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Environmental sensitivity spatial analysis for oil spill mitigation in rote Ndao district waters

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ABSTRACT

The marine ecosystems in the southern part of Rote Ndao District, within the Timor Sea, could be harmed by oil spills from ships or offshore rigs operated by oil and gas companies in the Timor Sea block, shared by Indonesia, Australia, and Timor Leste. The assessment using Environmental Sensitivity Index (ESI) maps using the thematic data. Areas identified as most sensitive to oil spills include West Rote district (Boa and Nembrala villages), and Southwest Rote district (Oeseli, Landu, and Manuk villages and Ndana islands). The beach type in Rote Ndao which is dominated by sloped sandy beach is a substrate type that is easy to clean from oil spill. Conversely, the biodiversity component has the highest sensitivity. The socio-economic components that are most sensitive to the effect of oil spills are the main sources of livelihood include seaweed cultivation, fisheries, and marine tourism. Oil spill mitigation in Rote Ndao must be focused on oil spill risk management in the hotspot area based on the environmental sensitivity index. A plan to prevent oil spills can be created, targeting these hotspots to establish an early warning system for effective mitigation.

Introduction

The Arafura and Timor Sea (ATS) marine region has a high level of fishery resource potential (Ambari, 2019; Johnson *et al*., 2023). This area that borders the Coral Triangle is considered home to the highest marine biodiversity in the world (Burke et al, 2011). The Arafura Sea stretches over an area that is 1,290 km long and 560 km wide, with an average depth of around 50-80 m (165-265 ft). The Arafura Sea is known as one of the places in Southeast Asia that experiences strong seasonal upwelling which affects the food chain system of fisheries stocks (Prabawaningtyas, 2017). Therefore, the contribution of the Arafura Sea and Timor Sea regions towards Indonesia's fisheries production are naturally quite large, from both small-scale and large-scale fisheries, which includes several high economic value fish species. These fisheries provide livelihoods for millions of people in the region and contribute significantly to the community's food security. In Rote Ndao as part of Timor Seas, having high capture fisheries activity predominantly characterized by small-scale fisheries, constituting more than 70% of the total from capture fisheries. (Ninef *et al*., 2019) and It has high potency for seaweed cultivation (Sunadji and Dewi, 2019; Andayani and Pamungkas, 2018).

In addition to the high levels of biological resource potential, the ATS region also has enormous oil and gas potential. One of the largest discovered reserves in Southeast Asia is in the Arafura Sea, namely the Masela Block with a predicted 10.73 trillion cubic feet of gas reserves, this block is often referred to as the "Abadi" field (Nainggolan, 2017). Several other reserve blocks in the waters of Timor Sea are currently still in the exploration stage.

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These waters also have an important role in the shipping sector in Indonesia, as the Timor Sea is part of the Indonesian Archipelagic Sea Lane (ALKI) III which links the Pacific Ocean to the Maluku Sea, Seram Sea, Banda Sea, Ombai Strait, Savu Sea, and finally into the Indian Ocean. However, there is an equally big risk from oil and gas exploration activities, namely oil spills. Oil spills are one example of marine pollution incidents that primary cause of human error and additional factor contributing to such incidents is fatigue loading can be caused by leaks in oil and gas facilities (Ogunbiyi *et al*., 2023; Fuad *et al*., 2021), tanker ship operations (ballast water), ship repairs and maintenance (docking), mid-sea loading terminals, bilge waters (wastewater, oil and lubricants resulting from engine processes), ship scrapping, and tanker accidents. The most substantial category of environmental pollutants globally originates from hydrocarbons derived from crude oil (Sayed *et al*., 2021; Mangku *et al*., 2020). In 2019, leaking underwater wells owned by Pertamina, Indonesia's state-owned oil company, polluted 4.5 km2 of sea and harmed the livelihoods of many locals. These incidents highlight the need to minimize risks associated with offshore oil spills, as restoring polluted ecosystems takes a considerable amount of time (Sukma, 2019). Similar with the case from Pertamina in Cilacap from pipeline leak at the loading and unloading facilities that contaminated the tourist area of Teluk Penyu Beach and impact to residents and 13,900 fishermen in the area that could not go to ocean within 15 days (Mangku *et al*., 2020). The contamination of the marine environment due to human activities is a significant concern. The resulting losses encompass material, biological, and socio-economic aspects. While these losses can be quantified monetarily, their recovery requires a specific timeframe (Sari, 2021).

Risk of oil spill incidents can be identified through thematic maps relevant to the Environmental Sensitivity Index (ESI) and environmental parameter data which supports the analysis of hotspot areas that are vulnerable to be affected by oil spills. It is important to map the condition of sensitive areas around oil and gas exploration areas to mitigate environmental pollution due to oil spills, and then take priority actions to protect areas that are considered sensitive (Putra, 2017).

The Environmental Sensitivity Index requires analysis for describing environmental characteristics. This study will also identify and evaluate sensitive areas around oil and gas concession areas as a guide in developing oil spill mitigation strategies. The research objectives regarding spatial analysis of environmental sensitivity in Timor Sea waters around Rote Ndao are: to obtain data related to coastal resources that are sensitive to potential oil pollution; to compile an Environmental Sensitivity Map and an Environmental Sensitivity Index (ESI) by conducting a Study of Environmental and Socio-Economic Resources that are at risk against oil spills; and to determine and prioritize at risk resources based on the oil spill risks-worst case discharge scenario. Various methods have been employed and elucidated to assess shoreline sensitivity to oil spills, encompassing the use of GIS (Geographic Information System) applications and remote sensing techniques is one of the approaches (Nurfitri *et al*., 2018). ESI systematically collects information in standardized formats related to coastal shoreline sensitivity, biological resources, and human-use resources. These ESI maps are crucial for identifying sensitive areas before a spill occurs, allowing for the establishment of protection priorities and the pre-planning of cleanup strategies (Alaagib *et al*., 2021).

Materials and Methods

Location and time of research

This research focuses on the coast of Rote Ndao District (Figure 1) with data collection carried out in January – April 2023.

Materials and Tools

Equipment and materials used in this research include: Scuba diving equipment, 1m x 1m Quadrant Transect, Roll Meter, Underwater Camera, Environmental Sensitivity Index Handbook, Stationery, Computer, ArcGIS Software and ER Mapper.

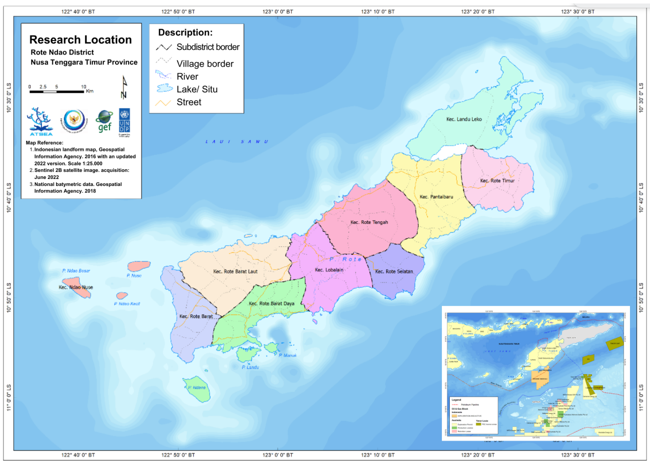

Figure 1. Research location.

Data Collection and Analysis Methods

This research was conducted using an exploratory descriptive method with both quantitative and qualitative approaches. A descriptive research aims to describe the nature of something that is taking place when the research is carried out and to examine the causes of certain symptoms (Sugiyono, 2009).

Data collected in this research consists of both primary data and secondary data. The collected secondary data was sourced from the ATSEA-2 Program under the collaboration between the Ministry of Maritime Affairs and Fisheries and the United Nations Development Programme (UNDP). Secondary data in this research relates to biodiversity, social and economic diversity in Rote Ndao District over the last 5 years, while primary data was taken when research was done to verify biodiversity and socio-economic data in the Rote Ndao District area.

The thematic maps that are grouped into the features mentioned above are then analysed spatially using a map overlay modelling approach. Details of the environmental sensitivity index analysis framework can be seen in Figure 2.

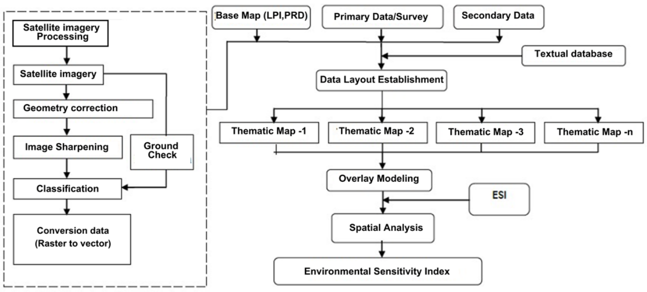

Figure 2. Environmental Sensitivity Index Analysis Framework.

Determination of Coastal Environment Sensitivity for Oil Spills

The environmental sensitivity of coastal waters can be determined through an Environmental Sensitivity Index (ESI). High levels of ESI values indicates high levels of environmental sensitivity both ecologically, socio-economically, and in relation to challenges faced by efforts to handle oil spills in affected areas (Setyonugroho, 2019). The mapping of Environmental Sensitivity Index in the waters of Timor Sea, Rote Ndao was carried out by considering 3 (three) thematic sensitivities, namely:

1. Beach type and general environmental sensitivity to oil spills;
2. Biodiversity in the form of ecosystems, habitats, species and sensitive key natural resources;
3. Sensitive socio-economic features;

Present beach types were identified using 10 meter resolution Sentinel 2B satellite imagery supported by high resolution images obtained from Google Earth and online ESRI image data. These data sources represent the most recent satellite images available for the research location. Biodiversity resource mapping was conducted, which covers:

1. Conservation areas and areas with important biodiversity;
2. Type of coastal habitat/ecosystem (mangroves, coral reefs, seagrass and other coastal habitats); and
3. Species of marine animals that are protected and threatened by extinction.

Sensitive socio-economic features that were mapped include: non-biological resourcess that are at risk of being directly affected by oil spills, areas used by humans that are economically affected, and areas that could be useful for access or installation of oil spill handling equipments. These features can be grouped into several categories:

1) Capture fisheries, including subsistence fisheries (seasonal fishing activities or businesses), traditional fisheries, commercial fisheries, and fishing villages;
2) Aquaculture;
3) Freshwater resources;
4) Tourist and recreational areas (hotels, restaurants, marinas, beaches, recreational fishing, diving, etc.);
5) Ports (including activities and infrastructures);
6) Industrial activities (dependence on marine transportation);
7) Infrastructures related to oil exploration, production and transportation activities; and
8) Cultural sites (archaeological, historical, religious, etc.)

Rank categorization for socio-economic features was carried out based on community activity patterns in the study location. This research then ranked them into 5 main activities that could be affected if there was an oil spill, namely: Capture Fisheries, Aquaculture, Settlement, Port, and Tourism Activities.

Data on socio-economic features were obtained from the Ministry of Maritime Affairs and Fisheries, the Ministry of Tourism and relevant agencies at the sub-district level within the study area. This includes district profiles, village profiles, and population data figures. These data were then verified through field checks and interviews with relevant parties.

Development of the Environmental Sensitivity Index (ESI) refers to the 2019 Version 4.0 Guide developed by NOAA. Several index classifications analyzed during this research include:

1. Beach Type index classification

The index ranges from 1 (low sensitivity) to 10 (very high sensitivity) based on:

1) Beach type (grain size, slope) which determines the penetration and/or accumulation capacity on the beach, and the movement of oil;
2) Exposure to waves (and tidal energy) that determines the natural retention time of oil on the beach; and
3) General productivity and biological sensitivity.

Table 1. Beach type vulnerability scores

No	Beach Type	Vulnerability Score
1	Index 1 and 2	Very Low
2	Index 3,4,5 and 6	Low
3	Index 7	Medium
4	Index 8	High
5	Index 9 and 10	Very high

Source : NOAA, 2019

2. Biological Resource Vulnerability index classification

Sensitive natural resources can be ranked based on their recovery time following an oil spill incident. Meanwhile, marine wildlife species that are protected, vulnerable and endangered can be classified based on their conservation status on the IUCN red list.

Table 2. Biodiversity vulnerability scores

No	Percent Cover of Mangroves, Seagrass and Coral Reefs (%)	Vulnerability Score
1	0 – 9,9	Very Low
2	10 – 24.9	Low
3	25 – 49.9	Medium
4	50 – 74.9	High
5	75 – 100	Very high

Source: NOAA, 2019 modified based on relevant Indonesian regulations

3. Socioeconomic vulnerability index classification

Socioeconomic vulnerability includes resources that can be affected by oil spills and other natural and/or man-made disasters. Oil spills can have serious economic consequences, particularly by affecting fisheries, tourism and other commercial activities. There are nearly 100 available "types" of Environmental Sensitivity Index for socio-economic features that are used, but not all are applicable for every region (NOAA, 2019). Socio-economic categorization in the context of Rote Ndao district includes capture fisheries, aquaculture, settlements, tourism and port activities.

Table 3. Capture fisheries vulnerability scores.

Criteria	Activity Importance	Number of Fishers	Income /month (Million IDR)	Duration in case of spill	Index
5	Primary Livelihood	>1500	>4	Several years and very difficult to address	16-20
4	Additional Livelihood (often)	1250-1500	3 – 4	Several years and difficult to address	12-16
3	Additional Livelihood (sometimes)	1000-1250	2 – 3	Several years and medium criteria if addressed	8-12
2	Non-Fisher	750-1000	1 – 2	Several years and easy to address	4-8
1	Non-Fisher	<750	<1	Short period and easy to address	<4

Table 4. Aquaculture vulnerability scores

Criteria	Activity Importance	Number of Aquaculture Farmers	Income /month (Million IDR)	Duration in case of spill	Index
5	Very Intensive	>10	>4	Several years and very difficult to address	16-20
4	Intensive	6-10	3 - 4	Several years and difficult to address	12-16
3	Semi-intensive	2-5	2 - 3	Several years and medium criteria if addressed	8-12
2	Traditional	1-2	1 - 2	Several years and easy to address	4-8
1	Very Traditional	<1	<1	Short period and easy to address	<4

Table 5. Settlement vulnerability scores

Criteria	Settlement Type	Population Density (ind/km²)	Income /month (Million IDR)	Duration in case of spill	Index
5	Luxurious	>1000	>4	Several years and very difficult to address	16-20
4	Permanent	500-1000	3 - 4	Several years and difficult to address	12-16

3	Semi-permanent	250-500	2 - 3	Several years and medium criteria if addressed	8-12
2	Non-permanent (fixed)	51-250	1 - 2	Several years and easy to address	4-8
1	Non-permanent (moving)	1-50	<1	Short period and easy to address	<4

Table 6. Tourism vulnerability scores

Criteria	Facility	Number of Worker	Income /month (Million IDR)	Duration in case of spill	Index
5	Luxurious	>10	>4	Several years and very difficult to address	16-20
4	Good	6-10	3 - 4	Several years and difficult to address	12-16
3	Medium	2-5	2 - 3	Several years and medium criteria if addressed	8-12
2	Poor	1-2	1 - 2	Several years and easy to address	4-8
1	Very Poor	<1	<1	Short period and easy to address	<4

Table 7. Port vulnerability scores

Criteria	Port Facility	Number of Worker	Income /month (Million IDR)	Duration in case of spill	Index
5	Luxurious	>100	>10	Several years and very difficult to address	16-20
4	Permanent	75-100	5-10	Several years and difficult to address	12-16
3	Semi-permanent	50-75	2,5-5	Several years and medium criteria if addressed	8-12
2	Non-permanent (fixed)	25-75	1-2,5	Several years and easy to address	4-8
1	Non-permanent (moving)	<25	<1	Short period and easy to address	<4

Results

Information on environmental sensitivity for the area around Rote Ndao District is important for determining pollution prevention strategies. The selection of priority areas for pollution management can be discerned from the Environmental Resources Map. Information on the map includes coastline types, coastal ecosystems, conservation areas, and socio-economic activities. The vulnerability score are describe in Tabel 8.

Table 8. vulnerability scores

Category	Description	Location	ESI
Beach type vulnerability	4: Coarse Grained Sand Beaches	Rote Ndao	2
	10F: Mangroves	Rote Ndao	5
	2A: Exposed, Wave-Cut Platforms (Bedrock)	Rote Ndao	1
	1A: Exposed, Rocky Shores	Rote Ndao	1
	3A: Fine to Medium Grained Sand Beaches	Rote Ndao	2
	1C: Exposed, Rocky Cliffs w/Boulder Talus Base	Rote Ndao	1
	8A: Sheltered Scarps (Bedrock)	Rote Ndao	4
	9A: Sheltered Tidal Flats	Rote Ndao	5
	10D: Scrub and Shrub Wetlands	Rote Ndao	5
	5: Mixed Sand and Gravel Beaches	Rote Ndao	2
	1B: Exposed, Solid Man-Made Structures	Rote Ndao	1
Capture fisheries vulnerability	Papadak/Haholok	Rote Barat Daya	4
	Papadak/Haholok	Rote Timur	4
	Fishing ground	Rote Barat	2
	Fishing ground	Lobalain	2
	Fishing ground	Pantai baru & Rote Selatan	2
	Fishing ground	Rote Timur	2
	Fishing ground	Landu Leko	2
Aquaculture vulnerability	Budidaya Rumput Laut	Rote Barat	5
	Budidaya Rumput Laut	Rote Selatan	5
	Budidaya Rumput Laut	Landu Leko	5
Settlement vulnerability	Historical Site	Rote Barat Daya	4
	Fish Bank	Rote Timur	4
Port vulnerability	Dermaga	Dermaga Batutua	3
	Dermaga	Dermaga Pulau Landu	3
	Pelabuhan	Pelabuhan Oeseli	3
	Pelabuhan	Pelabuhan PELNI	3
	Pelabuhan	Pelabuhan Perikanan	3
	Pelabuhan	Pelabuhan Penyeberangan Papela	3
	Pelabuhan	Pelabuhan Pantai Baru	3
Tourism vulnerability	Pantai Wisata	Pantai Pukuafu	4

	Pantai Wisata	Pantai Oesosole	4
	Pantai Wisata	Pantai Sai Oebole	4
	Pantai Wisata	Pantai Tiang Bendera	4
	Resort	Nembrala	4
	Surfing	Pantai Bo'a	3
Biodiversity vulnerability	Wildlife Reserve	Harlu	2
	Hunting Park	Pulau Ndana	2
	Marine National Park	Taman Nasional Perairan Laut Sawu	3

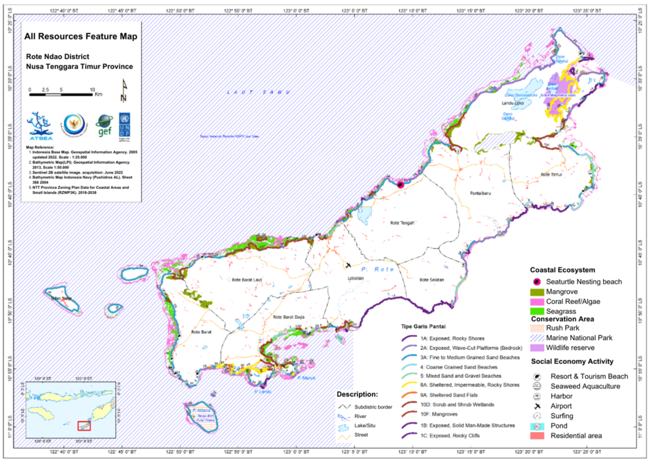

Figure 3. Map of Rote Ndao District Environmental Resources.

Overlay of spatial use is also informed based on conservation area status as shown in Figure 3. The Indeks of the conservation area consist from 3 area. Harlu Wildlife reserve, Pulau Ndana Hhunting park and Taman Nasional Perairan Laut Sawu. The information shows the Northen and western part of Rote Ndao have high biodiversity indeks score compare to the southern part of the island.

Coastline Sensitivity

Based on the results of overlaying environmental resource thematic maps by beach type and analyzing them based on the Environmental Sensitivity Index, it was identified that there are beaches in several villages that are categorized as very sensitive to the risk of oil spills. The area dominan with the characteristics of sheltered tidal flats, sand, mud flats and mangroves area. This areas identified with the highest sensitivity ranks with index 9-10 are found in 4 major area that come from several villages within the districts of Southwest Rote (Rote Barat Daya), Northwest Rote (Rote Barat Laut), Landu Leko and parts of Lobalain and East Rote (Rote Timur).

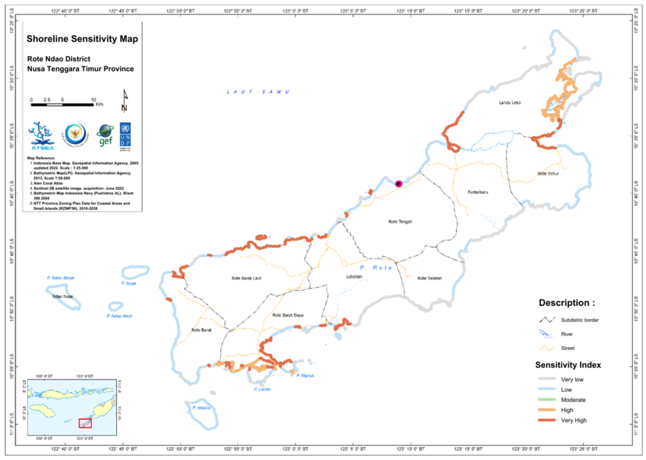

Figure 4. Map of Rote Ndao District Coastline Sensitivity.

Overall Resource Map of Rote Ndao District covering Landu Leko District, and Lobalain shows the highest indeks score. Shows in Figure 5, the coastal area have high risk from the oil spill impact. It could impact not just marine ecosystem, it also human activity and the MPA of Savu Sea that covers norther area of Rote Ndao.

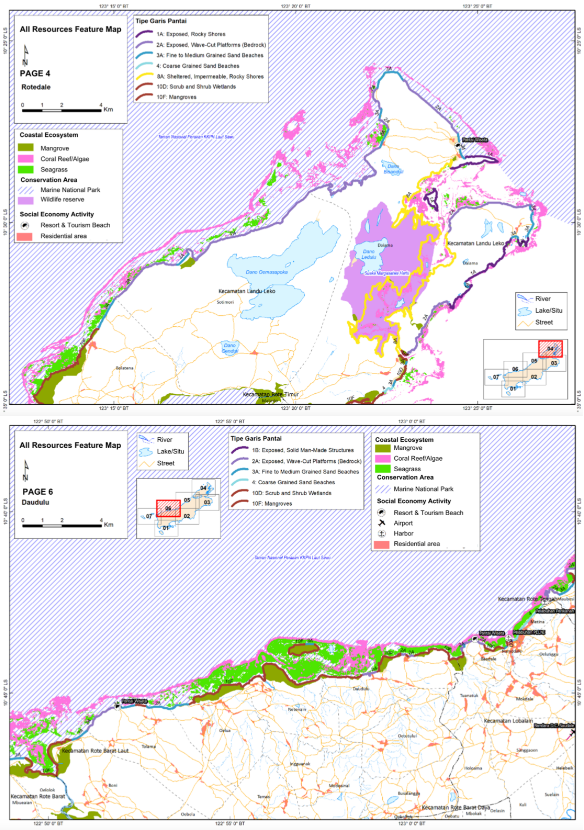

Figure 5. Overall Resource Map of Rote Ndao District Covering the Northern Part (a) Landu Leko District, (b) Northwest Rote District, Lobalain and a small part of West Rote.

Protection Priority

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Regarding the oil spill risk factor, the most sensitive area is located on the Southern side of Rote Ndao district which is part of the waters of Timor Sea. This is also based on what was observed during the previous oil spill incident, namely the Montara oil spill. The areas with the highest disaster sensitivity out of the several districts mentioned in Figure 6 which border the waters of Timor Sea and possesses the highest parameters for resources are the West Rote district which includes the Boa village and Nembrala villages, the Southwest Rote district specifically in the islands of Landu, Manuk and Ndana - Oeseli, and West Rote district in Nembrala village.

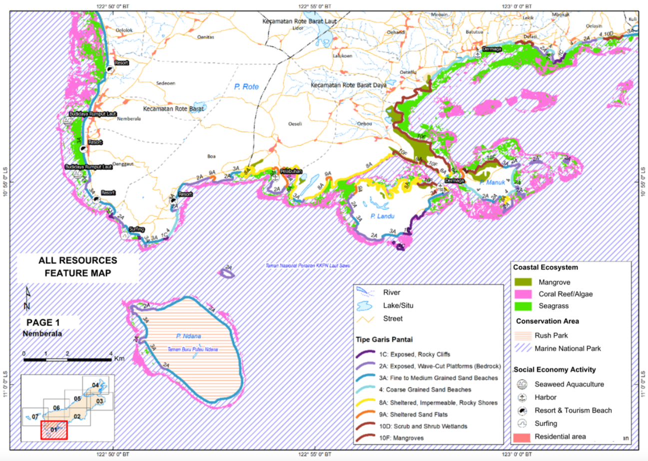

Figure 6. The overall resource map covers Southwest Rote District (Landu Island, Manuk Island, Ndana Island) and West Rote District.

Discussion

Environmental Sensitivity Index

The combination of environmental sensitivity between 'beach type', 'biodiversity' and 'socio-economic' components shows that the biodiversity components are the most sensitive compared to the other types of components. The biodiversity components that are most sensitive to the impacts of oil pollution are 'turtle migration and nesting areas' and 'coral reefs'. Roughly 30% of oceanic sea turtles exposed to minimal to moderate oiling and all turtles heavily coated with oil are anticipated to have perished (Harms 2019). Rote Ndao waters also the migration route of marine mamals species that covers all the area. Contamination from oil spill from terrestrial and marine origins poses a significant environmental challenge. Each year, over 1.3 × 106 metric tons of crude and refined oil are introduced into the marine environment (NRC 2013).

The contamination arising from oil spills not only pollutes water bodies but also gives rise to pollution in coastal regions. Among the coastal ecosystems, the mangrove forest stands out as particularly susceptible to the impacts of oil spills (Hoff *et al*., 2014; Duke, 2016). Smoothing: The spread of oil spills is influenced by the tidal range, as tides serve as a contributing factor in transporting oil to coastal areas (Huynh & Bui, 2003; Kim *et al*., 2013). Additionally, the Southern part of Rote Ndao, which is exposed to open seas, is also influenced by seasonal variations. The tidal range plays a crucial role in oil spills as it generates currents that can spread oil (Hayes *et al*., 1992). The higher the tidal range, the wider the area exposed to tides, consequently increasing the extent of the area susceptible to oil spills.

Both of these are protected ecosystems in the waters of Rote Ndao and are included in the Savu Sea marine protected area. In addition to their use as a protected area, the coral reef and turtle areas are also used for tourism at the study location. In addition to the biodiversity components, some other components that are also very sensitive to oil pollution include floating net cage aquaculture areas, and tourism areas, especially at diving tourism sites.

The Mangrove area has a high potential for the impacts of oil pollution and will experience significant damage both economically and ecologically compared to other areas. The hotpsot dominanly in the area that have mangrove covers. Therefore, this area should be a top priority for prevention in the event of an oil spill (Rikardi *et al*., 2021).

Based on analysis results, areas with the highest level of environmental sensitivity to oil spills from oil and gas blocks are found in the Southern part of Rote Ndao district, especially along the villages of Nembrala, Boa, Oeseli and Landu Tii. This area can be categorized as a hotspot if an oil spill occurs again in the future. Regular monitoring efforts and capacity building for early reporting systems to inform authorities can be focused on this area.

Located close to active oil platforms within the Timor Sea JPDA (Joint Petroleum Development Area), this area has a large risk of oil spills. The Area are managed by Australia and Timor Leste with article 10 of the Timor Sea Treaty that will provide cooperate to protect the marine environment of the JPDA so as to prevent and minimize pollution and other environmental harm from petroleum activities (AMSA, 2019). Several oil rigs are currently in operation and several blocks will be commissioned soon (for example, the Barossa Project), the oil and gas development trend will increase aggressively in the future.

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Residents of the Southern coast of Rote Ndao district have experienced the negative impact of an oil spill that took place in 2009, it also impact more than 90.000km^2 polluted waters (Lumentah *et al*., 2023). This incident caused many residents to lose their jobs and caused economic losses, although to date no compensation has been provided. Legal submissions have been made to Australian courts since 2010 and the first court decision that was in favor of Indonesian farmers was issued in March 2021. However, it will take longer for a final resolution to be achieved.

The high sensitivity at the study location means that it is an important area that requires special handling if an oil spill does occur, so that the oil spill response process does not cause further damage to components that are sensitive to oil contamination. There needs to be good cooperation between stakeholders in dealing with oil spills, both from the government as regulator and the private sector as industrial actors in areas bordering the waters of Timor Sea.

Oil Spill Mitigation

Study locations with high sensitivity levels to oil spill can be managed through a combination of several oil spill mitigation methods. Readiness in responding to mitigation efforts in sensitive areas needs to be improved. In accordance with Presidential Regulation 109 of 2006, Ministry of Transportation Regulation No. PM 58 of 2013, and SKK Migas PTK 005/2018, the division of oil spill response areas is based on three intervention areas according to their respective authorities described in Table 8.

Hotspot areas that are most sensitive to oil spills in Rote Ndao district are located under the area of authority of East Nusa Tenggara Province, which is in Tier 1 and 2. Efforts to minimize the impact of oil spills can be managed at an early stage by developing a Local Oil Spill Contingency Plan which is included in Tiers 1 and 2. This contingency plan would regulate resource mobilization, emergency response operations, use of chemicals at the spill site, and cooperation with other stakeholders. The plan would play an important role in oil spill preparedness, response and cooperation in the event of an oil spill incident. This plan would also provide a certain level of awareness for coastal residents on the potential occurrence of oil spills. A crucial aspect of a robust oil spill contingency plan involves addressing areas potentially affected by contamination, guided by the environmental sensitivity, which reflects the environment's capacity for recovery in the aftermath of an oil spill (Hernawan & Risdianto 2020). This is undertaken to support the development of response strategies and prioritize protection measures for coastal resources (Mursalin *et al*., 2014).

The scope of this contingency plan would also be strengthened by the establishment of communication schemes at various levels starting from coastal communities up to reporting for designated institutions at the provincial level. Therefore, early warning mechanisms becomes crucial for areas with high levels of vulnerability to the impacts of oil spills, such as the Southern parts of The Rote Ndao District.

Table 9. Tier definition in Indonesia

TIER	PERPRES 109/2006	PERMENHUB No. PM 58/2013	SKK MIGAS PTK-005/2018
1	Categorization of emergency response to oil spills that occur inside or outside Port, or oil and gas business units or other activity units, which are capable of being handled by the facilities, infrastructure, and personnel available at the port or oil and gas business unit or other activity units.	Management of pollution that occurs in waters and/or ports that originates from ships, other activity units and port activities that can be handled by personnel, equipment, and materials available at other activity units and ports.	Emergency situations that can be handled by the Local Emergency Response Team (Site Emergency Response Team - ERT) formed by each operating organization / business unit.
2	Categorization of emergency response to oil spills that occur inside or outside Port, or oil and gas business units or other activity units, which are not capable of being handled by the facilities, infrastructure, and personnel available at the	Management of pollution that occurs in waters and/or ports that originates from ships, other activity units and port activities that cannot be handled by personnel, equipment, and materials available at other activity units and ports	Emergency situations that cannot be handled by the Local Emergency Response Team (Site ERT) so they require support/assistance from Emergency Management Team in Indonesia (Incident Management Team – IMT) and SKK Migas.

	port or oil and gas business unit land or other activity units based on tier 1 level.	based on Tier 1 level.	
3	Categorization of emergency response to oil spills that occur inside or outside Port or oil and gas business units or other activity units, which cannot be handled by areas based on tier 2 levels or spread across the territorial boundaries of the Unitary State of the Republic of Indonesia.	Management of pollution that occurs in waters and/or ports that originates from ships, other activity units and port activities which can be handled by personnel, equipment, and materials available in other activity units and ports based on Tier 2 level or spread across the territorial boundaries of the Unitary State of the Republic Indonesia.	Emergency situations that cannot be handled by the Emergency Management Team and SKK Migas so that they require support/assistance from the Emergency Response Team outside the management and SKK Migas in the form of national, regional, and international resources

The potential user groups for sensitivity maps in oil spill response possess diverse needs corresponding to their roles within the incident management organization and the magnitude of the oil spill. Tier I, II, and III. Tier 1 events typically relate to operational activities at a fixed location or facility. Tier 2 spills are more likely to surpass the Tier 1 response area, potentially being larger and necessitating additional resources from various sources. Consequently, a broader array of stakeholders may participate in responding to a Tier 2 event. Tier 3 spills, due to their larger scale and potential for significant impacts, demand substantial resources from national and international sources.

The incident management systems activated would vary depending on the event's scale based on Decision makers (Response Coordinator): Formulate the general response strategy at the national or regional levels (mobilized for Tier II and III oil spills only); On-Scene Commanders and Operations Managers: Devise response tactics, manage spill response operations in the field; On-site responders: Implement operations directly at the spill site (Jones *et al.*, 2012).

According to the contingency plan, authorities must establish an early warning system to facilitate two-way communication between themselves, the local community, the private sector, and academia in the region. The local community should have the capacity to identify the characteristics of an oil spill and include an effective reporting mechanism to inform authorities at Tiers 1 and 2 promptly. Additionally, the local community could be involved in assisting with beach cleanup efforts in the event of an accident.

Conclusion

Environmental sensitivity analysis conducted for the coastal areas of Rote Ndao District shows that sensitive areas are in at least 5 coastal districts based on biodiversity, beach type and socio-economic parameters. However, in areas with a combined risk of oil spills from oil and gas blocks in the Timor Sea, the analysis shows hotspots in areas with the highest resource parameters that borders the Timor Sea waters, namely West Rote district which includes the Boa Village and Nembrala villages, Southwest Rote district specifically on the islands of Landu, Manuk, Ndana and Oeseli.

An oil spill mitigation program can be developed focusing on these hotspot areas to ensure that there is an early warning scheme and monitoring is in place and also for oil spill mitigation through the provincial authority of East Nusa Tenggara province at Tier 1 and Tier 2 levels, which also includes the Rote Ndao District mitigation plan from oil and gas platform and shiping activities with provided Oil Spill Contingency Plan (OSCP).

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