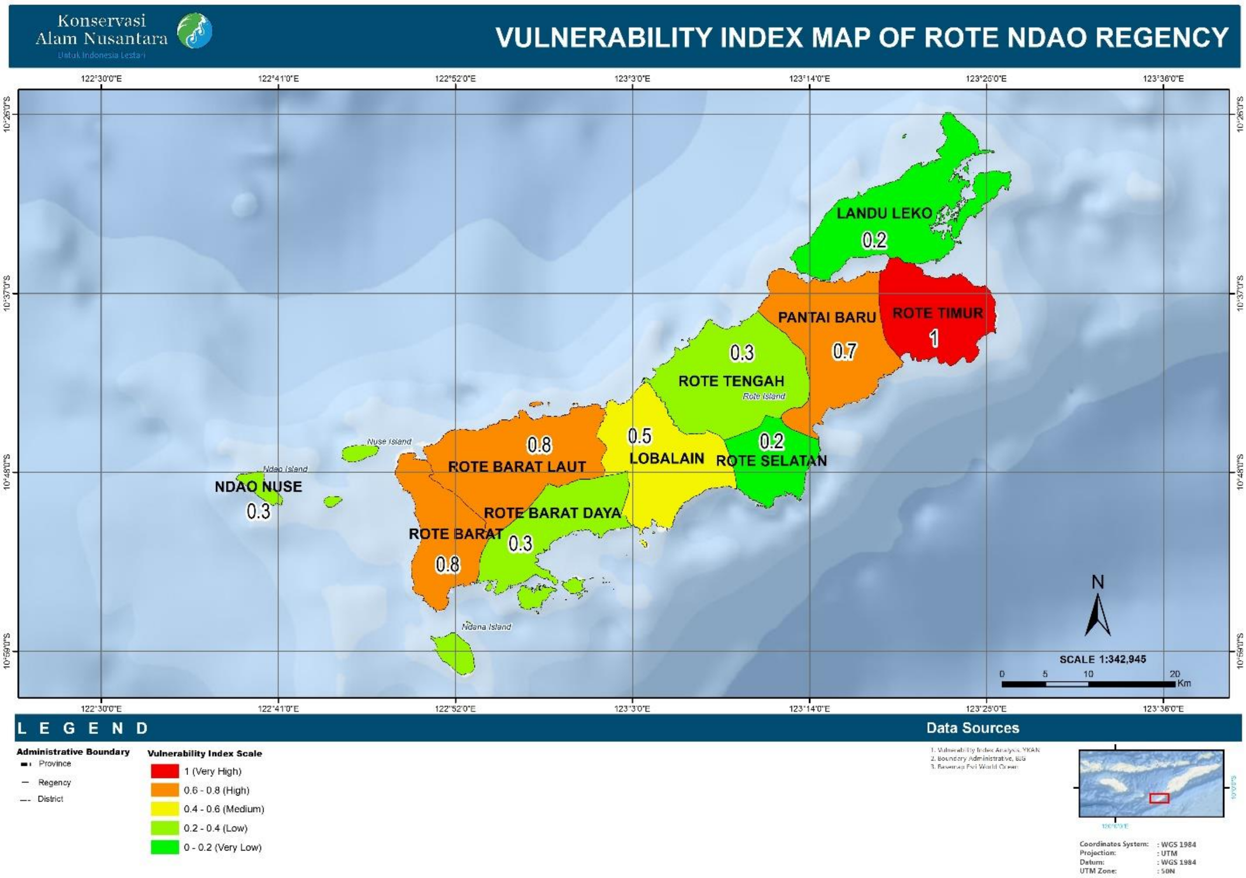


Figure 127 Vulnerability Map of Rote Ndao Regency

The value of the Disaster Risk Index (IRBI) of Rote Ndao Regency for multi-threats is 142.4 with a Medium risk class and ranked 281 in Indonesia (BNPB, 2018). This shows that Rote Ndao indeed is vulnerable to disasters, which are mainly floods and strong winds, according to the findings in section 9.2.1. As the southernmost regency, Rote Ndao is exposed to the climate variability from the Indonesian waters, Timor Sea waters and the Indian Ocean. The exposure values for all the districts presented are similar to that of Raja Ampat and Pandeglang with values ranging from 0.2 to 0.6, where East Rote has the highest index of 0.6. The sensitivity of the area is the highest in Lobaian for 0.7, followed by West Rote with 0.49. Having 0.24 as the adaptive capacitive index, the Vulnerability of Rote Ndao Regency was the highest in East Rote (1) and the lowest in South Rote (0.24). This numbers were shown in Figure 127 and Table 75.

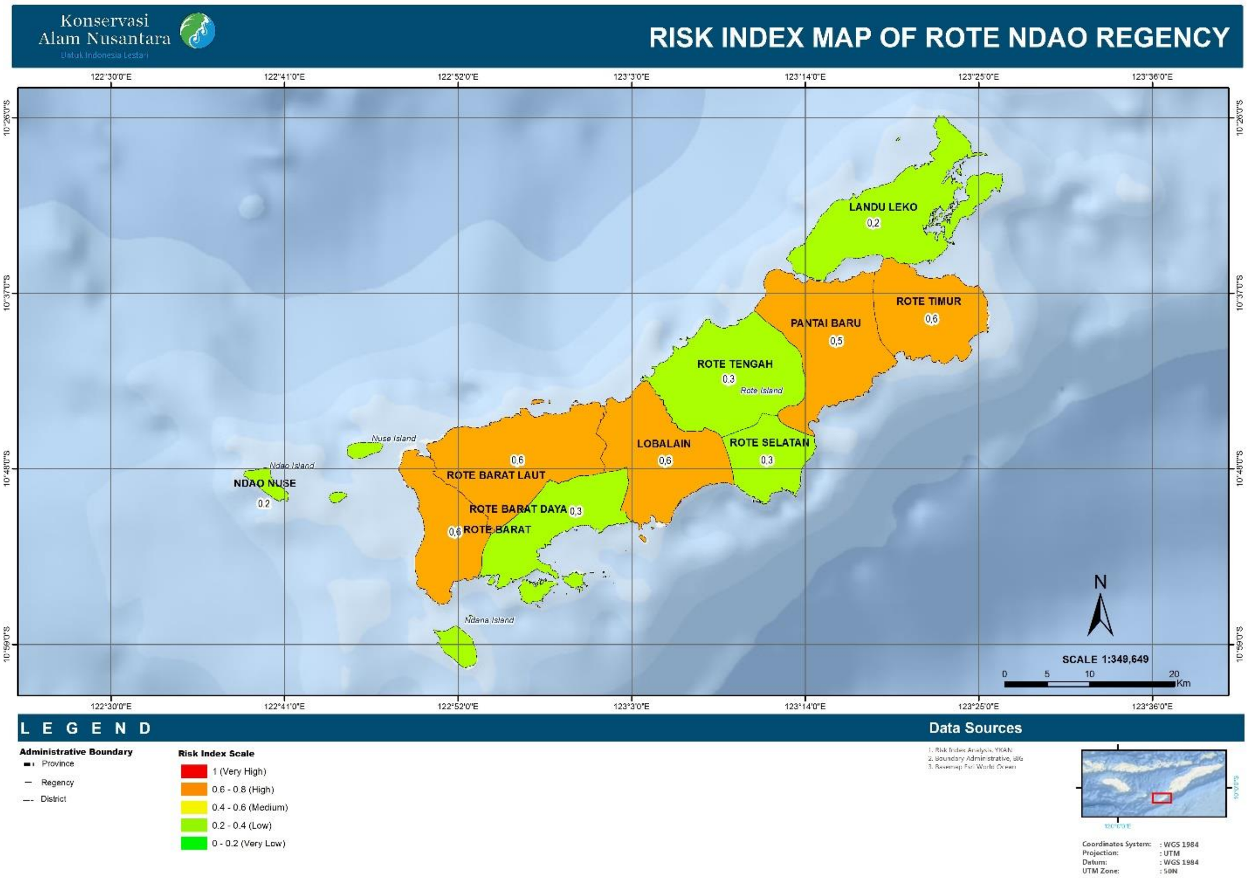


Figure 128 Risk Index Map of Rote Ndao Regency

According to the Hazard Index in Table 75, the highest number was obtained by Lobalain as of 0.8, followed by West Rote with the least index value sticks to Ndao Nuse and Landu Leko. As the newest districts, Nuse Ndao and Landu Leko are featured by a relatively high exposure (0.4 for Nuse Ndao) and a low to moderate sensitivity (0.32 for Landu Leko). Combined with the Vulnerability Index calculation, the overall Risk Index was the highest in West Rote and East Rote by 0.7 and the lowest in Landu Leko by 0.23. Apart from West Rote and Timur, two other districts in Rote Ndao are having high risk potentials, namely Lobalain and Northwest Rote. These areas were the ones considered as having 'high' risk (Figure 128). Looking closely by each of the index number, Lobalain and West Rote both are being the ones that have the highest number in both hazard and sensitivity scoring. As the capital city of Rote Ndao, Lobalain hold the most population and buildings, thus having high social and physical index counted within the Sensitivity Index. Further, West Rote is having the highest environmental index of all the districts while maintaining a balanced score between social, physical, and environment index.

Table 75 Risk Profile of Rote Ndao Regency.

District	Index Hazard	Index Exposure	Index Sensitivity	Adaptive Capacity Index	Index Vulnerability	Risk Index
Lobalain	0.80	0.20	0.70	0.24	0.58	0.68
West Rote	0.60	0.40	0.49	0.24	0.81	0.70
Southwest Rote	0.28	0.20	0.47	0.24	0.40	0.33
Rote Tengah	0.40	0.20	0.43	0.24	0.36	0.38
East Rote	0.49	0.60	0.45	0.24	1.00	0.70
Northwest Rote	0.49	0.40	0.53	0.24	0.88	0.66
Ndao Nuse	0.20	0.40	0.19	0.24	0.31	0.25
South Rote	0.49	0.20	0.29	0.24	0.24	0.34
Pantai Baru	0.40	0.40	0.47	0.24	0.78	0.56
Landu Leko	0.20	0.20	0.32	0.24	0.26	0.23

Source: Analysis, 2021.

In Rote Ndao regency, there were a total of 11 strong wind events and 10 floods that occurred within 20 years. According to the analysis in section 9.2.1, almost all of the affected came from strong wind and flooding events which happen quite frequently.

This study found that some of the strong wind and flooding events were induced by the tropical cyclone, although not always. There were quite a number of tropical cyclones formed and grow around Timor Sea and the Indian Ocean every year. Many of them can modify the weather in Rote Ndao both directly or indirectly. Through the study, some of the cyclones were caught having tracks above Rote Ndao and directly affecting the population in vicinity, even though it’s not frequent. Because tropical cyclones formed every year, some of them will potentially have an effect in Indonesia in the future.

Despite the tropical cyclones, Rote Ndao can be affected by a storm. A record in 2003 shows a total of 2400 people affected and 4 dead by a convective storm at that time. This study noted only one convective storm so far, but from the analysis in section 2.3.4, the storm might occur again in the future. The recorded data is showing how much a strong wind, whether it is a convective storm or a tropical cyclone, can affect people in Rote Ndao as the southernmost regency in Indonesia. Excluding the storm, strong wind occurrences only can be something to be expected every year as they can be a product of a tropical cyclone.

Regarding the coastal ecosystem, the coral reefs were found around the coasts of Rote Island evenly. Achmad et al (2013) shows that the hard coral cover percentage in the western part of Rote counts as the highest. The only record following the damage to coral reef from natural hazard is the climate change effect where in 2010 it was found that about 60% corals in Rote Ndao was bleached (Wouthuyzen et al, 2018). It was unfortunate that there were records about destructive fishing around the western part of Rote Island. It is known to be very damaging to corals and they will not be fully recovered in a short time. Apart from close anthropogenic damage, there was also the tragedy of Montara Oil leakage where the oil spill damaging most of the marine ecosystem in the surrounding area, including coral reef ecosystem.

Following the possible recurring risks that were analysed previously, the risk scenario of Rote Ndao Regency in monetary terms is also calculated and presented in the following figure. The calculations were done using the Blue Guide with inputs from the recorded disaster events and risk profiles of the regency. The approaching scenario forecasts the total damages and losses for the next 20 years with 5% discount rate to reveal a summary figure based on present currency value.

SCENARIOS

Basic approach (simplified)	
Timeframe (years into the future)	20
Discount rate	5%

In the basic approach, the three scenarios are automatically generated based on the data you entered above. Scenario A assumes that the level of damages and losses will remain the same as it was over the past 10 years. Scenario B assumes an increase by 10% (progressive increase by 2.5% every 5 years). Scenario C assumes an increase by 20% (progressive increase by 5.0% every five years). The discount rate of 5% is applied across all three scenarios to reveal a summary figure based on **present currency values**.

	SCENARIO A	SCENARIO B	SCENARIO C
Assumption for this scenario	The level of damages and losses will not change, compared to the past ten years: 0%	The level of damages and losses will progressively increase by*: 10%	The level of damages and losses will progressively increase by*: 20%
Year 1	24,302,500,000	24,910,062,500	25,517,625,000
Year 2	23,087,375,000	23,664,559,375	24,241,743,750
Year 3	21,933,006,250	22,481,331,406	23,029,656,563
Year 4	20,836,355,938	21,357,264,836	21,878,173,734
Year 5	19,794,538,141	20,289,401,594	20,784,265,048
Year 6	18,804,811,234	19,745,051,795	20,685,292,357
Year 7	17,864,570,672	18,757,799,206	19,651,027,739
Year 8	16,971,342,138	17,819,909,245	18,668,476,352
Year 9	16,122,775,031	16,928,913,783	17,735,052,535
Year 10	15,316,636,280	16,082,468,094	16,848,299,908
Year 11	14,550,804,466	15,642,114,801	16,733,425,136
Year 12	13,823,264,243	14,860,009,061	15,896,753,879
Year 13	13,132,101,030	14,117,008,608	15,101,916,185
Year 14	12,475,495,979	13,411,158,177	14,346,820,376
Year 15	11,851,721,180	12,740,600,268	13,629,479,357
Year 16	11,259,135,121	12,385,048,633	13,510,962,145
Year 17	10,696,178,365	11,765,796,201	12,835,414,038
Year 18	10,161,369,447	11,177,506,391	12,193,643,336
Year 19	9,653,300,974	10,618,631,072	11,583,961,169
Year 20	9,170,635,926	10,087,699,518	11,004,763,111
Total damages and losses over 20 years	311,807,917,413	328,842,334,565	345,876,751,716
Annualised average	15,590,395,871	16,442,116,728	17,293,837,586
		*In 2.5% increments every 5 years	*In 5.0% increments every 5 years

Figure 129 Risk Scenarios for Rote Ndao Regency (Analysis, 2021).

The summary in Figure 129 shows the damages and losses forecast in three scenarios A, B, and C. Following the recent monetary values calculation for the past ten years (Section 7.2.1), the forecasted monetary values for the next 20 years counts as IDR 311.81 billion with an annual average of IDR 15.59 billion (Scenario A). Scenario B takes into account the increasing level of damages and losses by 10% and by that, the total value elevates to IDR 328.84 billion. The forecasted annual average for Scenario B is IDR 16.44 billion, which takes into account a 2.5% of increments every 5 years. The most extreme scenario, Scenario C, have a 20% increase of damages and losses from Scenario A, which leads to a higher value of IDR 345.87 billion in total and an annual average of IDR 17.29 billion, with a 5% increments every 5 years.

10. Conclusions and Recommended Locations for Future Programming

10.1 Conclusions: Comparison of the Risk Profile in Selected Coastal Areas

This study provides a consolidated disaster events in the past twenty years for the selected hazards in each location, its risk profile, as well as preliminary monetary valuation of the risk scenario. Consequently, this chapter provides risk profile comparison of all locations. From natural hazards aspect, the most frequent and destructive hazard is floods by strong winds, with one exception in Raja Ampat which also frequently struck by earthquake albeit modest. Flood and strong wind are both caused by hydrometeorological factors, which highly dependent to changes in climate.

Even though this frequent disaster events (flood and strong wind) mostly impacted the coastal community, little is known for its direct impact onto the coral reef. As seen in chapter 4.2.1, there is an indication of sedimentation on the neighboring coral reef area due to massive flood events in Makassar in 2019. A similar condition of sedimentation indication is also found in Berau, particularly in Segah River. Segah River also used for shipping coal and other goods to other region. This river carried out large amount of sediment onto the sea. Depending on the season and ocean current, this large plume of sediment could also block the coral reef in Derawan or Maratua (1). While for strong wind events, impact for coral reef is very little known and studied, even though a strong wind events is frequent, its impact is only known to damage light structure or poor constructed houses.

On the other hand, rare and extreme hydrometeorological events such as storm or tropical cyclone event, as seen in chapter 5.4 4 in Nusa Penida also impacted the coral reef due to extreme coastal surge. Impact of TC could result in very high intensity of rain accompanied with strong wind which push water to surge coastal area. As seen in figure 18, occurrences of TC have a higher probability in the southern part of Indonesia rather than in the northern part. In the southern part, TC occurrences is likely to impact within three study area namely, Pandeglang, Klungkung and Rote Ndao. With regard of the TC track and geographical location of the three location which lie in border with Indian Ocean, there is high probability that in the future TC would impact heavily both on communities and coral reefs. The recent Tropical Cyclone Seroja on April 2021 in East Nusa Tenggara, and affecting Roted Ndao Regency, shows initial evidence of impact to the coral reefs.

Other hazard events with lesser frequency are more likely to have greater impacts both on coastal community and coral reef ecosystems. These events are earthquake and tsunami disaster events, such as shown in Pandeglang and Klungkung. In Pandeglang, earthquake and tsunami devastated communities in its coastal districts o also transported large boulder of coral to the beach due to tsunami waves (see chapter 3.2.1). While in Klungkung, massive Lombok Earthquake has also destroyed coral reef in Nusa Penida as well as shook the building in the Nusa Penida (see chapter 5.2.1.). Tsunami also possess threat to community and coral reef in Rote, Berau and Raja Ampat. From 500-year tsunami probability assessment, the area is exposed from tele / regional tsunami, i.e. those generated from afar. Rote is exposed from tsunami from subduction zones in its southern borders, Berau is exposed to tsunami from Central Sulawesi and Sulawesi Sea and Raja Ampat is exposed from its active faults in the “Bird Head” islands group and from far field tsunami.

With regards to hazards from volcanic eruptions, there are only two locations which are directly at risk, namely Pandeglang and Klungkung. In Pandeglang, from the last eruption in 2018, it is still little known for its impact for the coral reef in the surrounding reef. As mentioned before (see chapter 3.4), an indication of changes in coral density in Sangiang Island is known because of the eruption. While in Klungkung area, the impact of lava flow from Mount Agung has not reached the sea and impacted the surrounding reefs and its volcanic ashes impact is not known. In conclusion, impact of volcanic eruption is still very little known in the study locations, however the probability of occurrences of the volcanic eruption for this area is in medium probability.

In terms of occurrences, anthropogenic disaster events are not as frequent as those caused by natural hazards, but its damages have a clear impact on the coral reef and eventually to the coastal community itself. As seen in every location (see table 15, sub chapter 2.3.5) each categories of anthropogenic disaster could lead significant loss in the coastal and marine community and ecosystem. Marine accidents have a strong relationship with marine traffic activities. Human error both intentional or unintentional have led to accidents which caused grounded ships, sink ships or loss of life. In the study area, Raja Ampat, Makassar, and Wakatobi has substantially higher number of marine accidents due to their community characteristic and geography. Coastal community in these regions are mainly seafarer community, which relies much on the sea as their livelihood. Based on the marine traffic data, these three locations have a dense traffic from and to the seaports around within the location. It should be noted, however, that potentially the marine traffic data is under-estimated, since marine traffic data only recorded AIS data for ships above 35 GT, while most of the ships fleet is smaller than 35 GT. A high density of marine traffic could lead more risk to the community and also to the coral reef (from the dangers of pollution, grounding, wreck and tourism).

In addition, anthropogenic disaster such as destructive fishing is the most concerning issues in the forthcoming future for the coral reefs’ ecosystem. All area in this study has a historical record regarding destructive fishing and there is no sign of stopping although law enforcement is already applied. A positive comeback comes from Klungkung Regency which has establish marine protected area with all of it requirements which are in line with local traditional wisdoms. This has made destructive fishing reduce and switched to tourism. Although it should be noted too, there is destructive activities outcome from tourism such as land reclamation (see chapter 5). Land reclamation is not exclusively happening in Klungkung, whereas in Makassar reclamation is massive due to two major projects namely Makassar Center Point and Makassar New Port. In other area local people usually use hard coral for building materials, hence the disruption is not as extensive as major reclamation projects.

With regards to slow onset hazard analysis, this study has found that all regions have cases of bleaching events with different degree of severity. The most extensive bleaching reports in all sites observed in Makassar and Klungkung with degree of severity reaches 60% (Wouthuyzen et al 2018). If not handled with serious interventions, this event could severely impacted coastal community, especially those who depends their lives on marine resources. Further studies elaborate that if there are no measures of mitigation against climate change, the impact on coral reef in the upcoming years will be worsen (see chapter 2.3.4).

To provide a comparative perspective, the table below provides a multi-hazards risk index of all locations (BNPB, 2018), The study locations have high risk due to multi-hazard, except Wakatobi which has moderate risk. The multi-hazard risk from BNPB assessed all occurred hazard in Indonesia including the hazard which either did not affect the corals such as landslide or the hazard did not occur in coastal area. It should be noted that the IRBI index was operationalized at regency level and include all type of hazards and not specifically for those studied in this report, hence, the risk information is only for reference.

Table 76 Risk on & Study Locations Based on Indonesian Multi-hazards Disaster Risk Index (IRBI).

Location Paramater	Risk index / IRBI (2019)	Risk class, IRBI	Risk rank IRBI (out of 534 cities/regencies)
Pandeglang	215.2	High	5
Makassar	131.78	High	341
Klungkung	163.39	High	154
Wakatobi	135.6	Moderate	322
Rote Ndao	142.4	High	281
Raja Ampat	135.74	High	321
Berau	202.4	High	34

Source: BNPB, 2018

As the basis for risk comparison of the 7 study sites, Table 77 below summarizes the risk profile and the anecdotal evidence of damages to coral reefs.

Table 77 Risk Profile Comparison from This Study in 7 Locations.

Natural Hazard Risk Parameters	Pandeglang	Klungkung	Makassar	Wakatobi	Berau	Raja Ampat	Rote Ndao
Number of NH Disasters from 2000-2020	108	28	34	23	7	12	23
Most frequent events from 2000-2020	Floods	Floods, strong wind	Flood	Strong wind	Strong Wind, Floods	Earthquake, Strong wind	Strong wind, Floods
Worst disaster event (single)	Tsunami Krakatau 2018	2018 Lombok Earthquak e	South Sulawesi Flood 2019	None	Flood	2015 Earthquake	None
Monetary value of future scenario of damage & losses (IDR)	59,035.93 Billion	2,718.3 Billion	247.4 Billion	53.8 Billion	1.7 Billion	69.5 Billion	15.6 Billion
Probability of tsunami based on number of Earthquake Disasters from 2000-2020	0.80	0.40	None	0.10	0.05	0.30	0.05
Coral Damages Evidence by Earthquake from 2000-2020	Y	Y	None	None	None	None	None
Earthquake Probability damages (PGA Analysis)	High	High	Low	Low	Low	Medium	High
Probability of tsunami based on number of Tsunami Disasters from 2000-2020	0.05	None	None	None	None	0.05	None
Coral damages evidence due to tsunami from 2000-2020	Y	None	None	None	None	None	None
Tsunami Probability (PTHA, Horspool et al, 2014)	High	High	Low	Medium	Low	Low	High
Probability based on number of flood disasters from 2000-2020	2.7	0.15	1.05	0.15	0.1	0.1	0.5
Coral damage evidence by flood from 2000-2020	None	None	Y	None	Y	None	None
Flood Probability	Low	Low	Medium	Low	Medium	Low	Low
Probability based on number of strong wind disasters from 2000-2020	0.5	0.5	0.65	0.75	0.2	0.15	0.55
Coral damage evidence by strong wind from 2000-2020	None	None	None	None	None	None	None
Strong Wind Probability damages	Low	Low	Low	Low	Low	Low	Low
Probability of based on number of coastal surge disaster from 2000-2020	0.5	None	None	0.15	None	0.05	0.05

Natural Hazard Risk Parameters	Pandeglang	Klungkung	Makassar	Wakatobi	Berau	Raja Ampat	Rote Ndao
Coral damage evidence by coastal surge from 2000-2020	None	Y	None	None	None	None	None
Coastal surge probability damages	Low	Medium	Low	Low	Low	Low	Low
Probability of based on volcano disaster from 2000-2020	0.05	0.1	None	None	None	None	None
Coral damage evidence by volcanoes from 2000-2020	Y	None	None	None	None	None	None
Volcano probability damages	Low	Low	None	None	None	None	None
SLR rate (cm/year; Bappenas, 2018_	0.74-0.75	0.74-0.75	> 0.76	0.75-0.76	0.75-0.76	0.75-0.76	> 0.76
Coral Reef status observation (Hadi et al, 2019 – LIPI)	Fair	Poor	Poor	Good	Poor	Good	Fair
Coral Bleaching Evidences	Yes	Yes(3)	Yes(2)	Yes(2)	Yes(2)	Yes(2)	Yes
Coral bleaching prediction (Bappenas, 2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Summary	**High**	**High**	**Medium**	**Low**	**Low**	**Low**	**Medium**

Source: Analysis, 2021.

Based on the hazards and risk profile due to natural hazards and anthropogenic hazards, a risk matrix table is generated in Table 78. It is shown that from seven study location, coastal communities and ecosystems in Pandeglang, Klungkung and Makassar are having the highest risk. This is followed with Raja Ampat with medium risk, and Wakatobi, Berau, and Rote Ndao with lower risk. At the end, this qualitative classification could give valuable input for future DRR and conservation programming in the future, which should be followed by an in-depth and onsite studies.

Table 78 Summary of coastal risk (community and coral reefs) parameters in all study location.

Coasta zone risk parameters	Pandeglang	Klungkung	Makassar	Wakatobi	Berau	Raja Ampat	Rote Ndao
Summary of Natural Hazard risk parameter	**High**	**High**	**Medium**	**Low**	**Low**	**Low**	**Medium**
Summary of Anthropogenic Hazard Risk Parameter	**Medium**	**Medium**	**High**	**Medium**	**Low**	**High**	**Low**
Risk SUMMARY	HIGH	HIGH	HIGH	LOW	LOW	MEDIUM	LOW

Source: Analysis, 2021

In addition to risk profiling, this report also provides initial on stakeholder mapping and local capacity analysis. Generally, all locations are having moderate interest towards DRR and risk insurance programming. Regardless of the pattern and dynamics of the relationship between stakeholders in the seven locations, it is notable that the interest and stance level of most stakeholders tends to be neutral-to-positive. In other words, there is significant support towards various programs and activities for disaster risk reduction and marine conservation and protection in all seven locations. Conflict relationship pattern is quite dominant in Makassar City and Rote Ndao Regency, and relatively less in Klungkung Regency and Pandeglang Regency.

1. **Pandeglang Regency.** The stakeholder identification and mapping in Pandeglang District show that the momentum of emergency response and recovery activities from the 2018 Tsunami is still ongoing. This can be used further for the initiation of coral reef conservation programs/activities or general coastal protection, while integrating disaster risk reduction (DRR) programs or nature-based solutions (Eco-DRR). Data compilation and analysis show that there are joint programs/activities between the Ministry of Marine and Fisheries, Provincial Marine and Fisheries Agencies, City/Regency Marine and Fisheries Agencies, community groups, and business owners in coral reef conservation efforts. However, there is still a need for further analysis on whether these relationships are ceremonial or strategic. Although there is currently some major development in the Tanjung Lesung Tourism SEZ and massive Carita Beach tourism activities, there are no significant conflicts in this location.

2. **Makassar City.** According to the stakeholder identification and mapping, relationships between actors in Makassar City are dominated by dynamics regarding the development of the Central Point of Indonesia (CPI) and Makassar New Port reclamation areas which have been going on for several years. The dynamics have initiated the conflict between local government institutions, business actors, NGOs, and community groups, including the fishing communities. In addition, a sub-network of disaster management actors was identified, in which was post-emergency response of the January 2019 floods in South Sulawesi. As a result, the sub-network of actors focusing on coral reefs conservation did not show dominant in the stakeholder network, if there was any, including in an archipelago in the western part of Makassar City and the Kodinrangeg Island.

3. **Klungkung Regency.** The stakeholder identification and mapping in Klungkung Regency shows a concrete working relationship, not only based on the organizational structure of the governmental agencies, but also vertically between the Bali Province agencies and the Klungkung Regency agencies. The analysis result found a single driving actor in coastal protection development, Coral Triangle Center (CTC). CTC acts as a Driver actor in Nusa Penida conservation by assisting with the Nusa Penida Marine Conservation Unit's tasks and duties. However, conflict relationships were found in the development plan of the Integrated Cultural Center by the Bali Provincial Government and a jetty by a private developer in Nusa Penida island. The cultural center will be located in Gunaksa Village, Klungkung Regency, which is a tsunami-prone area. Meanwhile, the jetty construction was reported to cause damages to the coral reefs and environment.

4. **Wakatobi Regency**. Wakatobi Regency, according to current analysis, has the number of stakeholders relative to the other 6 locations. The analysis shown that the relationship in terms of disaster risk reduction is very normative, only based on generic regulations and without any indication of concrete programs/activities in DRR or coastal and marine protection. The main Driver actor in Wakatobi Regency is the Wakatobi National Park Agency (technical implementation agency under the Ministry of Environment and Forestry). There is a sub-network in the conservation planning and monitoring of Wakatobi Marine National Park initiated by the Wakatobi National Park Agency, by involving several NGOs and local community groups such as Forkani, traditional community groups, and the Dewara Group.

5. **Berau Regency.** The relationship between stakeholders in Berau District is quite influenced by two main conservation areas are managed by two different ministries: Derawan MPA under the Ministry of Marine and Fisheries, and the Sangalaki-Semama Islands under the Ministry of Environment and Forestry. The Derawan Conservation Area (KKP3K KDPS) is managed by BPSPL (technical implementation agency under

the Ministry of Marine and Fisheries) and East Kalimantan Government. There are already some programs collaborations with non-governmental organizations, including GIZ, TNC, WWF, and Mulawarman University. Meanwhile, the Sangalaki-Semama islands management is done by the East Kalimantan BKSDA (UPT under the Ministry of Environment and Forestry).

6. **Raja Ampat Regency.** In Raja Ampat Regency, there are two sub-networks, one each on disaster management and environmental conservation. Based on the analysis results, the Raja Ampat Regent was very inactive both in the environmental protection and disaster management. This caused the stakeholder network in Raja Ampat Regency to be in the two separate sub-networks. Disaster management in Raja Ampat is not going well, with indications of the possible influence of the BPBD fund corruption case that was still under investigation until 2018. The environmental and coastal conservation sub-network in Raja Ampat shows better congruence among stakeholders with various track records of cooperation between the national government agencies, NGOs focusing on and coastal environmental protection (including TNC) as well as a massive investment in marine conservation through COREMAP-CTI program.

7. **Rote Ndao Regency.** The stakeholder identification and mapping in Rote Ndao Regency indicated normal coordination among governmental agencies in the regency level in Rote Ndao. The findings show that the indigenous people in Rote Ndao are led by the FKTAPB (ruled by Manaleo Inahuk/King). FKTAPB, which shows great concern for marine protection, has a dominant political influence in Rote Ndao. More collaborative relations in Rote Ndao Regency also occur with the implementation of the COREMAP-CTI program. However, a major conflict relationship is still ongoing with PTTEP (PTT Exploration and Production (PTTEP) Australasian) who owns the oil drilling rig and responsible for the 2009 Montara incident. The Coordinating Ministry of Maritime Affairs and Investment proposed the solution for this matter by inviting a 3rd party to conduct a fair loss assessment.

Table 79 Local Capacity Comparison.

Location Parameter	Pandeglang	Klungkung	Makassar	Wakatobi	Berau	Raja Ampat	Rote Ndao
BPBD Type	B	A	N/A	A	N/A	A	B
BPBD central to network (Y/N)	Yes	No	Yes	Yes	Yes	Yes	No
Enviro Agency Type	A	A	A	N/A	N/A	N/A	N/A
Env Agency central to network (Y/N)	Yes	No	Yes	No	No	No	No
Marine Agency type	B	B	A	N/A	N/A	N/A	N/A
Marine Agency central to network (Y/N)	Yes	No	No	Yes	No	Yes	Yes
Current existence of a BLU or relevant BUMD to DRR & Marine	No (BLU LPMUKP activity)	No	No	Yes	No (BLU LPMUKP activity)	Yes	Yes
DRR Forum	No	Yes	No	Yes	Yes	No	Yes
Enviro/marine protection forum	No	Yes	Yes	Yes	No	No	Yes
Type of strategic actors identified in the network	Multiple	Multiple	Multiple	Single	Multiple	Multiple	Multiple
Complexity of conflict	None	Low	High	None	Low	Low	High
Women champions/ Women's group	No	Yes	No	Yes	No	Yes	Yes
DM Strategy Planning doc	Yes	No	Yes	No	No	N/A	N/A
KRB doc	Yes	Yes	Yes	Yes (draft)	No	Yes	N/A
Spatial planning doc	Yes, 2011-2031	Yes, 2013-2033	Yes, 2015-2034	No	Yes, 2016-2036	No	Yes, 2013-2033
MPA document & existence	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DRR budget (final year, IDR)	24.4 billion	3.8 billion	7.5 billion	3.4 billion	1.9 billion	N/A	N/A
Realized local income (2019, million IDR)	2,210,158	1,215,589	4,117,588	819,176	2,649,842	1,204,953	812,863
SPDAB Score / Adaptive capacity index	0.274	0.359	0.325	0.188	0.226	0.154	0.239
SPDAB rank (maximum 5)	Class 2	Class 2	Class 2	Class 1	Class 2	Class 1	Class 2

N/A: Not yet rated.

Source: Analysis, 2021

Table 80 SWOT Analysis of each location relative to “DRR, coastal conservation, and risk insurance”

Location	Traits			
	Strengths	**Weaknesses**	**Opportunities**	**Threat**
Pandeglang	✓ No existing conflicts identified within stakeholder network ✓ Local government with high interest to environmental issues ✓ High priority on DRR due to momentum from the 2018 tsunami recovery ✓ Local income relatively higher than other locations and significant increase in last 2 years ✓ Ongoing coral reefs protection programs under collaboration framework between MMAF, local government, and private actor. This should be sustained and used for leverage	✓ Vast geographic areas, which means the local government OPDs have higher operation cost to reach/manage program in coastal areas ✓ Southern coastal sub-districts are lagging in their development compare to those in tourism zone ✓ High disaster risk index according to BNPB IRBI 2020	✓ Tanjung Lesung SEZ may bring potential external investment. This can be leveraged for a environmentally friendly program. ✓ High interest from MMAF for allocating resources and program related to coral reefs to Pandeglang	✓ Tanjung Lesung SEZ may bring potential external investment. This may also possed a threat should the investment disregards risk reduction aspect.
Makassar	✓ Has the highest local income and size of economies compared to other 6 locations ✓ Outer islands of Makassar city with coral reefs distribution not yet disrupted by reclamation activities ✓ Relatively higher human capital available and competent organizations (e.g., universities, NGOs)	✓ Open conflict within actors in the city around coastal reclamation (existing and planned ones) ✓ Most local government agencies are in neutral category for DRR and environmental conservation ✓ As one of the national strategic area and development engine (PKN) Makassar will continue to have capital inflow that increase development activities and potentially hampering the environment ✓ High disaster risk index according to BNPB IRBI 2020	✓ Major construction projects by national government (CPI and Makassar New Port) makes strong justification for the needs of coral reef insurance ✓ Fund and capital inflow from private developers and national government from the development projects ✓ As capital of Mamminasata agglomeration area, program success in Makassar might trigger duplication in surrounding areas	✓ Open conflict between actors in the city and actors from Jakarta around coastal reclamation (existing and planned ones)
Klungkung	✓ Existing pro-environment actors & activities with access to	✓ Lack of existing DRR regulation, disaster management plans, and	✓ Existing collaboration initiatives with BMKG towards Bali as	✓ Major tourism construction projects (e.g., jetty, potentially

Location	Traits			
	Strengths	**Weaknesses**	**Opportunities**	**Threat**
	multiple stakeholders (NGO, national government, community groups, private entities) ✓ Existence of relevant programs in the area, e.g., coastal and marine patrols, coral reef conservation, reef check	considerations of DRR in spatial and development plans High disaster risk index according to BNPB IRBI 2020	InaTEWS backup station. Implementation of program and this initiative will showcase a holistic approach to coastal DRR ✓ DRR priorities from provincial level government ✓ International exposure as nature-based tourism destination ✓ Bali is hosting GPDRR 2022, and investing DRR program can have a better selling point	causing damage in Nusa Penida District) causing conflicts between external private actor and local government agencies / local communities
Wakatobi	✓ No existing conflicts identified within stakeholder network ✓ Existing MPA arrangement by MMAF and established single agency in charge of MPA conservation (Wakatobi National Park Agency) ✓ Good working relations between ministries, local government, and local communities	✓ Lack of existing DRR regulations, risk assessment, and disaster management plans	✓ Ongoing collaboration and interests from major international NGOs with potential access to external funding	✓ *There is no significant threat factor identified*
Berau	✓ Possible available funding through CSR from companies in the area ✓ Active collaboration between Province and Regency government ✓ Local income relatively higher than other locations and significant increase in last 2 years ✓ Existing collaboration with various local and international NGOs ✓ Existing MPA and KSPN arrangement	✓ Lack of existing DRR regulation, disaster management plans, and considerations of DRR in spatial and development plans	✓ Active (dominant) participation of provincial government in DRR, environmental protection, and marine and fisheries ✓ Provincial government has capital leeway to finance Berau	✓ Natural resource exploitation might cause complicated environmental protection and advocation (mining and palm plantation) ✓ Increased trend of tourism activities, may resulted in fatigue and additional stressors to coastal ecosystem

Location	Traits			
	Strengths	**Weaknesses**	**Opportunities**	**Threat**
Raja Ampat	✓ Available fund for Environmental Services and Maintenance activities using fees collected by BLUD ✓ Existing BLUD and experience to collect and manage fee charged to visitors ✓ Local reliance on marine based tourism assures support from related local agencies in Raja Ampat ✓ Sustained *Sasi* practice by local community, including traditional community leaders and religious groups	✓ DRR leading agency (LDMO) has bad track record due to corruption case ✓ Lack of existing DRR regulations and disaster management plans or considerations of DRR in spatial and development plans ✓ High disaster risk index according to BNPB IRBI 2020	✓ External donors have positive valuation to invest activities in the area (COREMAP-CTI) ✓ Incoming research and community development on marine protection following the national program implementation ✓ Interests and ongoing contributions from multiple international NGOs	✓ Weak collaboration between regency and provincial level agencies
Rote Ndao	✓ Strong and harmonized institutional and traditional cooperation ✓ Presence of an Integrated Marine Fisheries Center supported by a state-owned company ✓ Local economies depend on marine and fisheries resources, hence local government and communities are aware with the protection function ✓ Sustained *Sasi* practice by local community, including traditional community leaders and religious groups	✓ Unavailability of local budget for funding (the regency has the smallest in local income compared to other locations) ✓ Lack of existing DRR regulations, disaster risk map, and disaster management plans ✓ High disaster risk index according to BNPB IRBI 2020	✓ External donors have positive valuation to invest activities in the area (COREMAP-CTI) ✓ Vast access for the local government to research and capacity building resources / programs on marine protection following COREMAP-CTI implementation ✓ The 3rd party valuation and mediation on Montara oil spill damages provide additional leverage for the local government and communities to have higher compensation	✓ Montara oil spill case remained unfinished for over 12 years, dragging the recovery efforts

Source: Analysis, 2021.

10.2 Recommended Locations, its Justifications, and Potential Follow Up Activities

Risk-transfer oriented Programming Scenario

With reference to the locations' risk profile, solely looking into the level of risk and the potential of a manageable coastal risks, this studi conclude that the prioritized areas would be Pandeglang, Makassar, Klungkung, and Raja Ampat. In a more orderly manner, this study ranks every site on study based on their severity (damage loss) due to natural hazard and their anthropogenic factors. As summarize in sections 10.1, it is concluded that the area with high risk to low risk (in orderly) are:

1. Pandeglang
2. Makassar
3. Klungkung
4. Raja Ampat
5. Wakatobi
6. Rote
7. Berau

It is obvious due to its existing existing hazards and its potential damages, Pandeglang is ranked first among the rest. Makassar on the other hand, although its existing hazard low and its number of potential threats limited, but due to its high vulnerability it also has lot of potential loss and damages in the future. While Klungkung, on the other hand due to its vulnerability is lower than the Makassar, it is placed on the third place. At last position is Berau which have minimum existing hazard and also has minimum known damages sits on the last risk of all the seven sites.

Quick Win Programming Scenario

If for further implementation the program aims to achieve quick wins in 3 pilot locations, the proposed location is Klungkung, Raja Ampat, and Pandeglang. These recommendations are based off several factors, namely key stakeholder stance/interest, stakeholder network congruence, existing previous TNC programs, and access to funding.

Klungkung Regency easily makes the cut due to several reasons. First, conservation issue in one of the MPA located in a world-know tourist destination will surely have a high selling point. Pilot program implementation in Klungkung Regency, Bali will easily gain acknowledgement from important international organizations. Bali as the host of Global Platform for Disaster Risk Reduction in 2022 only adds to this advantage. Moreover, as shown in the stakeholder identification and network analysis, stakeholder networks in Klungkung shows the best synergy between local government agencies, provincial government agency, NGO, and local communities. Moreover, international and national exposure on importance of DRR in Nusa Penida MPA and Bali strategic tourism area potentially result in future funding opportunities from influential organizations.

Klungkung Regency also showcases high-functioning stakeholder synergy in coastal protection through routine program conducted jointly by local government agency (UPTD-KKP) and NGO (Coral Triangle Center/CTC). CTC is one of the partner organizations of TNC in Klungkung is categorized Driver actor. By using the existing connection between TNC and CTC, collaboration with local actors in the program implementation has tendency to be smooth sailing with little to no collaboration challenges.

The second location recommendation for quick wins is Raja Ampat Regency. Firstly, TNC has established a high positioning in the marine protection affairs in Raja Ampat through pioneering Raja Ampat MPA planning and implementation since 2003. According to the stakeholder analysis, Driver stakeholders in Raja Ampat has shown strong relationships with TNC and will be ready for new collaboration in this program.

In terms of funding availability in Raja Ampat, it is important to consider potential external donor, namely GEF World Bank funded major investment, COREMAP-CTI, which was planned to be implemented since 2020. If the program is to be implemented simultaneously with COREMAP-CTI, TNC needs to collaborate with BAPPENAS team-in-charge for COREMAP-CTI in Raja Ampat Regency as the key collaboration actor.

Third and fourth option for quick wins are close call between Pandeglang Regency and Berau Regency. In this recommendation, Pandeglang has better advantage to Berau Regency due to simpler to solve conflict. While Pandeglang stakeholder network shown some conflict between developers and local community, conflicts between local government and nature-based exploration companies in Berau might be more complicated to resolve and could become future threat to the program. Moreover, Tanjung Lesung SEZ in Pandeglang Regency will add some leverage to program potential funding source and support from national government agencies/ministries. Pandeglang Regency government has also put high prioritization for DRR since the tsunami in 2018 which recovery efforts are still going on until present. This combined with local government interest in environmental issues in Pandeglang Regency will make the program intention to be easily accepted and gain better support and collaboration. For quick win in Pandeglang Regency, since according to current information TNC has not conducted previous programs or collaborations in Pandeglang Regency, strong trust and good relationship with Pandeglang government must be built early on. Pandeglang Regency also have relatively high income compared to other location, ranking 3rd out of 7.

Recommendations for future programs and activities to support risk insurance formulation.

Data and information processed in this report is limited due to remote works / remote engagement. At the same time, consultation processes with key stakeholder are also not assigned to this Study. Hence, the following activities can be considered for future activities:

1. Onsite and micro level risk assessment for the relevant and selected hazards, including natural and anthropogenic hazards.
2. Onsite data collection for filling the gaps on anthropogenic hazards. As this study pointed out, a structured process of data collection in maritime accidents or groundings are more recent than natural disasters. Hence, this step is crucial since this study also shows that the anthropogenic factors more influential to the risk profile of coastal areas and coral reefs.
3. Onsite engagement with the selected project's location to validate the initial stakeholder mapping results of this study. This can also support and provide additional buy-in to the program.
4. Based on the variation of disaster damage and losses data, this study recommends that the potential and insurable assets (in addition to YKAN's intention to provide coral reefs insurance) are housing and public buildings, e.g., schools or hospitals.
5. Cross-sectoral study to investigate initial success and technical factors of agriculture-based insurance scheme, particularly those covered as part of climate-insurance. Since as discussed in Chapter 2, the study found more insurance-related scheme in agriculture sector.

Annexes

1. Past disaster events caused by natural hazards (1 spreadsheet)
2. Past disaster events caused by anthropogenic hazards (1 spreadsheet)
3. High-resolutions maps and
4. Processed layers
5. List of stakeholders by locations
6. SPDAB findings of each location
7. Scenario for potential monetary damage and losses

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