Coastal Protection of Southern Part of The Bintuni Bay From Oil Spill: An Environmental Sensitivity Index Approach

Perlindungan Pesisir Selatan Teluk Bintuni dari Tumpahan Minyak: Suatu Pendekatan Indeks Sensitifitas Lingkungan

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ABSTRACT: The southern part of Bintuni Bay with highly sensitive ecosystem conditions has evolved into an oil and gas industry where potential impacts on coastal and offshore environments need to be anticipated and planned comprehensively for environmental protection from oil spills. The main problem is the determination of areas that are sensitive and vulnerable to oil spills. This study is to analyze the factors and components that affect the level of environmental sensitivity and mapping Environment Sensitivity Index (ESI) to the oil spill. The study was carried out by identifying and assessing each land units of its and use. Land use and land cover are interpreted through the use of satellite imagery with classification methods of guided satellite imagery. Field survey was also conducted in order to improve the accuracy of land use interpretation. Data analysis was performed by spatially by GIS method. The result indicated that ESI can be divided into five categories, are very sensitive (2,395.98 hectares or 2.38%), sensitive (13,133.53 hectares or 13.07%), moderately sensitive (17,902.78 hectares or 17.81%), low sensitive (52,409.14 hectares or 52.14%) and not sensitive (14,681.48 hectares or 14.61%). Although the study area is dominated by low sensitivity category, however the coastal protection from oil spill still should be prioritized.

Keywords: coastal protection, Environmental Sensitivity Index, Oil Spill, Bintuni Bay

ABSTRAK: *Wilayah bagian selatan Teluk Bintuni dengan kondisi ekosistem yang sangat sensitif telah berkembang menjadi industri minyak dan gas dimana potensi dampaknya terhadap lingkungan pesisir dan lepas pantai perlu diantisipasi dan terencana secara komprehensif untuk perlindungan lingkungan dari kemungkinan tumpahan minyak. Masalah utamanya adalah penentuan daerah yang sensitif dan rentan terhadap tumpahan minyak. Penelitian ini menganalisis faktor dan komponen yang berpengaruh terhadap tingkat sensitivitas lingkungan dan pemetaan Indeks Sensitivitas Lingkungan (ISL) terhadap tumpahan minyak. Studi ini dilakukan dengan cara identifikasi dan penilaian unit lahan pada setiap penggunaan lahan. Penggunaan dan penutup lahan diinterpretasikan melalui penggunaan citra satelit dengan metode klasifikasi citra satelit terbimbing. Guna meningkatkan akurasi interpretasi penggunaan lahan juga dilaksanakan survei lapangan. Analisis data hasil penilaian unit identifikasi dilakukan secara spasial dengan metode SIG. Hasil penelitian menunjukkan bahwa ESI dapat dibagi menjadi lima kategori, yaitu sangat sensitif (2.395,98 hektar atau 2,38%), sensitif (13.133,53 hektar atau 13,07%), cukup sensitif (17.902,78 hektar atau 17,81%), sensitif rendah (52,409.14 hektar atau 52,14% dan tidak sensitif (14.681,48 hektar atau 14,61. Meskipun sebagian besar daerah daerah penelitian termasuk dalam kategori sensitif rendah, namun demikian perlindungan dari tumpahan minyak harus tetap diprioritaskan.*

***Kata Kunci**: perlindungan pantai, Indeks Sensitivits Lingkungan, tumpahan minyak, Teluk Bintuni*

INTRODUCTION

A coastline is an area where land meets the sea or ocean (Triatmojo, 1999), while the coastal area is a region between land and sea that is influenced by both of them (Dahuri *et al*., 2001). The effect of weather, climate and land activities may have a further impact to the sea (Dahuri, 2002). In addition, the intensive development in this area can arise a conflict between various parties/stakeholders (Wardhani *et al*., 2011).

Oil and gas industry covering both upstream and downstream activities may potentially pollute the various sensitive coastal ecosystem (Mukhtasor, 2007). This potential negative impact of an onshore and offshore petroleum industry in Indonesia could occur due to the miss management, bad planning, and bad operating. Several incidents have been occurred in the coastal area due to oil and gas industry are: accidental drilling of oil and gas wells (26%), ship crash (22%), structure failure (10%), ship friction (9%), explosion/ fire of oil refinery/terminal (9%), vessel sink (7%), human error (5%), military action (4%), equipment error (2%), other accident (6%). The oil gas industry accident both in coastal and offshore almost certainly has a probabley pollutant source in all production stages (Anonim, 2004 in Mursalim *et al., 2014*). This oil spill in marine environment can provide significant impact to the marine resources (Mursalin *et al.,* 2014).

Handling contaminated areas is one priority of considerably contingency plan. This includes allocation of resources so the treatment can be executed effectively and efficiency in accordance with environmental sensitivity that represents the level of reaction of the coastal area to recover in the event of an oil spill (Utantyo *et al.*, 2003). Significant effort has been performed in the developing sensitivity mapping components of oil spill contingency plans around the world (Petersen *et al.*, 2002).

A comprehensive information on the sensitivity levels of each category of a susceptible environment is an important requirement for effective oil spill disaster management. The ESI analysis should be done prior to the oil spills (Oyedepo and Adeofun, 2011), as an essential step in oil pollution preparedness, response, and cooperation efforts. The ESI map a crucial tool to assist responders during an incident (Anonim, 2011)., It is an essential component of oil spill contingency planning that indicates substrates demanding specific clean-up actions and response options considering ecological, recreational and commercial concerns (Halls *et al.*, 1997 *in* Carvalho and Gherardi, 2008), and it is used for the most efficient application of the available response resources, making the cleanup operation would be more effective (Filho *et al.*, 2009). The ESI classifies coastal environments according to their relative sensitivity to oil spills, taking into consideration natural, physical and biological processes (Filho *et al.*, 2009). ESI analysis is one of methods in determining the aspect of landscape planning in the coastal area, as has been performed by Budiyono *et al.* (2013).

Oil spill sensitivity map an important tool to develop the best-suited oil spill response strategies. Considering various types of the shore and more importantly the most sensitive coastal sites, the oil spill sensitivity maps can also guarantee fast and effective oil spill response operations (Anonim, 2011).

Based on the SKK Migas map on the oil and gas working area, the Bintuny bay is one of the prospective area for oil and gas industry. There are on going and planning oil and gas industry. Unfortunately, the Environmental Sensitivity Index (ESI) documents that may support the development of good and robust oil spill contingency plans in this area are not available for the moment. The ESI Analysis is useful to anticipate and to provide a fast response for coastal and marine protection (including habitat, ecosystem and other resources) from the oil and gas activities impact, particularlty hydrocarbon pollution (Risdianto and Hernawan, 2014). Therefore, this study is conducted to identify the condition of the study area, and to recognize which area that might be vulnerable from the oil pollution. For that, we perform the ESI mapping related to the oil contamination.

Geological Condition

According to Anonym (2016), physiographically, the study area classified as low-lying alluvial and litoral plains. Alluvial and litoral lowlands are composed of alluvial and litoral deposits and sediments of Steenkool Formation overgrown with savanna, swamp forests, mangroves and dense forests in several places.

Geologically, the study area is belong to the Bintuni Tertiary Basin which occupies the eastern edge of the Vogelkop and the Bomberai Peninsula, with a longitudinal form that extends in north-south direction. The Bintuni Basin is limited by the Arguni factoring fault on the east, the Sekak ridge on the west, the northern Plateu Ayamaru and the Tarera-Aiduna fault system in the south (Figure 1). The basin covers an area of 30,000 km^2 with 22,000 feet of sedimentation. Lithology of the research area is composed of upper Steenkool Formation (dominated by quartz sandstone and conglomerate) and the lower part (dominated by clay or shale), deposited in the Pliocene (Anonim, 2016).

Morfological Condition

Based on Shuttle Radar Topography Mission (SRTM) data, morphology of the study area in general are are flat and low land area with elevation below 100 m (Figure 2).

METHOD

The study was conducted in 2015. The study area focused on the onshore area, southern part of Bintuni Bay, appoximately 10 km from the coast line. Administratively, it locates in the Teluk Bintuni District (sub district: Babo, Aroba, Sumuri) and Fakfak District (sub district: Tomage, Bomberai and Mbahamdandara), West Papua (Figure 3).

General steps of this study are shown in Figure 4. ESI, describing relatively sensitivity level of the environment, is as result of determinant components and is presented as an ESI map using spatial analysis of a Geographical Information System (GIS) method.

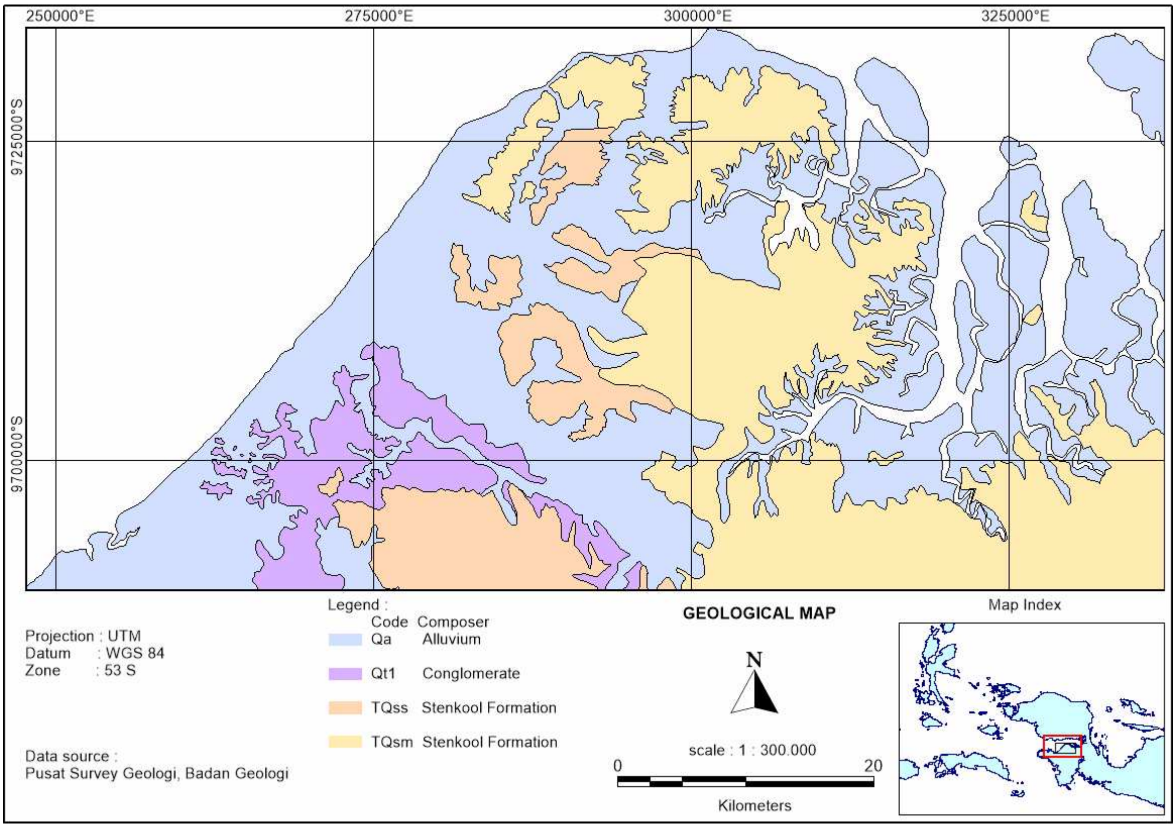

Figure 1. Geological map of the study are (Anonym, 2016 and references there in)

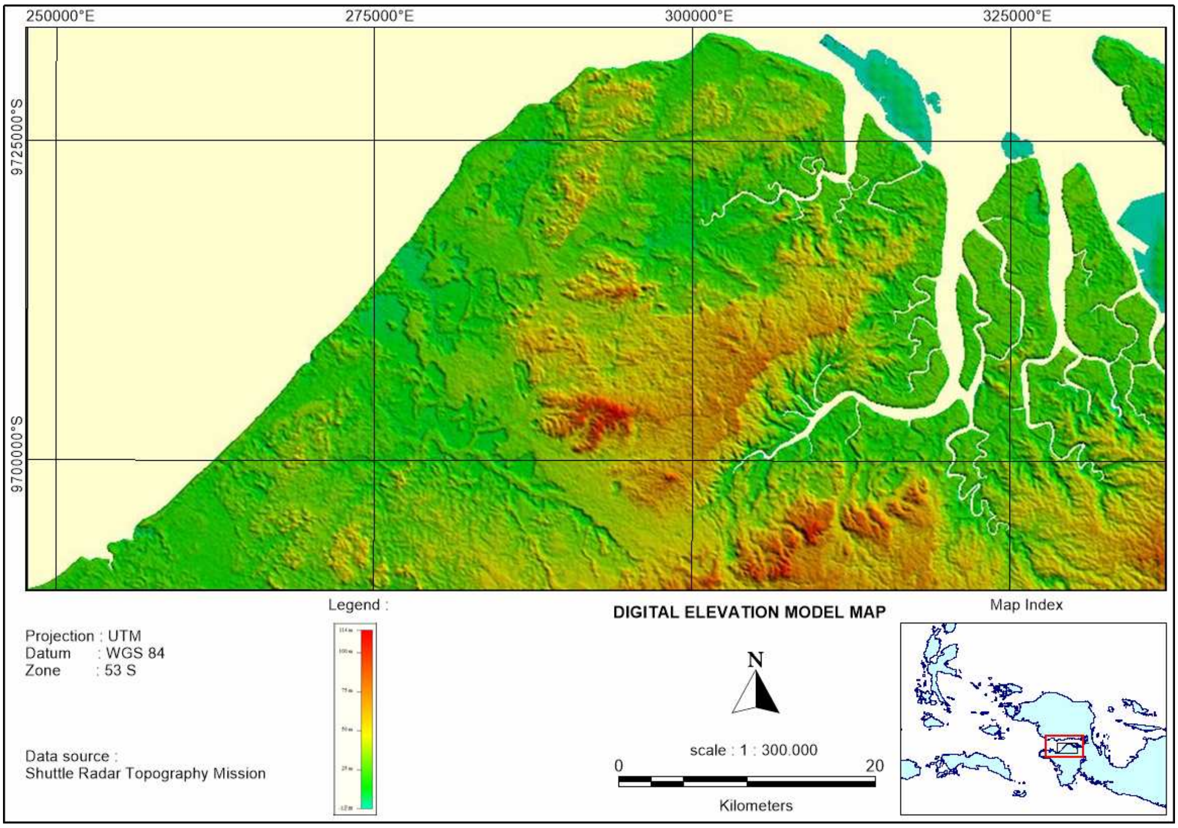

Figure 2. Elevation of the study area (SRTM data)

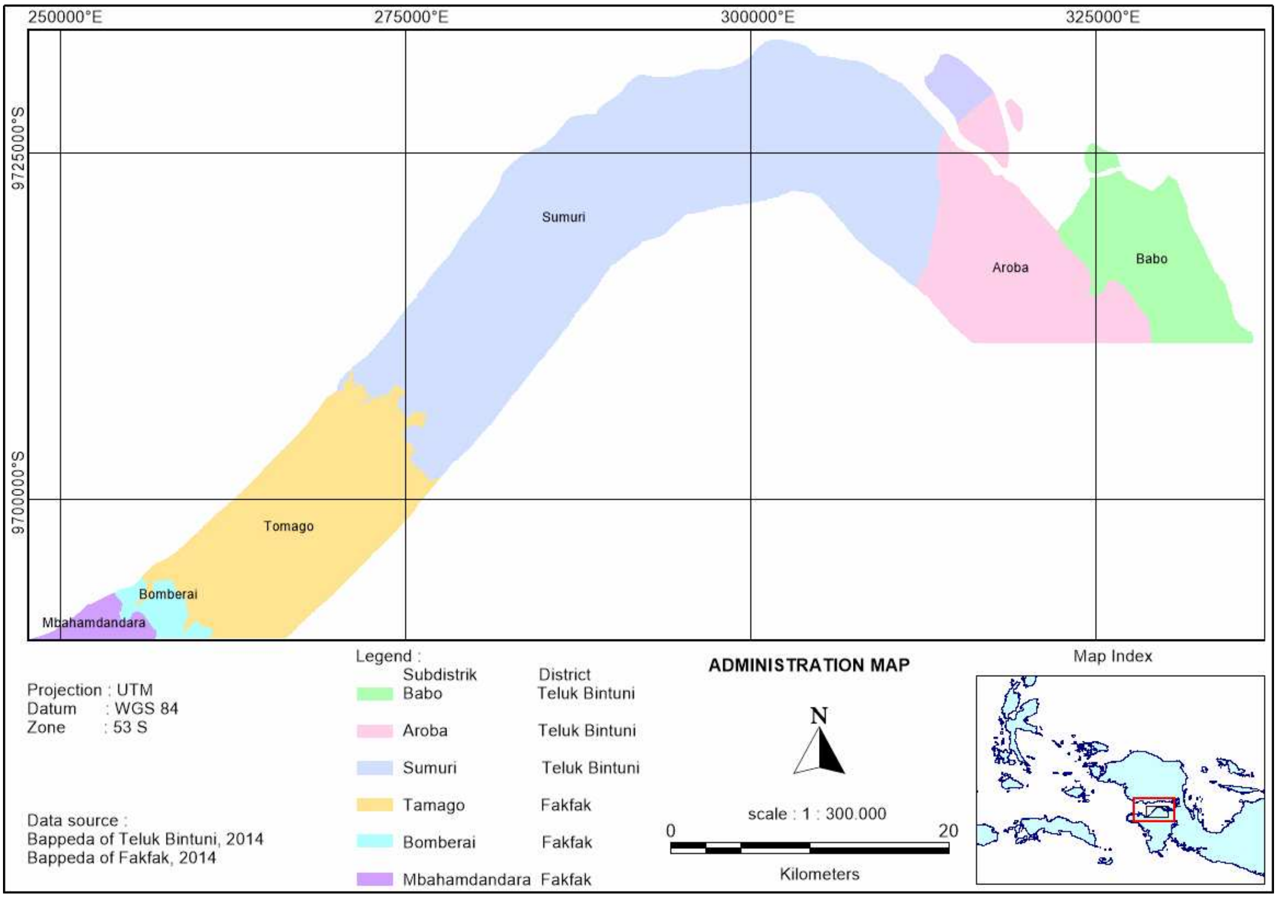

Figure 3. Study Area of the Southern Part of the Bintuni Bay

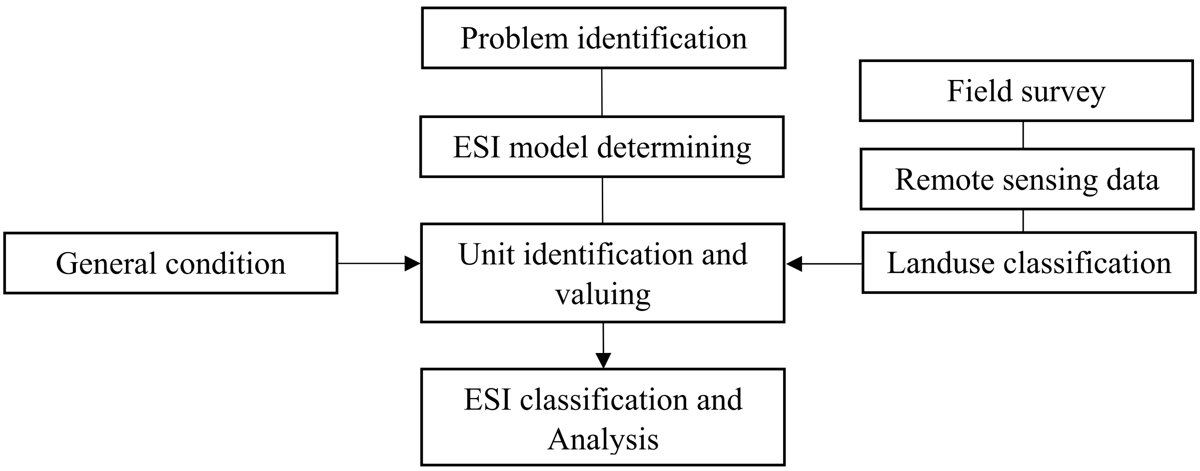

Figure 4. Step diagram of the ESI Study

Using spatial database planning, all natural and artificial resources that are composed of various thematic map, were overlaid into one composite map by the GIS software. All components value were calculated into total ESI value. Based on this map information, environmental sensitivity data could be accessed, operated and manipulated easily and promtly for quickly response handling with regard to the oil spill (Utantyo *et al.*, 2003). GIS can be effectively used for the preparation of ESI map, because it provides fast and simple way to identify the different classes of shoreline present in the coast (Murali *et al.,* 2010).

We used the imagery data from Landsat ETM+ which is acquired in 22nd, April 2014 from USGS and digitalglobe data from the Google Earth. General condition of the study area was obtained from secondary data, i.e. geological data from geological map, morphological data and digital elevation obtained from SRTM (Shuttle Radar Topography Mapping).

The determination on ESI model was carried out based on suitability of model to the study location. Previous researcher has developed the method of ESI analysis and classification through various mathematical model, function, and formula. Schallier *et al.* (2013) formulate methodology of ESI analysis by dividing into three factors of vulnerability, i.e. exposure (for beach and open water), ecological sensitivity (for habitat) and economical sensitivity (for socio-economical utilization of coastal area). The exposure of resources describe the distribution of contaminant source of the oil spill that contaminates the coastal area. The determining factors of exposure are the elevation of coastal line and substrate type. Ecological sensitivity is particularly affected by the impact of oil spill and restoration by biological process. Mosbech *et al.* (2000) determined ESI as total quantity of priority index, where priority index is a function of species relative sensitivity, species relative abundance, time and oil residency. Haryani (2005) stated some factors that must be considered in order to describe the impact of oil spill to the coastal resources are coastal type/characteristic, sediment grain size, and tidal level. Rahmania (2005) indicated that important factor to determine vulnerability level of the oil spill in an area is social factor. This social factor is the important place related to daily society activity based on an important function of the place. Based on Anonim (2002), the sensitivity level of an area is determined by coastal characteristic (sediment type, current and wave condition, morphology and slope), biological resources (especially for vegetation around the coastal area) and land use of coastal area (Nedi *et al.* 2010).

The Fisheries Faculty of Bogor Agriculture Institute (*Institut Pertanian Bogor*-IPB) as team of *Pusat Kajian Sumberdaya Pesisir dan Lautan*-PKSPL) has developed a formula for classifying ESI since 1995 which involving three elements, i.e. vulnerability value (VV), conservation value/ecological value (CV) and social value (SV). PKSPL-IPB considers that all value index (VV, CV, and SV) have a similar effect from the oil spill. Hence, the value of all index in ESI determination are assumed as similar value (Wahyudin, 2013).

Based on conditional consideration in evaluating and classification of ESI analysis, the formula developed by PKSPL IPB is the suitable formula for Indonesia region. In order to evaluate and determine ESI classification, several factors that influence ESI classification, are:

- Important Value Index of Mangrove, acquired from a formula of Mueller-Dombois dan Ellenberg (1974), Soerianegara dan Indrawan (1985).
- Coral reef condition and live coral coverage, acquired from coral transect method, formula was adopted from English *et al.* (1994).
- Important Value Index (IVI) of seagrass, using INP of mangrove
- Quantity of fish
- Biological productivity and sensitivity (coastal characteristic classification)
- Vulnerability level of habitat type in coastal
- Condition of coastal habitat and ecosystem, including distance from beach/estuary, ecosystem condition and used technology
- The condition of forest, plantation, farm, farmyard
- Coastal area using
- Settlement condition
- Open water condition
- Grass/brush condition.

The ESI analysis was performed by overlaying modeling in GIS method. The ESI value for polygon unit from overlaying result that has specific environmental character value will be determined by a formula from Gundlach (1978), Anonim (1994), Romadhon (2008), Wardhani, *et al.* (2011), i.e.:

$$ESI = VV \times CV \times SV \qquad \text{........(1)}$$

Where:

ESI = Environmental Sensitivity Index

VV = Vulnerability Value, describing the class of resources that reflect the level of vulnerability of habitat, land use, and land cover affected by an activity.

CV = Conservation/Ecological Value, describing representativeness, uniqueness, integrity and relationship to other class of resources.

SV = Social Value, describing the impact of the economy, social and culture from an activity (such as oil spill) to a class of resources.

All components, i.e. vulnerability, conservation/ ecology, and social have a range value between 1 to 5. The minimum value (1) indicates not sensitive, and the maximum value (5) refers to high sensitive. The composite value of ESI is a multiplication of these components, where the range value from 1 (insensitive) to 125 (high sensitive). This formula was developed by Anonim (2009), adopted from Gundlach (1978) and Anonim (2002).Specific for vulnerability index criterion was developed by Sloan (1993).

Interpretation of landuse/lancover was carried out for identification and assesment of VV, CV and SV by satellite imagery data. Field survey was carried out in May 2015 in order to assist and validate landuse/ lancover interpretation.

Based on the Sloan (1993), the habitat and ecosystem that vulnerable to the oil spill are shown in Table 1.

Table 1. Sensitivity level of ecosystem and habitat in coastal area

Sensitivity level	Keterangan	Type of habitat
5	High sensitive	a. Mangrove b. Swamp area c. Sheltered rocky tidal d. Sheltered flood land Special shesltered (example for special purpose, extinct biota)
4	High	a. Coral reef b. seagrass
3	Moderate	a. moderately exposed water (cape, pier/jetty)
2	Low	a. Rocky beach b. Sandy beach
1	Not	a. Exposed rocky tidal flat b. Exposed water (offshore) c. Rocky subtidal (hard rock/rocky) d. Soft rocky subtidal

(Source: Sloan, 1993).

Data calculation and analysis of ESI were performed by using tabular analysis (Wardhani, *et al.* 2011) with previous formula (1). The acquired ESI values from all study area are classified into five (5) classes of sensitiveness based on the value distribution. the classifications of sensitivity index are:

a. Highly sensitive, with ESI value: 100<ESI<125.
b. Sensitive, with ESI value: 75<ESI<99.
c. Moderately sensitive, with ESI value: 70<ESI< 74
d. Less sensitive, with ESI value: 25<ESI<49
e. Insensitive, with ESI value: 1<ESI<24

RESULT

Land Use and Land Cover

Guided satellite imagery classification result 10 classes of land use and land cover, are airport, BP Tangguh facilities, forest, historical site, mangrove, mix sago forest, plantation, savanna, settlement and river (Figure 5 and Table 2). The widest area of land use and land cover is forest, that has 62,404.40 ha or 54.9% of the study area, Mangrove: 25, 288.59 ha and savanna: 14,663.97 ha. The total area of three widest area are 102,355.96 ha or more 90% of total study area.

Sensitivity Index

Levels of sensitivity in the study area can be divided into five classes, i.e. highly sensitive, sensitive, moderately sensitive, less sensitive and insensitive (Figure 6 and Table 3).

Generally, the study area mostly has less sensitive category with ESI value vary from 25-45, reaching 52.1% or 52,409.14 ha with ESI values varying from 27 to 45 (Figure 7 and Table 4). Most of the less sensitive areas are forest areas (42,445 , 58 ha), savanna or open field (1,652.63 ha) and mixed sago forest (914.18 ha), which spread widely in the study area.

The ESI value of mangrove forest vary from 55,05–73,4 is moderately sensitive, and this area covers 10,767.87 hectares. The level of utilization and dependence of the surrounding community on the mangrove forest ecosystem is very high. The value of ESI type of forest cover ranges 52,5 – 60, and classified as moderately sensitive. This is almost found in all study areas, and that includes natural forest or production forest with 3 (three) levels of vulnerability, conservation of 4 and social value of 4.5. The forest coverage of the moderate sensitive is 7,034.29 hectares.

The insensitive classification has ESI value varies from 3 to 20, and 14.6% of total area with land use in the form of settlements (226.91 ha), plantations (986.79 ha), mixed sago forest (555.55 ha) and savanna or open land (12,912.22 ha), and distribution spread widely most of the study area. The presence of an ESI as insensitive due to its low conservation rate (varies from 1 to 2), and a low social value.

The sensitive area is only mangrove forest in the vicinity of Tofoi and Babo river area (13,133.53 hectares). The ESI value of mangrove forest vary from 36.7 – 82.575 as low sensitive – sensitive classification. Mangrove forest is very important ecosystem since its roles are both for the Irarutu (Babo) subdistrict community and for the carrying capacity of the environment such as a spawning / breeding and enlarging various types of rsery ground for aquatic biota (fish and shrimp) and terrestrial. Therefore, the functional shift of this area is only temporary and after

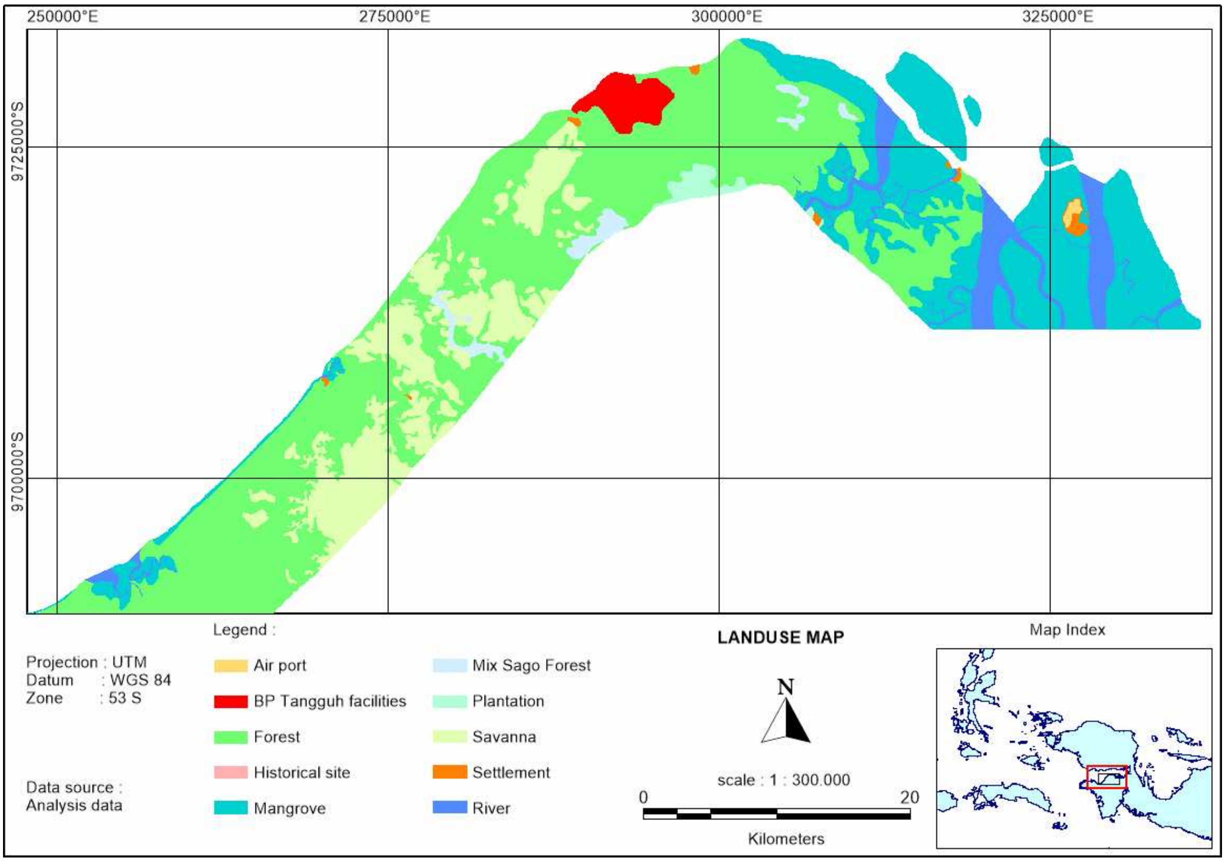

Figure 5. Land use and land cover map of the study area

Table 2. Wide area of land use and land cover in the study area

No	Category	Area (Ha)	Percentage
1	Air port	172.589	0.2
2	BP Tangguh facilities	2,053.86	1.8
3	Forest	62,404.40	54.9
4	Historical site	1.57	0.0
5	Mangrove	25,288.59	22.3
6	Mix sago forest	1,570.34	1.4
7	Plantation	986.80	0.9
8	Savanna	14,662.97	12.9
9	Settlement	394.91	0.3
10	River	6,051.73	5.3
	Total	113,587.76	

Table 3. Summary of ESI classification of study area

LANDUSE	VV	CV	SV	ESI	CLASSIFICATION	CODE	AREAL	ID_ESI
Historical site	5	5	5	125	High sensitive	01	1.56813	STS_SSF_01
BP TANGGUH Facilities	5	5	5	125	High sensitive	01	2,053.86	BPF_SSF_02
Settlement	5	5	5	125	High sensitive	01	167.955	PM_SSF_01B
Airport	5	5	5	125	High sensitive	01	172.588	BND_SSF_01
Mangrove	5	3.67	4.5	82.575	sensitive	02	13,133.53	MV_SF_07
Mixed sago forest	5	3	3.5	52.5	moderate sensitive	03	100.617	HSC_SSD_02B
Forest	5	3.5	3	52.5	moderate sensitive	03	468.44	HT_SSD_11B
Forest	5	4	3	60	moderate sensitive	03	6,561.19	HT_SSD_09B
Mangrove	5	3.67	4	73.4	moderate sensitive	03	147.854	MV_SSD_11
Mangrove	5	3.67	3.5	64.225	moderate sensitive	03	10,520.43	MV_SSD_06
Mangrove	5	3.67	3	55.05	moderate sensitive	03	99.5849	MV_SSD_02
Forest	3	4	4.5	54	moderate sensitive	03	4.65939	HT_SSD_01
Forest	3	3	3	27	Less sensitive	04	2.78957	HT_SRD_10
Forest	5	3	3	45	Less sensitive	04	4.45743	HT_SRD_10B
Savanna/open field	5	2	4	40	Less sensitive	04	1.22077	SV_SRD_04B
Mangrove	5	3.67	2	36.7	Less sensitive	04	414.167	MV_SRD_09
Forest	3	3.5	3	31.5	Less sensitive	04	1,037.99	HT_SRD_11
Forest	3	4	3	36	Less sensitive	04	41,403.34	HT_SRD_08
Mangrove	5	3.67	1.5	27.525	Less sensitive	04	927.839	MV_SRD_04B
Mixed sago forest	3	3	4	36	Less sensitive	04	376.675	HSC_SRD_05
Mixed sago forest	3	3	3	27	Less sensitive	04	278.096	HSC_SRD_03
Savanna/open field	4	2	4	32	Less sensitive	04	478.934	SV_SRD_10
Savanna/open field	5	2	2.5	25	Less sensitive	04	1,172.48	SV_SRD_60B
River	3	3	3	27	Less sensitive	04	6,051.75	SNG_SRD_05
Mixed sago forest	3	3	3.5	31.5	Less sensitive	04	259.407	HSC_SRD_02
Settlement	3	1	1	3	Insensitive	05	42.539	PM_TSF_15
Settlement	5	1	2.25	11.25	Insensitive	05	45.4572	PM_TSF_14
Mixed sago forest	3	1	1.5	4.5	Insensitive	05	257.906	HSC_TSF03
Plantation	2	1	4	8	Insensitive	05	601.701	PKB_TSF01
Mixed sago forest	5	1	1.5	7.5	Insensitive	05	297.64	HSC_TSF03B
Plantation	5	1	4	20	Insensitive	05	359.178	PKB_TSF03
Settlement	5	1	1.5	7.5	Insensitive	05	95.8514	PM_TSF_17
Settlement	3	1	1.5	4.5	Insensitive	05	43.0663	PM_TSF_12
Savanna/open field	4	2	5	20	Insensitive	05	12,912.22	SV_TSF_59
Plantation	2.5	1	4	10	Insensitive	05	25.9153	PKB_TSF05

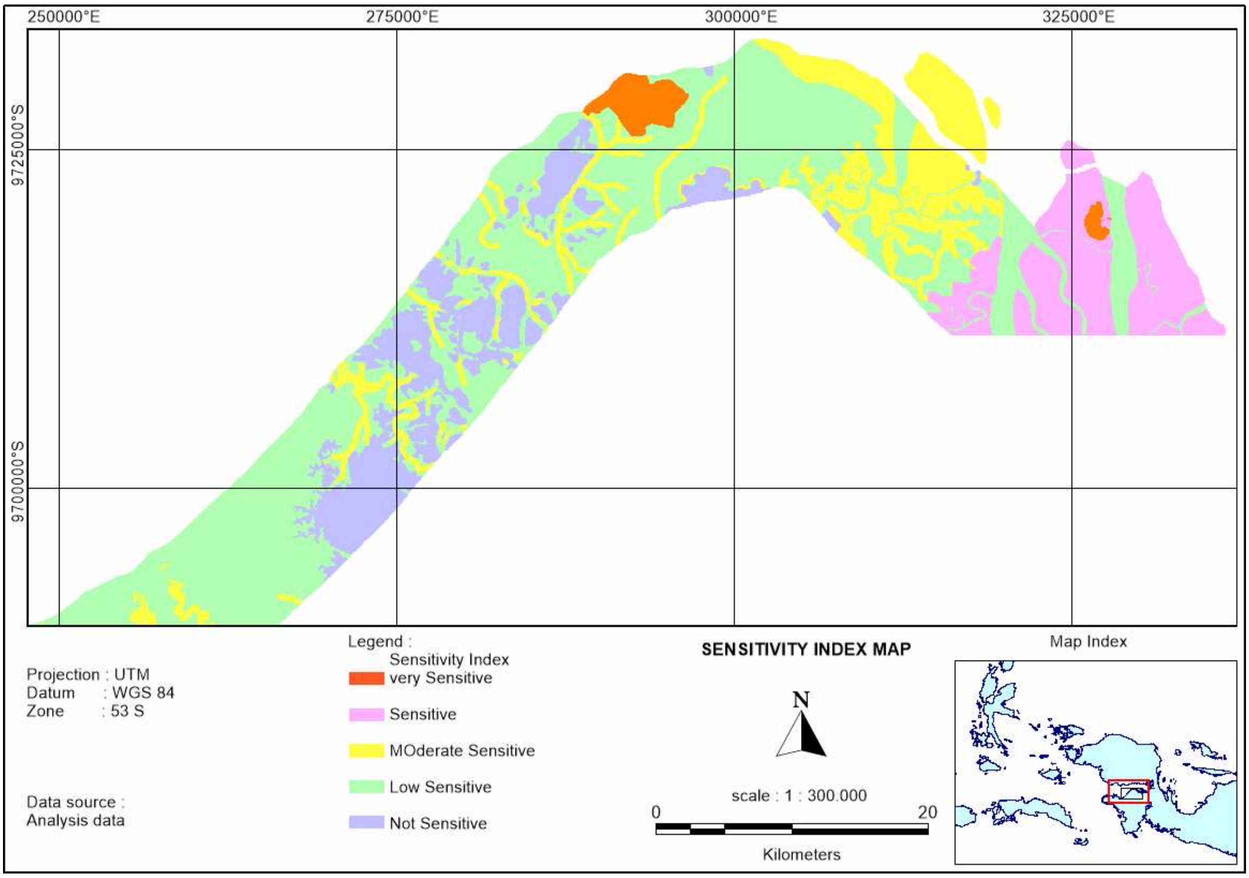

Figure 6. ESI map of the study area

Table 4. Wide Area of ESI classification

No	Category	Area (Ha)	Percentage
1	High sensitive	2,396.01	2.4
2	Sensitive	14.154.55	13.1
3	Moderate Sensitive	25516.88	17.8
4	Less sensitive	56740.74	52.1
5	Insensitive	14,779.58	14.6
	Total	113,587.76	

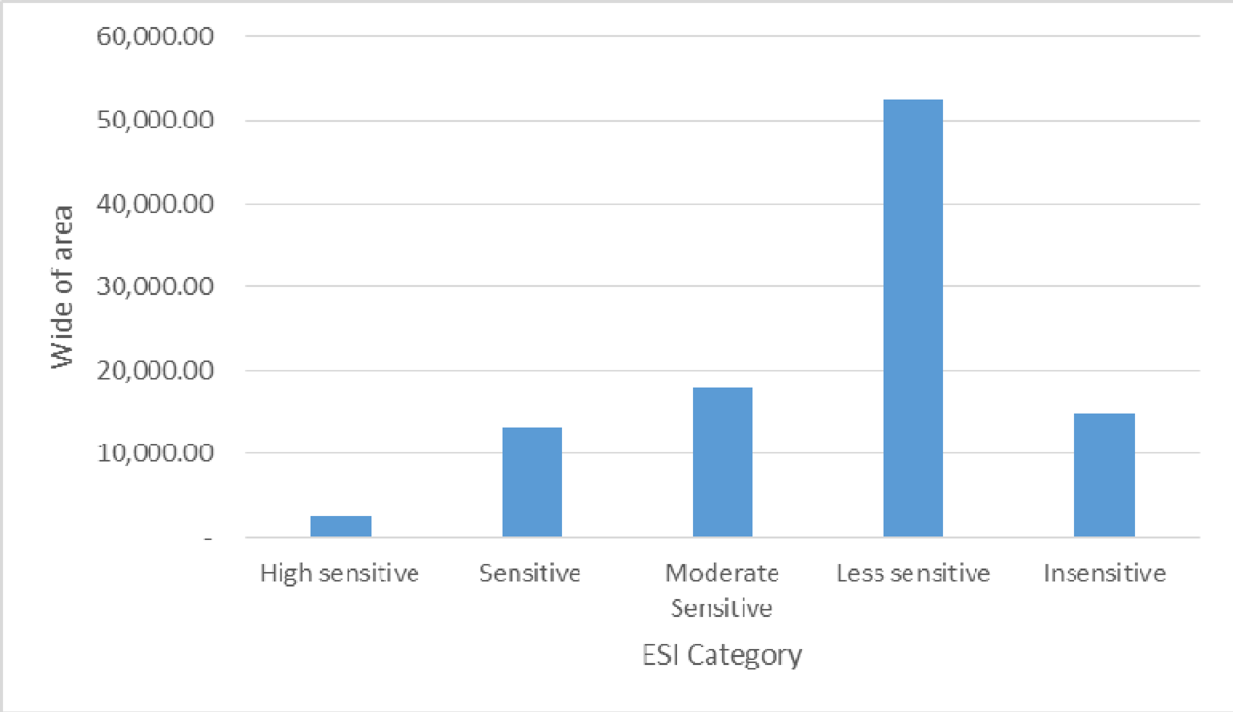

Figure 7. Grafik of ESI classification wide area

completion of activity must be immediately to maintain environmentally carrying capacity and sustainability of the mangrove.

The highly sensitive of 2,395.98 Ha are located at the BP Tangguh project site in which the type of land use is BP Tangguh facility and settlements, and also Babo airport. These two areas are highly sensitive because the facility may not compensatory considering the very costly.

DISCUSSION

Generally, the ESI analysis can show the level of environmental sensitivity to oil spills. The extent of the areas that are less sensitive and insensitive compared to the more sensitive areas due to the condition of the study area that is mostly forest and open area or savanna. The dependence of community on forests and sago forest areas can still be replaced with other areas, as the availability of the area is still large compared to population density.

The extent of less sensitive in the study area because basically the research area is mostly forest area, savanna (Table 2), and has not been used for many other activities, so it has low SV value, although it has high vulnerability value (VV). This low SV condition illustrates that the rate of utilization and dependence of communities around this area of one forest area can be replaced by other forest areas because of the vastness of the forest area, although they depend on the forests. The level of use and dependence of the people closest to the sago forest ecosystem is relatively moderate to quite high. The sago forest ecosystem is one of the livelihood for the surrounding community. Due to the low sensitive criteria, sago forest areas in the study area can be used for other activities. Utilization process can be done by providing compensation to the surrounding community who depend on the existence of sago forest ecosystem.

The forest ecosystem is classified as sensitive since the level of utilization and dependence of the community to the forest is relatively very high for the fulfillment of their life needs. Arrangements and forest cover of sensitive forest cliffs are also located along the river. This is very much due to the forest area along the river boundary which has the value of vulnerability and the relatively high conservation value (VV = 5 and CV = 4), but the relatively moderate social value (SV = 3). The relatively moderate value of SV indicates that the presence of forests along the river is not the main source of the fulfillment for the surrounding community. Generally, land use and land cover types that classified as sensitive can be used for other activities, as temporary activities with limited areas, and can be recovered naturally without having to go through special handling like reforestation program after post activities. The using this type of land use for another utilization needs to be compensated, if it has been utilized by the surrounding community.

Variations in SV are more caused by differences in the number of human resources (such as the number of workers), socioeconomic facilities (the number of houses and infrastructure that support daily activities), and the utilization of water resources for daily living needs. Communities around this location have other sources for the fulfilment of their livelihoods and are not dependent on the existence of mixed sago forest ecosystems, so the SV value is low. The area of sago forest in the research area can be utilized for other activities. Utilization process can be done by providing compensation to the community around whose depends on the existence of sago forest ecosystem.

The difference in mangrove ESI level is more due to the different levels of mangrove use (as social values) of each location, although all mangrove areas have a very high degree of disagreement. The dependence of communities to mangrove forest (such as in Babo area) make the ESI level is very high sensitivity to oil spills.

In sensitive and high sensitive areas, the oil spill will affect the sustainability of the surrounding community who rely on livelihood. Oil spills in the mangrove area is very difficult to clean and will disrupt the ecosystem in the mangrove area and very long-lasting effect. Serious efforts are needed to prevent an oil spill. Early handling is needed in the event of an oil spill, such as disaster mitigation, localizing the disaster area, giving priority handling.

CONCLUSION

The ESI criterion in this study area shows that about half of the Bintuni bay coastal area is less sensitive due to the coverage of forest, savanna and mix sagoo forest. Nevertheless, effort of protection are still necessary to anticipate since oil spill can damage and its effect on those coastal ecosystem is difficult to remove. Those efforts include the mitigation, localize and prioritize the handling of oil spill.

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