MANAGEMENT STRATEGIES TO PROTECT COASTAL AREAS FROM OIL-POLLUTED SEAWATER (A CASE STUDY OF COASTAL AREAS IN BEKASI REGENCY)

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MANAGEMENT STRATEGIES TO PROTECT COASTAL AREAS FROM OIL-POLLUTED SEAWATER
(A CASE STUDY OF COASTAL AREAS IN BEKASI REGENCY)

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LEMBAR PENGESAHAN TESIS

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Makassar, 9 September 2021

Yang Menyatakan

Pramadania Agustine

FOREWORD

Bismillaahirrahmaanirraahim

Alhamdulillaahi rabbil ‘aalamin

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PRAMADANIA AGUSTINE

ABSTRAK

Pramadania Agustine. Strategi Pengelolaan untuk Melindungi Wilayah Pesisir dari Air Laut yang Tercemar Minyak: Studi Kasus Wilayah Pesisir di Kabupaten Bekasi (Dibimbing oleh Herman Parung, Patricia Dale, Chris Frid dan Peter Davey).

Penelitian ini bertujuan untuk memberikan rekomendasi rumusan kebijakan yang dapat diambil oleh pemerintah daerah setempat untuk melindungi wilayah pesisir dari air laut yang terkontaminasi minyak, terutama yang bersumber dari insiden tumpahan minyak.

Dalam merumuskan rekomendasi tersebut, beberapa tahapan dilakukan dalam penelitian ini. Analisis geografis dilakukan dengan mengoptimalkan aplikasi GIS untuk memetakan kondisi lahan termasuk penilaian perubahan penggunaan lahan selama beberapa tahun dan menyajikan deteksi sebaran tumpahan minyak yang terjadi. Selain analisis geografis, penelitian ini juga menggunakan analisis Statistik, analisis Strength Weakness-Opportunity-Threat (SWOT) dan Analytical Hierarchy Process (AHP).

Hasil penelitian ini menunjukan perubahan lahan di Muara Gembong selama 20 tahun terakhir (2000-2020), dari 14.475,46 ha pada tahun 2000 menjadi 12.869,70 ha pada tahun 2020. Adanya abrasi dan akresi mempengaruhi perbedaan luas total. Hasil ini menggambarkan permasalahan yang dihadapi kawasan Muara Gembong sebelum kejadian tumpahan minyak. Setelah melakukan penilaian terhadap kondisi geografis, dilakukan penelitian mengenai sejauh mana dampak yang ditimbulkan oleh tumpahan minyak dan persepsi masyarakat terhadap kejadian tersebut. Analisis statistik menunjukkan bahwa terlepas dari dampak signifikan yang ditimbulkan oleh kejadian tumpahan minyak, masyarakat pesisir Muara Gembong tidak menganggap kejadian tersebut sebagai bencana yang memerlukan kesiapan, seperti jika terjadi gempa bumi atau tsunami. Temuan ini semakin menekankan pentingnya pengelolaan wilayah pesisir yang lebih baik. Berdasarkan serangkaian analisis yang dilakukan, mulai dari analisis SWOT hingga AHP dirumuskan bahwa sinergi dan koordinasi antar instansi terkait merupakan strategi terpenting dalam perancangan strategi pengelolaan strategis kawasan pesisir Muara Gembong dari pencemaran minyak.

Kata Kunci: dampak lingkungan; polusi minyak; pengembangan pesisir.

ABSTRACT

Pramadania Agustine. Management Strategies to Protect Coastal Areas from Oil-Polluted Seawater: A Case Study of Coastal Areas in Bekasi Regency (Supervised by Herman Parung, Patricia Dale, Chris Frid and Peter Davey).

This study aims to provide recommendations for policy formulations that can be taken by local governments to protect coastal areas from seawater contaminated with oil, especially those originating from oil spill incidents.

In formulating these recommendations, a number of assessment stages were carried out. Geographic analysis is carried out by optimizing GIS applications to map land conditions including assessment of land use changes over several years and presenting detection of the distribution of oil spills that occur. In addition to geographic analysis, this study also uses Statistical analysis, Strength-Weakness-Opportunity-Threat (SWOT) analysis and Analytical Hierarchy Process (AHP).

This study showed the land changes in Muara Gembong during the last 20 years (2000-2020) from 14,475.46 ha in 2000 to 12,869.70 ha in 2020. The existence of abrasion and accretion influences the differences in the total area. This result illustrates the problems faced by the Muara Gembong area prior to the oil spill incident. After that, study was carried out on the extent of the impact caused by the oil spill and the community's perception of the incident. The statistical analysis shows that regardless of the significant impact caused by the oil spill incident, the Muara Gembong coastal community does not consider the incident a disaster that requires readiness, such as in the case of an earthquake or tsunami. These findings further emphasize the importance of better coastal area management. Based on a series of analyses carried out, starting from the SWOT analysis to AHP, it was formulated that synergy and coordination between related agencies is the most important strategy to protect Muara Gembong coastal area from oil pollution.

Keywords: environmental impacts; oil pollution; coastal development.

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LIST OF ABBREVIATIONS

AHP	Analytical Hierarchy Process
API	American Petroleum Institute
DEM	Digital Elevation model
ESI	Environmental Sensitivity Index
ETM+	Enhanced Thematic Mapper Plus
FWS	US Fish and Wildlife Service
GIS	Geographic Information System
GNOME	General NOAA Operational Modelling Environment
HAZMAT	Hazardous Materials Response Division
IPB	Institut Pertanian Bogor (Bogor Agricultural Institute)
ITOPF	International Tanker Owners Pollution Federation
LAPAN	Lembaga Penerbangan dan Antariksa Nasional (National Institute of Aeronautics and Space of the Republic of Indonesia)
LULCC	Land Use and Land Cover Change
OLI	Operational Land Imager
NDVI	Normalised Difference Vegetation Index
NOAA	National Oceanic and Atmospheric Administration
PHE ONWJ	Pertamina Hulu Energi Offshore North West Java
SAR	Synthetic Aperture Radar
SWOT	Strength-Weakness-Opportunity-Threat

SPSS	Statistical Package for the Social Sciences
TRIS	Thermal Infrared Sensor
USGS	United States Geological Survey

CHAPTER I

INTRODUCTION

A. Background

The oil spill incident that occurred in the Java Sea in July 2019, further emphasized the importance of long-term spatial planning for coastal protection. Research conducted by Maitieg (2017) revealed that understanding the oil risk and vulnerability is key for this type of planning. Douvere et al. (2007) argued that such planning is needed to quickly respond to events/problems that occur to minimize negative impacts, resulting in a decrease in the quality of aquatic and terrestrial ecosystems.

According to Laffon et al. (2016), oil pollution negatively impacts aquatic ecosystems and terrestrial ecosystems, such as creating health problems for coastal residents (people and biota). Given the significant potential impact that may arise from oil pollution, Laffon et al. (2016) considered oil pollution, especially an oil spill, as an ecological disaster. This is in line with Stikova et al. (2008) who considered that an event could be considered a disaster when it has a severe impact on society and causes social, economic, or environmental loss. Therefore, it is increasingly clear that the threat of oil pollution in the future needs to be taken seriously (Ivshina et al., 2015).

The discussion about terrestrial ecosystems that are affected by oil pollution in the sea cannot be separated from the matter of coastal area planning. Coastal management planning is an important instrument to determine the dynamics of coastal communities related to utilization patterns and appreciation of coastal and marine resources (Zefri et al., 2009). However, in its utilization, the Muara Gembong Coastal Area (the study area), is still considered to be unsustainable due to the irregular use of space (Setra & Asyiawati, 2019). Land use that has been carried out has not considered environmental capability and carrying capacity. For this reason, it is necessary to monitor land changes so that the negative impacts due to land change can be overcome and coastal management in the future can be sustainable. The first objective of this study is to assess land changes in Muara Gembong and the impact on coastal residents, especially when an oil spill occurs.

Coastal planning in the context of controlling pollution in coastal and marine areas is one form of efforts to conserve the coastal environment and the natural resources it contains (Putra, 2018). One approach that can be taken in overcoming the impact of disasters or incidents in the region is to involve the aspect of preparedness (Stikova et al., 2008). Carter (1991) defines preparedness as actions that enable stakeholders to be able to respond to a disaster situation effectively. Since the perception of disaster risk can shape a person's intention to perform preparedness behaviour, the second objective of this study is to determine the extent of community perceptions of risk to oil spills, and how this perception affects their preparedness in the face of such event.

Considering that oil pollution is a major threat to environmental sustainability, government policies are needed to minimize the possible future impacts (Albert et al., 2018). The third objective of this study is to formulate initial recommendations for coastal development policies using a SWOT analysis. This stage analyses the strengths, weaknesses, opportunities, and threats of the management of the Muara Gembong coastal area, in relation to alternative development of the area in the future. From the SWOT analysis, several recommendations for coastal management strategies were developed. To ensure that each recommendation is feasible, further analysis of the recommendations using tools such as geographical analysis will be performed.

As the fourth objective of this study, an Analytical Hierarchy Process (AHP) will be carried out to ensure that this research will produce better final decisions justified by the analysis. The SWOT analysis will then be carried out as a priority analysis, covering aspects such as the actors, resource utilization and management strategies. The application of a combination of SWOT and AHP analysis in this study is expected to improve the quantitative aspects of strategic planning, allowing the results obtained to be used for the formulation of appropriate alternative strategies (Górener et al., 2012).

B. Research Questions

One form of pollution that may occur in the western Java Sea that may threaten the coastal area of Muara Gembong are oil spills caused by offshore oil mining activities. To address this potential threat, it is necessary to formulate policy recommendations that can be implemented by the local government to protect the Muara Gembong coastal area in the event of an oil spill. Therefore, in this study, problems that need to be resolved consider the following research questions, including:

1. To what extent has land change occurred in Muara Gembong over the last few decades, and how was the impact on coastal residents, especially during an oil spill?
2. To what extent do community perceptions of risk from oil spills affect their preparedness in the face of such events?
3. What kind of policies can be implemented to protect coastal areas?
4. What are the appropriate management strategies to protect coastal areas from oil-polluted seawater?

C. Aim and Objectives

This study aims to provide scientific-based management directions for coastal area management while still considering its geographical conditions. Thus, in the future, the coastal area of Muara Gembong can be protected from seawater contaminated with oil.

To achieve this, several objectives were set, including:

1. To identify land changes that have occurred in Muara Gembong and the impact on coastal residents, especially when an oil spill occurs.
2. To analyse the extent to which community perceptions of risk to oil spills affect their preparedness in the face of such events.
3. To determine the most applicable strategy to protect the coastal areas in Muara Gembong District from oil pollution.

D. Significance of the Study

This research is expected to provide an overview of the management strategies to protect the coastal areas from oil pollution. More specifically, this research is expected to be beneficial for several parties, including:

- For the private sector
  This research is expected to be used as input to be more aware of the impact of oil pollution on coastal resources. Also, this research is expected to provide input in developing strategies for implementing community development programs or Corporate Social Responsibilities (CSR).
- For academics and researchers
  This research is expected to provide additional literature on the ecological and social impacts of oil pollution on coastal areas and future management strategies.
- For the government
  This research is expected to provide input for policymakers (decision-makers) in managing and utilizing sustainable coastal resources. Also, it is expected that the government can develop appropriate coastal pollution prone management strategies to minimize the impacts that may arise in the future.
- For the community

This research is expected to be able to broaden people's insights about the impact of oil pollution on coastal areas, the things that cause it to occur, and management strategies to protect the coastal areas from oil pollution.

E. Scope and Limitations of the Study

The scope of this research focuses on the following crucial issues:

1. Among several sources of oil pollution in the sea, this research focuses on oil pollution from oil spills due to offshore oil mining activities;
2. Discussion on the efforts needed to control and minimize the impact of oil pollution that may occur is carried out from the local government's perspective.

The limitations of this research is that this study aims to promote the use of technical tools as a part of formulating management decisions, by giving some simulation techniques, but will not formulate the model itself.

F. Study Outline

In order to make easy the understanding of this thesis, an early brief is needed to illustrate the content of each chapter. Therefore, structure of the thesis below gives the description of the content shortly, as follows:

Chapter 1 is an introduction chapter. It will talk about background of the research which explains the research object, research questions, research objectives, significance of the study, the scope of the study and structure of thesis.

Chapter 2 is a literature review. This chapter presents some theories related to the research. The theories used in this research are the condition of coastal areas in Muara Gembong (land-use and land cover change), overview of preparedness, management of coastal area, oil spill impacts, and oil spill control.

Chapter 3 is a research methodology. It will explain the data that has been collected and the data processing.

Chapter 4 is results of analysis. This chapter discusses the results gained from the research analysis.

Chapter 5 is discussion. This chapter discusses more about findings and implications that need to be considered. It also discussed the obstacles and limitation of the research.

Chapter 6 is conclusion. This chapter consist of summary and recommendations. The summary based on the analysis on Chapter 4 and 5. Meanwhile, the recommendation can be used as an input for the government to make a policy that related.

CHAPTER II

LITERATURE REVIEW

A. Land Use and Land Cover Change Analysis

Humans and various kinds of development that occur change the global landscape (Paul, 2013). For example, population growth will be followed by an increase in the need for land for settlement. This then leads to land conversion from vegetated land to settlements and buildings due to urbanisation (Wiggers et al., 2020). As human population and activity rapidly increases, undeveloped land is quickly becoming a scarce natural resource. Land use and land cover change (LULCC) or land change is unavoidable due to the increasing demand for land use by population growth requirements (Wahyuni et al., 2014).

Land cover change and land use change have different meanings. According to Liping et al. (2018), land cover change is defined as the physical and biological changes in land cover by vegetation, including water. Whereas land-use change has a more complex meaning as it involves natural and socio-economic perspectives on changes in land use for human activities. The human activities impact changes in processes that occur on the earth's surface, including biogeochemistry, hydrology and biodiversity. The dynamics of land-use change often lead to changes in land quality due to the mismatch between land capability and its use (Wahyuni et al., 2014).

Although they are two different terms, land use and land cover are often used together to describe the type of human activities and the land used (Ryngnga & Ryntathiang, 2013). In some instances, the two terms are difficult to separate. For example, in forest vegetation land cover, there is land use for ecotourism, watersheds or timber production. Therefore, in general, especially in the use of remote sensing data on a semi-detailed scale, the two terms are combined with the designation of land use/land cover (Baja, 2012).

B. Coastal Community Preparedness Against Oil Spill Disaster

Disaster preparedness is a series of acts that enables governments, organizations, communities, and individuals to respond to a disaster situation quickly and efficiently (Carter, 1991). Disaster preparedness is a part of the disaster management process. Increased disaster preparedness is one of the important elements of pro-active disaster risk reduction activities, before a disaster occurs (LIPI, 2006).

LIPI (2006) states that the parameters for measuring community preparedness in anticipating disasters are:

- Knowledge and Attitude Towards Disaster Risk
  The knowledge they have can usually influence the attitude and concern of the community to be ready and alert in anticipating disasters, especially for those who live in coastal areas that are prone to oil spills.
- Policy Guidelines
  Oil spill disaster preparedness is very important and is a concrete effort to carry out disaster preparedness activities.
- Resource Mobilization

Resource mobilization is a crucial factor because the available resources, such as human, financial and important infrastructure for emergencies constitute a potential that can support or otherwise become an obstacle in disaster preparedness.

Further, the perception of disaster risk has become an important topic for policy makers who are concerned with safety issues (Sjöberg et al., 2004). Although there are differences in the models used to explain the perception of disaster risk, researchers and practitioners generally reach an agreement that the perception of disaster risk is important (Yong et al., 2017).

Perceived Risk is a subjective assessment of the likelihood that certain types of events may occur and the extent consequences are prioritised (Sjöberg et al., 2004). Yong et al. (2017) suggests that risk perception of disasters is a multidimensional structure consisting of beliefs about the risks and problems of natural disasters. The research investigates risk perception and disaster preparedness for natural disasters. Yong et al. (2017) reveals three psychological dimensions that underlie risk perception, such as:

- External Responsibility for Disaster Management
  External responsibility for disaster management reflects that individuals believe that the government, organizations and people have a role and are responsible for disaster preparedness and management. Individuals are willing to follow directions or calls from governments, organizations, communities and society for disaster management to reduce the risk disaster impact (Yong et al., 2017).
- Self-preparedness Responsibility

Self-preparedness responsibility represents the belief that individuals are in control and responsible for the risk of natural disasters through disaster preparedness. The likelihood of risk that individuals will receive as a result of a disaster depends on the efforts made to minimize this risk by implementing preparedness (Yong et al., 2017).

- Illusiveness of Preparedness

  The Illusiveness of Preparedness shows the individual's attitude in responding to disaster risk with a fatalistic attitude (surrender to fate), through rejection and wishful thinking. This attitude can increase the sense of uncertainty about disasters and a lack of control over risks as well as the view that disaster preparedness is a waste of time and efforts (Yong et al., 2017).

C. Management of Coastal Areas

The coastal area has to be carefully managed, especially in planning and allocating natural resources (Lamin-Wadda, 1999; Vallejo, 1993). To ensure this, effective coordination and cooperation between the relevant sectors, such as the government and the local community is required. This is in line with the Regulation of Minister of Maritime Affairs and Fisheries Republic of Indonesia number 14/MEN/2009 relating to Maritime Partners; which regulates that management of coastal areas and small islands is a process of planning, utilization, supervision, and control of coastal resources and small islands with several sectors.

Coastal development may have implications for existing ecosystems (Sevilla et al., 2019). There are two kinds of implications, direct impacts such as dredging and indirect impacts such as pollutants (Reefresilience, 2016). Given the differing nature of these impacts, it is necessary to consider management using a sustainable framework that can be applied to reduce a range of negative impacts. According to Jamil (2007), to develop a coastal area with sustainable framework, five management issues in ecological dimension need to be carried out:

- The existence of spatial harmony, between the preservation zone and the conservation zone;
- The rate of utilization of renewable resources. This should not exceed the renewable capacity of the resources within a certain period of time;
- Implementation of methods that do not damage the environment when exploiting mining materials and minerals;
- The rate of disposal of biodegradable waste which does not exceed the assimilative capacity of the coastal and marine environment; and
- Consideration of the characteristics and natural dynamics of the coastal and oceanic environment when modifying them.

D. Oil Pollution

Oil pollution refers to pollution caused by the spillage of oil creating negative ecological impacts on marine and terrestrial ecosystems (Macías-Zamora, 2011). There is widespread agreement in the literature that the magnitude of the impact caused by an oil spill depends on several factors: the number of spills, the condition of the spill location, the type of oil, and responsiveness in handling the oil spill (Adamu et al., 2016; Chang et al., 2014; Ramseur, 2010).

Generally, oil pollution in the sea can occur in various ways, such as water transportation (Sunar et al., 2007; B. Zhang et al., 2019), offshore exploration (Mukhtasor, 2007; B. Zhang et al., 2019), and originating from the mainland (P. Nwilo & Badejo, 2005). When oil enters the marine environment as a pollutant, oil immediately undergoes physical and chemical changes which can reduce the quality of seawater (Mukhtasor, 2007). This becomes a threat to biodiversity (Bassem, 2020) even though the oil may not be visible on the sea surface (Adzigbli & Yuewen, 2018).

1. Crude Oil Characteristics

To minimize the impact of future oil spills, it is vital to understand the types of oil that have polluted the sea. By understanding the types and characteristics of oil, it is expected that it will facilitate handling incidents. Thus, the impact on coastal residents and the environment can be minimized.

Crude oil is mainly made from a combination of hydrocarbons and 10% of molecules, including Oxygen, Sulphur, and Nitrogen (Adzigbli & Yuewen, 2018). Crude oil that has just come out of the exploration contains various types of chemicals in gas, liquid, or solid. Based on statement by PHE ONWJ, the type of oil spilled in the Java Sea is crude oil with a waxy clumping characteristic (Fikri, 2019). Table 2.1 details the characteristics of crude oil.

Table 2.1 Crude Oil Characteristic (Fingas, 2012)

Property	Units	Gasoline	Diesel	Light Crude	Heavy Crude	Intermediate Fuel-Oil	Bunker C	Crude Oil Emulsion
Viscosity	mPa.s at 15°C	0.5	2	5-50	50 to 50,000	1,000 to 15,000	10,000 to 50,000	20,000 to 100,000
Density	g/ml at 15°C	0.72	0.84	0.78 to 0.88	0.88 to 1.00	0.94 to 0.99	0.96 to 1.04	0.95 to 1.00
Flash Point	°C	-35	45	30	60	80 to 100	>100	>80
Solubility in Water	ppm	200	40	10 to 50	5 to 30	10 to 30	1 to 5	-
Pour Point	°C	-	-35 to 1	-40 to 30	-40 to 30	-10 to 10	5 to 20	>50
API Gravity		65	35		10 to 30	10 to 20	5 to 15	10 to 50

As shown in Table 2.1, Fingas (2012) formulated an outline of crude oil characteristics by describing each oil property. The first characteristic is viscosity, which determines the fluid's internal resistance to flow (Saeed et al., 2016). It shows the tendency for crude oil to float or sink. Clark et al. (1989) stated that the lower the oil viscosity value, the faster oil will spread. The other property is density; where the oil will float on the water if the density of the oil is less than water. The flash point is an essential indicator of the safety of an oil spill clean-up operation (Wang et al., 1964). According to Wang et al. (1964), immediately after an oil spill, most crude oils have a low flash point so that the lighter components evaporate or disperse. Crude oil will be considered dangerous if the flash point is less than 60°C. The solubility in water indicates how much oil will dissolve in water at a known temperature and pressure (Wang et al., 1964). Solubility is important to understand, considering that dissolved oil components are often very toxic to aquatic life. A Pour Point is a procedure used to assess wax deposition.

Pour Point above ambient temperature indicates the amount of wax content (Oliveira et al., 2018). API gravity indicates the quality of crude oil (Dickson & Udoessien, 2012). The higher the API gravity, the lower the crude oil liquid's density, so that light oil has a high API gravity (Geary, 2017).

2. Behaviour of Oil at Sea

The distribution of oil into the water depends on the amount, characteristics and type of oil, weather conditions, waves, currents, and shoreline type (FWS, 2010). Pollutants originating from petroleum (petroleum hydrocarbons) have received enormous international, political, and scientific attention when polluting waters. This is due to the effect of oil on aquatic ecosystems, which can reduce the quality of seawater (Mukhtasor, 2007).

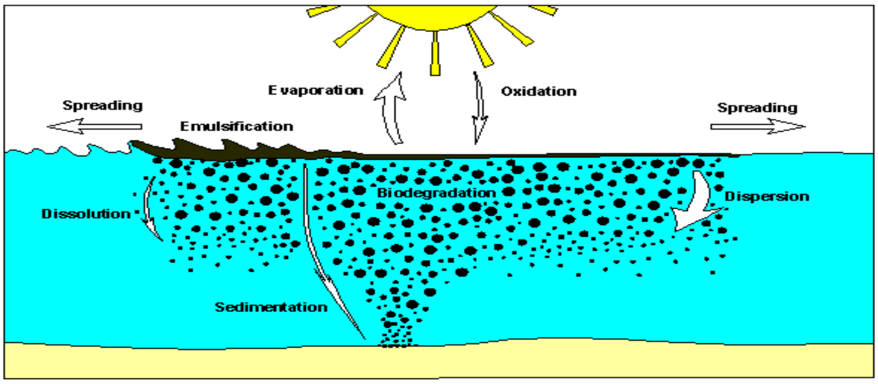


Figure 2.1: The Behaviour of Oil at the Sea

When oil enters the marine environment as a pollutant, oil immediately undergoes physical and chemical changes through various processes. According to ITOPF (2019), eight main processes as shown in Figure 2.1 are:

- Spreading

  The speed of the dispersion process depends on the ambient temperature and the composition of the oil.

- Evaporation

  The rate of evaporation depends on oil volatility, sea conditions, ambient temperature and wind speed.

- Dispersion

  The degree of oil dispersion is determined by sea conditions, oil properties and oil viscosity.

- Emulsification

  The process of oil emulsification is characterized by physical mixing which is promoted by sea level turbulence. This stage is a source of mortality for organisms, especially in eggs, larvae, and embryonic development because at this stage it is very susceptible to polluted environments.

- Dissolution

  Dissolution is determined by the condition and composition of the oil. This stage is accelerated when the oil is spread well in the water column.

- Oxidation

  The oxidation process takes place if there is contact between oxygen with oil or fat. This stage is promoted by the type of oil, sunlight, and form in which it is exposed to sunlight.

- Sedimentation

  This process occurs when oil in the sandy coastline is mixed with sand and then swept from the beach back into the sea and submerged.

- Biological degradation (Biodegradation)

Biodegradation is largely determined by the level of nutrients (phosphorus and nitrogen) in water, temperature and oxygen levels available.

3. Impact of Oil Pollution

Oil pollution as a result of oil spills or accidents is the biggest threat to the sea and its supporting ecosystems (Sayol et al., 2014). To assess the impact caused by oil spills, it is essential to have knowledge about the effects of oil physically, chemically and biologically (De Araújo et al., 2014). Physically, oil pollution can be seen in marine environments such as when beaches become dirty due to the sea surface being covered by a layer of oil on the surface of sea water. Chemically, petroleum contains aromatic hydrocarbon compounds which are toxic and can kill marine organisms. Biologically, the presence of oil pollution can disrupt the lives of organisms including fish. Therefore an intensive effort must be made to minimize oil pollution at sea.

a. Impact on Coastal Area

Coastal areas may have a significant impact from oil pollution (Bejarano & Michel, 2016). Extensive research has been conducted to see the degree of the impact of oil on coastal areas and its ecosystems, such as mangroves (Sodré et al., 2013) and rocky shorelines (Castège et al., 2014). A semi-quantitative sensitivity index which was earlier known as Environmental Sensitivity Index (ESI) as introduced by E. Gundlach and Hayes (1978) can be used to determine the sensitivity of coastal areas to oil pollution.

b. Impact on Natural Resources

In general, there are three main ecosystems on the coast that interact with one another, including mangroves, coral reefs and seagrass beds.

Since coral reefs and seagrass beds do not exist in the Java Sea, this section will focus on the impact on mangroves as the most vulnerable coastal habitat when exposed to oil pollution (Duke, 2016; Hoff, 2002).

c. Impact on Marine Biota

In general, oil pollution can cause damage to the food chain, which is described by the relationship between fish and plankton. According to Jiang et al. (2010), the hydrocarbon component of petroleum influences reproduction, the development, growth, and behaviour of marine life, especially in plankton. As a consequence, fish are killed and fish reproduction decreases due to a lack of plankton.

d. Impact on Animals

Oil pollution has a serious effect on ecosystems and organisms such as seabirds, particularly in their regenerative periods (Al-Majed et al., 2012). According to Michel and Fingas (2016), seabirds are exposed to oil through the food chain, physical exposure, absorption and consumption. Seabirds come in to contact with crude oil floating on the water's surface causing them to become smothered with oil and this can cause immediate mortality via suffocation. Crude oil disrupts feather integrity displacing insulating air between feathers leading to loss of water-proofing, thermal insulation and buoyancy. They become unable to dive or fly so they cannot forage to feed. Relatively quickly fat reserves are depleted and ultimately birds become severely hypothermic and emaciated causing significant mortality (Troisi et al., 2016).

E. Formulation of Management Recommendations

To formulate recommendations for the management of oil pollution, the combination of Strength-Weakness-Opportunity-Threat (SWOT) and Analytical Hierarchy Process (AHP) analysis will be used for this research.

This technique has been used in several environmental studies (Eslamipoor & Sepehriar, 2014; Masozera et al., 2006), but so far, there has been no use of this technique to prioritize planning policies for coastal areas prone to oil spills.

1. Strength-Weakness-Opportunity-Threat (SWOT) analysis

The SWOT analysis may be an organized arranging strategy to assess a project's strengths, weaknesses, opportunities, and threats (Rim-Rukeh, 2015). It is ordinarily utilized to identify strategic directions (Chambers, 2014). A SWOT analysis produces valuable information about the Muara Gembong coastal area's sustainability to stem the negative impacts that oil-producing companies may generate from their activities, such as oil spills.

A SWOT analysis scans the relevant information from the environment. The SWOT analysis will serve as part of program building, evaluation, and action planning (Olaniyi & Viirmäe, 2017). Piercy and Giles (1989) stated that a SWOT analysis uses knowledge about threats to calculate the risk so that actions are taken to mitigate, exploit, and avoid losses.

The two main components of a SWOT analysis are the internal situation indicators described by strengths and weaknesses and the indicators of the external environment described by opportunities and threats. Many European countries have used a SWOT analysis to select policy priorities and ensure horizontal policy coherence in their national strategies for sustainable development (Markovska et al., 2009). Further, the steps taken in determining the direction of pollution management strategies in the SWOT analysis in this study consisted of identifying and scoring internal and external factors and making the SWOT Matrix.

1. Internal and External Factors

   Identification of internal factors is carried out to determine the factors that become strengths and weaknesses as well as the identification of external factors that become opportunities and threats (H. Zhang & Chen, 2013). Then determine the weights of each parameter with the sum of all weights of 1.0 (with a value category of 1 = very important, 0.75 = important, 0.50 = standard, 0.25 = not important, 0.10 = unimportant). Determination of the weight of each factor uses a scale of 1, 2, 3, and 4, such as:

   - If the horizontal indicator is less important than the vertical indicator.
   - If the horizontal indicator is as important as the vertical indicator.
   - If the horizontal indicator is more important than the vertical indicator.
   - If the horizontal indicator is significant compared to the vertical indicator.

2. The SWOT Matrix

   The SWOT matrix can clearly illustrate how external opportunities and threats faced in managing coastal areas prone to oil pollution can be adjusted according to their strengths and weaknesses. Table 2.2 shows a SWOT matrix that generates four possible sets of strategic alternatives so that strengths and opportunities can be increased and weaknesses and threats can be overcome. (Aslan et al., 2012).

Table 2.2: The SWOT Matrix (Hunger & Wheelen, 2003)

internal / external	Strength (S)	Weakness (W)
Opportunities (O)	**S/O Based Strategies** Generate strategies here that use strengths to take advantage of opportunities	**W/O Based Strategies** Generate strategies here that take advantage of opportunities by overcoming weaknesses
Threats (T)	**S/T Based Strategies** Generate strategies here that use strengths to avoid threats	**W/T Based Strategies** Generate strategies here that minimize weaknesses and avoid threats

2. Analytical Hierarchy Process (AHP)

An AHP is a decision support model developed by Thomas L. Saaty in 1994. This decision support model describes complex multi-factor or multi-criteria problems into a hierarchy/level. According to Saaty (1994), hierarchy is defined as a representation of a complex problem in a multi-level structure. The first level is the goal/focus, followed by the next level, namely criteria, sub-criteria, and so on to the last level, namely alternatives.

Expert Choice is software that can solve problems based on the AHP method by comparing many alternatives with specific criteria. In this study, Expert Choice was useful in determining important priorities that were aligned with strategic objectives through stakeholder participation and support.

A vital tool needed to carry out the AHP method is the pairwise comparison table created for each criterion. According to Simon et al. (2019), for the AHP process, each alternative is compared to other alternatives according to the given criteria. Another matrix, as shown in Table 2.3, was then constructed to give relative weight to each criterion concerning the objective.

Table 2.3: The Pairwise Comparison Scale (Prasetyo & Handajani, 2019)

Intensity of Interest	Explanation
1	The two elements contribute equally
3	Moderate the importance of one element compared to other elements
5	Stronger importance of one element compared to other elements
7	One element is clearly essential and has domination in practice compared to the other element
9	One element is absolutely more important than other element, based on strong facts and evidences.
2,4,6 and 8	The value between the two elements approximates the value of consideration

F. Controlling Oil Pollution in Coastal Areas

Marine pollution by oil will cause a decrease in the quality of resources and damage ecosystems. Therefore it is necessary to control efforts. According to Nedi (2010), attempts to control oil pollution at sea must be carried out holistically through two aspects as a foundation, such as policy and technology utilization aspects.

1. Policy Aspect

Through its specialized agencies, the government plays a role in fostering, supervising, and controlling the occurrence of oil pollution. The oil pollution is caused by various oil and gas industry activities and transportation activities of ships and ports around the Java Sea. This policy instrument's existence is a control to prevent oil pollution that aims to minimize community losses and damage to the marine environment in the future.

One of the policies discussed in this study is a policy related to the utilization of land or land use conflict issues. Often in the land use process, aspects of land capability or suitability are ignored. This can lead to the harm of living organisms. Therefore, in this study, the level of suitability of land use in the Muara Gembong area will be assessed as a policy recommendation for local governments. Land suitability itself is a description of the level of suitability of a piece of land for a particular use. Land suitability evaluation has a strong emphasis on locations that have positive traits concerning the success of its production or use (Sitorus, 1985). The result of land suitability analysis is the land suitability map.

2. Technology Utilization Aspect

For effective management, local governments need to have administrative methods to appropriately deal with oil pollution and an indispensable tool for risk assessment, safety, and contingency planning as part of the decision support framework. To preserve the marine environment, the local government should have the ability to predict the evolution of an oil spill and have data to analyse extreme events and scenarios. Many current oil tracking models are used by various oceanographic centres. General NOAA Oil Modelling Environment (GNOME) is an oil spill distribution model that simulates the movement of oil affected by wind, currents, tides, and oil spills distribution. GNOME was developed by the Hazardous Materials Response Division (HAZMAT) of the National Oceanic and Atmospheric Administration Office of Response and Restoration (G. NOAA, 2002). HAZMAT uses this model during an oil spill to estimate the “best guess” of the oil spill distribution associated with the uncertainty of the oil spill distribution. The broad function of GNOME is to predict the effect of wind, currents, and other processes of movement in the ocean on oil spills in the sea. GNOME is also used to predict the uncertainty of oil spills' distribution and the condition of oil affected by the weather around oil spills (G. NOAA, 2002).

In predicting the distribution of oil spills, GNOME uses visual aids of splots consisting of black and red splots. Black splots represent GNOME's best guess for an oil spill, estimated to be 1-2 miles accurate in 48 hours. To make a best guess, GNOME assumes that; (1) the wind continues to blow rapidly at the speed and direction entered into the model, (2) the data in the Location File accurately represents the current pattern over the lifetime of the spill. Red splots represent GNOME's larger minimum regret trajectory estimates for the same spill. GNOME assumes a level of uncertainty based on the input data, so that the estimated prediction error of the oil spill trajectory will not be outside the area covered by the red splots with probability 90% (G. NOAA, 2002).

GNOME has two main modes, standard mode and diagnostic mode. In standard mode, location files are used in the form of polygon map information, currents, winds, oil characteristics, sea depths and other data. In this mode, the user only varies various additional parameters to see their impact on changes in the oil trajectory. Although using standard mode is very easy, the available location maps are very limited. If the desired location is not available, you can use the diagnostic mode (Salim & Sutanto, 2013).

The measurement of oil pollution control must be able to run effectively and efficiently. This can only be achieved if a good system of oil pollution control information is available. One example of the information needed is information related to the level of vulnerability or sensitivity of the coast to oil spills. The results of the analysis of the environmental sensitivity index (ESI) for oil pollution will be ESI maps. ESI maps provide a concise summary of coastal resources that are at risk if an oil spill occurs nearby (NOAA, 2000). This information is valuable to determine oil pollution control strategies and to save the surrounding ecosystem.

Furthermore, to ensure that both analyses can be carried out, there needs to be a supply of geographic data presented through the Geographic Information System. Weng (2010), states that Geographical Information Systems (GIS) is an integrated software package created specifically for processing geographic data with various purposes. GIS is able to do the processing, starting from data entry, storage, displaying information back to the user, and analysing the data.

G. Previous Research and Links to the Present Research

In the last few decades, research in the environmental field has increasingly been directed to understand whether there is a relationship between the phenomenon of changing environmental conditions and its impact on human-nature (Seymour, 2016). One of which is the research on the impact of oil pollution on the environment and surrounding communities. Research conducted by various authors focused on the impact of oil pollution on the environment (Albers et al., 1985); (Olita et al., 2012); (Partelow et al., 2015); (Seymour, 2016) and (Ventikos & Psaraftis, 2004). On the other hand, Albert et al. (2018) focused on the social impacts that emerged. This paper covers both aspects, however with a few differences and adjustments. For the environmental impact, this research will discuss the impacts not only for one specific species, as discussed in previous studies, but also discuss the environmental impacts experienced by various species, such as coastal areas, marine biota, animals, and natural research. For the social impact, the direction of the discussion will be slightly different as this study will focus on handling impacts with long-term strategies. This includes recommendations for optimizing the use of technological tools to minimize future impacts. In contrast, previous studies Albert et al. (2018) focused on short-term strategies for handling impacts by talking about compensation policies.

Furthermore, another distinguishing factor about this research compared to previous research conducted by Nedi (2010) and Samuels et al. (2013) is it aims to formulate a model of the distribution of oil pollution. The distribution simulation is not intended to formulate a model but only to promote the use of technological tools as a support for decision making. This is important to discuss in this study, because based on the results of interviews, the Bekasi Regency Government has not implemented an oil spill simulation system when an oil spill incident occurred. It is expected that the simulation results in this study can provide an overview of the importance of running oil spill simulations for coastal areas that are prone to oil spills.

The other difference in this research is related to the alternative selection method to be implemented to deal with oil pollution. The method used in the research conducted by Zafirakou et al. (2018), was PROMETEE analysis, in which a multi-criteria analysis method is to rank the options or treatment approaches to be carried out. Although this research and this study both aim to rank, the methods used are quite different. For this research, the AHP method will be used.

CHAPTER III

METHODOLOGY

A. Methodology Overview

The research used a qualitative and quantitative approach. The qualitative approach was chosen because this approach allows one to describe and clarify the meaning that underlies participants' behaviour. It also describes complex settings and interactions, identifies types of information, and explain the phenomena. Meanwhile, a quantitative approach is applied in systematic empirical investigation via statistical and computational techniques based on statistical data and numerical data gathered for SWOT and AHP analysis (Kurttila et al., 2000). Table 3.1 summarises the objectives, methods and outputs of the research.

Objectives	Input (variables)	Data collection Method	Respondents/ Sources	Data Analysis and Tools	Output
Analysing the extent to which land change occurred in Muara Gembong over the last few decades, and how was the impact of oil spill on coastal residents	-	Satellite imagery from landsat	https://earthexplorer.usgs.gov/	Visual interpretation of the landsat image GIS analysis	Land use maps for 2000, 2010 and 2020 Maps and data on land change trends
Analysing the extent to which community perceptions of risk to oil spills affect their preparedness	Indicators to community perceptions of risk affect their preparedness proposed by Yong et al. (2017)	Survey	Local people in coastal villages (six people per village).	The statistical tests used include descriptive analysis, normality test, linearity test and hypothesis testing using the SPSS application	The extent to which community perceptions of risk to oil spills affect their preparedness (Statistical Hypothesis)
Formulating recommendation of policy implications that can be implemented to protect the coastal area	-	Interview	Local government, Non-Government Organization (NGO) and coastal residents of Muara Gembong	SWOT analysis	Policy implications that can be implemented to protect the coastal area
Determining the right management strategy to protect the coastal areas from oil pollution	-	Interviews and observations.	Local government, NGOs, academics	AHP	The priority of coastal management strategy to protect coastal area from oil-polluted seawater

Table 3.1: Objective, Method and Output

B. Research Context

Generally, oil pollution in the sea can occur in various ways, such as water transportation (Sunar et al., 2007; B. Zhang et al., 2019), offshore exploration (Mukhtasor, 2007; B. Zhang et al., 2019), and originating from the mainland (P. Nwilo & Badejo, 2005). Among the various sources of pollution, the Java Sea faces the threat of pollution that can arise from offshore exploration activities. Unfortunately, in July 2019, the oil spills occurred beneath the offshore platform, located about 2 kilometers north of Karawang (JakartaPost, 2019). The oil spill then reached the Karawang, Bekasi, and Kepulauan Seribu regencies. Although the oil spill incident did not appear to have a significant impact on tourism, it is reported that it has deprived fishermen of fishing opportunities, loss of fishpond farmers, marine life and the health of coastal residents (JakartaPost, 2019).

As one of the coastal areas affected by the oil spill, the impact experienced by residents of the Muara Gembong coastal area in the Bekasi Regency cannot be ignored. Before the oil spill, the coastal communities of Muara Gembong experienced environmental problems caused by damaging land changes, such as annual tidal flooding and abrasion-accretion. When an oil spill occurs, seawater contaminated with oil quickly reaches human settlements and causes various impacts, including health impacts. Therefore, it is essential to deal with vulnerability to environmental changes by carefully considering social, economic, and environmental conditions in relation to sustainable development efforts (Shah, 2008).

One of the activities that poses an important threat to one of the environmental aspects is offshore exploration since it has risks and environmental impacts that threaten environmental damage in the form of oil spills (Setyonugroho et al., 2019). Thus, in developing coastal areas that are vulnerable to oil pollution due to oil spills, it is also necessary to plan an area development that considers efforts to reduce the impact and risk of coastal damage.

C. Data Sources

Data collected in this study is shown in Table 3.2.:

Table 3.2: List of Data Type and Source

Data Type		Data Sources
Perception of the risk of oil spill	Primary Data	Interview
Hydro-Oceanography condition	Secondary Data	Satellite images, NOAA, Related literature
Mangrove condition	Secondary Data	Satellite images, Indonesian National Institute of Aeronautics and Space, and Related literature
Type and characteristic of the oil pollution	Secondary Data	Related literature
Marine biota condition	Secondary Data	Related literature
Digital Elevation Model	Secondary Data	Geospatial Information Agency, Indonesia
Landsat image time series 2000, 2010 and 2020	Secondary Data	United States Geological Survey (USGS)
Satellite imagery	Secondary Data	Indonesian National Institute of Aeronautics and Space, and Related literature
Topography	Secondary Data	Geospatial Information Agency, Indonesia
Hydrology	Secondary Data	Geospatial Information Agency, Indonesia
Land-use map	Secondary Data	Geospatial Information Agency, Indonesia
Weather and climate condition	Secondary Data	Meteorology, Climatology, and Geophysical Agency
Tidal & wind	Secondary Data	Meteorology, Climatology, and Geophysical Agency, NOAA GOODS

Data Type		Data Sources
Population data	Secondary Data	Statistic Bureau of Indonesia
Information related to socio-economic impact	Secondary Data	Fisheries and Maritime Service of Bekasi Regency
Strategy formulation	Primary Data	Interview
Oceanography information	Secondary data	Indonesian Institute of Sciences
List of recipients of compensation	Secondary data	Fisheries and Maritime Service of Bekasi Regency
Fisheries product	Secondary Data	Statistic Bureau of Indonesia, Fisheries and Maritime Service of Bekasi Regency

To gather primary data, the researcher used an interview process and a questionnaire survey of 30 people. This number is determined based on the suggested minimum limit for social research (Singarimbun & Efendi, 2008). For this research related to crisis preparedness, all primary data were collected from coastal residents with the following characteristics listed in Table 3.3:

Table 3.3: Characteristics of Respondents for Statistical Analysis

Characteristics	Criteria	Quantity	Percentage
Gender	Male	18	60%
	Female	12	40%
Age	< 30	4	13.3%
	30 - 39	13	43.3%

Characteristics	Criteria	Quantity	Percentage
	40 – 49	6	20%
	50 – 59	4	13.3%
	> 59	3	10%
Occupation	Fishers	16	53.33%
	Freelance	2	6.67%
	Housewife	12	40%
Education	Graduates	0	0%
	High School	1	3.33%
	Middle School	6	20%
	Primary	20	66.67%
	Illiterate	3	10%
Income	< Rp 1.000.000	8	26.7%
	Rp 1.000.000 s.d. Rp 2.500.000	21	70%
	> Rp 2.500.000	1	3.3 %

For the purposes of compiling and prioritizing policy strategy recommendations, primary data in the form of respondents' opinions were obtained through interviews with relevant parties. The number of respondents for the SWOT analysis was 30 people consisting of 3 people from the local government, 3 academics, 3 people from NGOs, and 21 people from the coastal area of Muara Gembong. For the AHP, the number of expert respondents was three people, consisting of one from the local government, one academic, and one from NGO.

D. Data Collection

The data in this study were collected by the following methods.

- Primary Data were collected by,

  a. Field observations

  Field observations were made to obtain data and information by looking at the object of research directly.

  b. Interview/Survey

  The interview method was carried out by conducting direct questions and answers to respondents with the help of a questionnaire. There are 3 (three) types of questionnaires, including a questionnaire to determine the effect of risk perception on coastal community crisis preparedness, the SWOT questionnaire used to determine the company's internal and external factors and the AHP questionnaire used to select strategic priority alternatives that have been generated from the SWOT analysis.

- Secondary Data were collected by,

  a. Literature Review

  A literature study is a method used by taking data from several writings, actual information, books, agency official website page, or other literature issued by relevant and competent agencies/institutions.

b. <u>Interview</u>

The data collection method is by asking to the relevant institutions who published the information.

E. Data Analysis

In general, this research was conducted as shown in Figure 3.1. Figure 3.1 indicates the six steps of analysis used in this research. Further explanation regarding each stage in Figure 3.1 will be presented in sections 3.5.1 to section 3.5.6.

Figure 3.1: Data Technique Analysis

1. Overview of Land Use and Land Cover in Muara Gembong

Information about land use and land cover is required to solve problems on the earth's surface, such as zoning, disaster phenomena, and other related policies (Somantri, 2018). Over time, there have been changes in land efforts due to evolving living and economic systems. Every land change that occurs can be detected by identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989). Macleod and Congalton (1998) mentioned some critical aspects of land change detection, including detecting changes that have occurred, identify the nature of the change, measuring the area of change, and assessing the spatial pattern of change.

Analysis of land use and land cover change is the earliest analysis carried out in this study. It is important to understand the study area's conditions and capabilities before formulating a coastal area management strategy to minimize future oil spills' impact on coastal areas. It is expected that by conducting studies related to current land use and land cover, researchers can observe particular relationships between physical changes and policy. For example the relationship between the current conditions of the Muara Gembong land with the lack of prevention of seawater contamination from oil from entering the coastal areas.

A series of steps were taken to analyse the land change in the Muara Gembong area. The data used was secondary data, including Landsat 7 and Landsat 8 satellite imagery. Landsat images were obtained from the United States Geological Survey (USGS). Further, changes in land cover were identified by classifying the land cover. The land cover classification class consists of river bodies, buildings, agriculture, mangroves, ponds, seawater/puddles. The land cover classification is carried out using the supervised classification method. Due to limitations in conducting a ground check, the data used for the producer test utilised the RBI Digital Scale map data with scale 1:25,000 Edition-1 (1998/200) on the recording of Landsat

7 images in 2000. To test for accuracy samples (N=6) were taken randomly across six identified land uses.

2. Impact Assessment

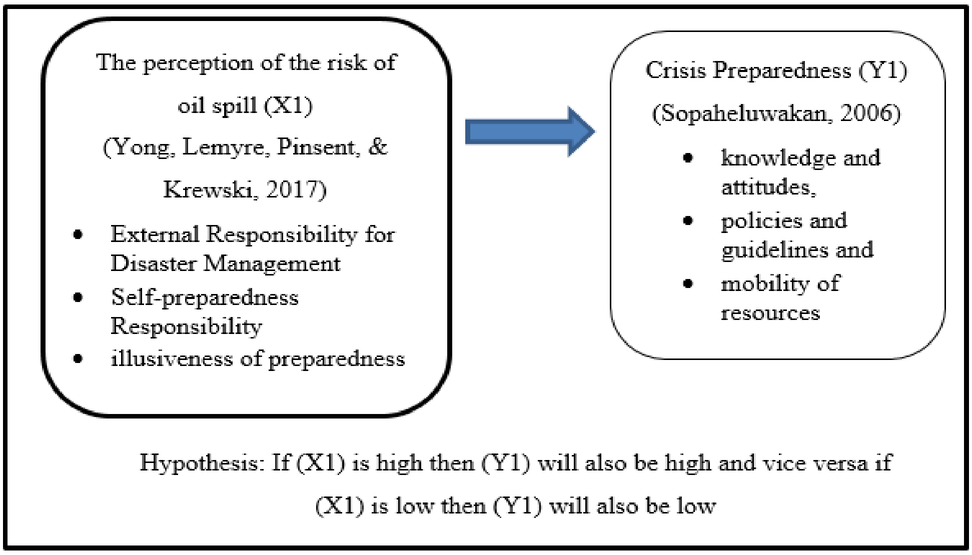
Oil pollution, as a result of oil spills or accidents, is the biggest threat to the sea and its supporting ecosystems (Sayol et al., 2014). According to DNV (2011), the impact of oil spills from pollution sources on the coast is identified into three impacts, including; the impact of spill response; ecological impacts of damage or pollution to natural resources; and social impacts due to loss or damage to social functions. Due to limited information about the impacts of spill response, the discussion in this section will focus on environmental impacts and social impacts.

This type of research conducted is ex post facto research. Meaning that the research is carried out after an incident has occurred (Sugiyono, 2015). It is important to study the impact of the incident. The impact description is carried out to emphasize the importance of improving efforts for preparedness and mitigation.

3. Analysing the Extent to Community Perceptions of Risk and Preparedness Regarding Oil Spill Incident

The purpose of disaster preparedness is to minimize the impact of disasters to maintain the survival and maintenance of quality of life by meeting basic human needs when a disaster occurs (Bradley & Bautista, 2010). Yong et al. (2017), found that the psychological dimensions of risk perception for natural disasters can be used, and are valid predictors of disaster preparedness. It is further argued that there are three main dimensions in disaster risk perception including; external responsibility for disaster management; self-preparedness responsibility, and illusiveness of preparedness (Yong et al., 2017). These dimensions will then be used as indicators in the statistical test of this study. The preparedness instrument is based on an adaptation of research from Sopaheluwakan (2006), which includes knowledge and attitudes; policies and guidelines; and mobility of resources. The core of this analysis is the influence of the independent variable (X1), the perception of disaster risk on the dependent variable (Y1), and disaster preparedness in coastal communities. Based on the explanation above, the framework of this analysis can be seen in the Figure 3.2. The statistical tests used included descriptive analysis, normality test, linearity test and hypothesis testing using SPSS application.

Figure 3.2: Conceptual Framework for Statistical Analysis



4. Formulating Policy Recommendations to Protect the Coastal Area

The first step to formulate recommendations for policies that can be implemented to protect the coastal area is to use a SWOT analysis. The

SWOT analysis will serve as part of the strategy for program building, evaluation and action planning (Olaniyi & Viirmäe, 2017). Piercy and Giles (1989) stated that SWOT analysis uses knowledge about threats to calculate the risk so that actions can be taken to mitigate, exploit, and avoid losses.

The analysis of coastal area development strategies is carried out by exploring internal factors such as strengths and weaknesses of coastal areas. External factors such as opportunities and threats that are, and are likely to be, faced by local governments in the future. Data from the results of in-depth analysis of the internal and external factors are then analyzed using several methods, including a SWOT Matrix (David & David, 2013), and AHP, which is used in the decision stage.

5. Assessment of Each Recommendation

Before the AHP analysis is carried out, each of the recommendations generated from the SWOT analysis needs to be reviewed. This is important to ensure that the strategy is feasible to implement. For example, there is a recommendation regarding spatial planning to respond to spatial use conflicts. Land capability and land suitability analysis is then carried out to convey a message that spatial planning is suitable for carrying capacity. Further accompanied by appropriate utilization to maintain balance and environmental sustainability and improve community welfare, especially in local coastal communities.

6. Determining the Right Management Strategy to Protect the Coastal Areas from Oil Pollution

AHP is a decision support model developed by Thomas L. Saaty in 1994. According to Marimin (2004), AHP has many advantages when explaining the decision-making process. This is because it can be depicted graphically, making it easy for all parties involved in the decision making. To carry out this step, Expert Choice software can be used to solve problems by comparing a number of alternatives with specific criteria (Prasetyo & Handajani, 2019). The idea of combining AHP and SWOT analysis is to systematically evaluate the SWOT factor and its intensity (Kurttila et al., 2000). By making a pairwise comparison, the decision maker will carry out a more in-depth analysis of the SWOT factor and the situation than the standard SWOT method (Yavuz & Baycan, 2013).

Adjusting from the AHP stages that have been carried out in previous studies, such as Mujahidawati et al. (2018) and Hung et al. (2018), here are the operational stages of AHP in analysing alternative strategies for managing the coastal area of Muara Gembong.

1. Develop a hierarchical structure, including; actors, aspects and strategy alternatives (see Figure 3.3).
2. Defining focus / objectives, namely alternative strategies for coastal area management in order to minimize the impact of oil spills that may occur in the future.
3. Defining stakeholders in the management of the Muara Gembong coastal area.
4. Defining the utilization aspects.

5. Determine alternative strategies by classifying the six strategic recommendations from the SWOT analysis results into three groups of strategic alternatives.
6. Create a pairwise comparison matrix that describes the relative contribution or influence of each element to the goal or criteria a level above it.
7. Define the pairwise ratio.
8. Compiling a pairwise comparison questionnaire.
9. Tabulate the questionnaire result data in the form of a matrix.
10. Perform geometric meanings to obtain 1 round value from a number of respondents.
11. Input the geometric mean data into the software.
12. Run Expert Choice 2000 software.

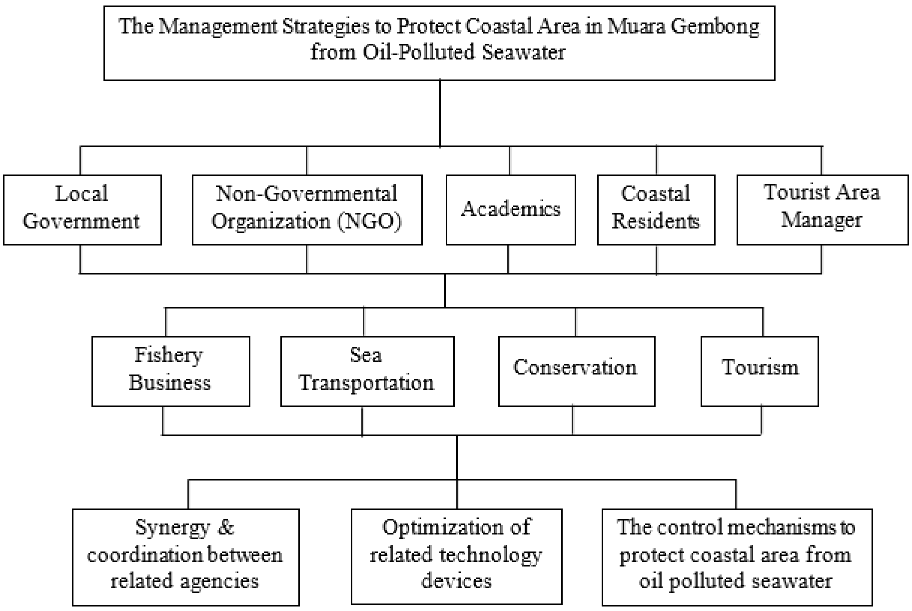


Figure 3.3: Hierarchy of Management Strategies Alternatives

F. Study Timeframe

Due to the Covid-19 pandemic, this research was entirely carried out in Indonesia from January 2020 to May 2021, as shown in Table 3.4. In general, there are 2 main stages in the preparation of this thesis, including working on the proposal and working on the final thesis.

Table 3.4: Study Timeframe

Num	Agenda	2020												2021				
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
1.	Proposal																	
	Project outline																	
	Research proposal																	
	Preparation for proposal seminar																	
	Proposal Seminar																	
	Data collection																	
	Preliminary data collection																	
	Research plan (adjustment)																	
2	The Thesis																	
	Introduction																	
	Literature Review																	
	Method																	
	Research poster presentation																	
	Collecting Data																	
	Data Analysis																	
	Result and Discussion																	

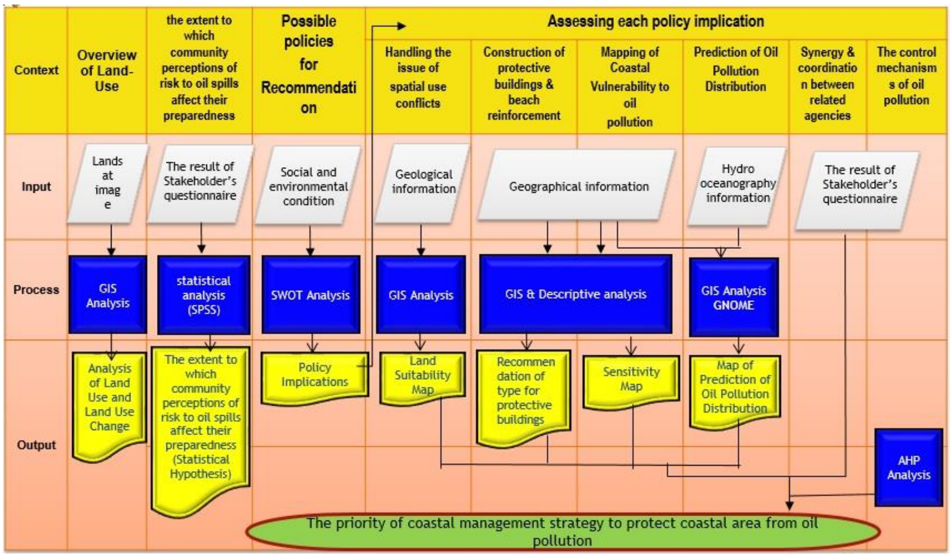
Num	Agenda	2020												2021				
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
	Conclusion																	
3	Submission																	

G. Study Flowchart

This research comprises six main stages: analysis of land use change, analysis of the impact of oil spill incident, analysis of community perception of oil spill incident, SWOT analysis for formulating policy recommendations to protect the coastal area from oil-polluted seawater, analysis of each policy recommendation, and AHP analysis for prioritizing management strategy.

The research begins with an analysis of the geographical conditions of the Muara Gembong coastal area. Geographical analysis conducted by comparing the land changes in the area during the last 20 years (2000-2020). After conducting an assessment of geographic conditions, research was carried out on the extent of the impact caused by the oil spill and the community's perception of the incident. A series of analyses then carried out, starting from the SWOT analysis to AHP, to formulate the priority of coastal management strategy to protect coastal area from oil pollution in the future. This process is briefly illustrated in the Figure 3.4.

Figure 3.4: Study Flowchart



CHAPTER IV

RESULTS

A. Overview of Land Use and Land Cover in Muara Gembong

1. Overview of Muara Gembong as Study Area

When the oil spill occurred, several coastal areas were affected by the incident, including the coast in Karawang Regency, the coast in Bekasi Regency, and the coast in Kepulauan Seribu Regency (Sulaiman, 2019). Even though Muara Gembong is not the worst affected coastal area, the discussion about the coastal management strategy of Muara Gembong in the future can be useful. Not only to minimize the impact if an oil spill occurs again in the future but also to help overcome the various coastal problems of Muara Gembong. Based on the results of observations, literature studies on previous research, and interviews with several related parties, it is known that there are several problems faced in the management of the Muara Gembong coastal area, including:

- Mangroves are decreasing due to increased logging and aquaculture conversion, settlements, residents, and agricultural land. Based on the land use pattern from 1990 to 2000, there has been the conversion of mangrove land to ponds. Currently only 2% of the total area of mangrove land remains (Jamil, 2007). Apart from being a very productive ecosystem, mangroves are coastal protectors to resist erosion due to abrasion (Winterwerp et al., 2020). The scarcity of coastal protectors ultimately causes seawater contaminated with oil spills to reach settlements quickly.

- Land use that has been carried out has not fully paid attention to the coastal environment's capability and carrying capacity. For example, several areas on the coastline, which should have been a mangrove area, has become a residential area (Maulani et al., 2021). Ernawati (2016) states that many people from other areas such as Banten, Indramayu, Tegal, and Jakarta have migrated to the coastal area of Muara Gembong. As a result, residents in residential areas close to the coastline were affected during abrasion and oil spills.
- A weak monitoring system is exacerbated by implementing government policies that are less anticipatory, less reactive, and less optimal, causing inevitable damage to ecosystems in coastal areas. This can be seen from the local government's role during the oil spill in July 2019, who were more concerned with the coordination aspect ("Gubernur Jabar Minta Pertamina Tanggung Jawab Penuh atas Insiden Tumpahan Minyak di Karawang," 2019) and tended to leave technical and operational matters to PHE ONWJ as the one responsible for the oil spill incident. For information, based on the results of searching for information in the mass media and confirmation with the local government, Pertamina is the party most responsible for this oil spill incident. This is evidenced by the entire process of handling until recovery is coordinated directly by Pertamina.

2. Geographical Review

Muara Gembong is a district with the largest area in Bekasi Regency with a total area of ±160.54 km2 consisting of six villages (see Figure 4.1). It is located at 05°54'50" - 06°04'30" south latitude and 106°59'04" - 107°06'47" east longitude. Five of six villages in Muara Gembong district are located at beaches and bordered by Java Sea waters. The area of each village in Muara Gembong district is as follows:

- Pantai Bakti Village : 34,42 km^2

- Pantai Sederhana Village : 12,00 km^2
- Pantai Bahagia Village : 30,10 km^2
- Pantai Harapan Jaya Village : 51,94 km^2
- Pantai Mekar Village : 14,57 km^2
- Jayasakti village : 17,51 km^2

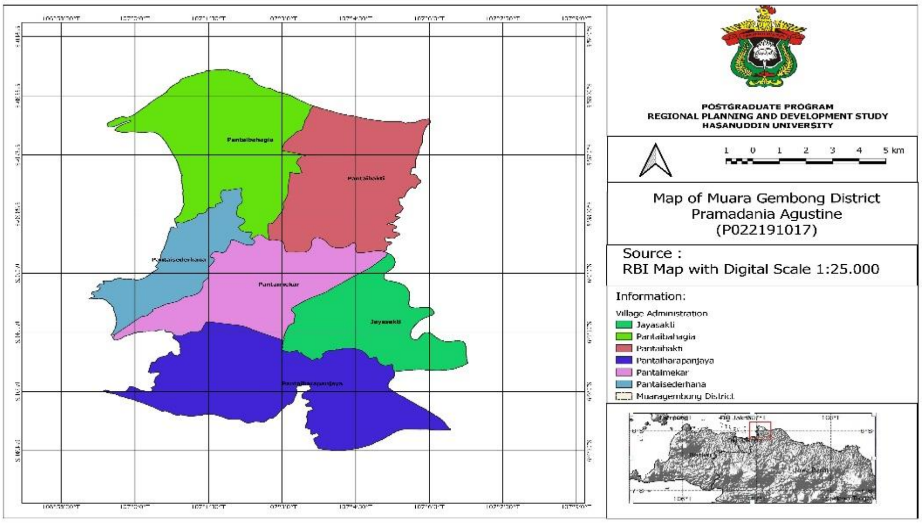


Figure 4.1: Map of Muara Gembong District

The location of Muara Gembong District is quite strategic as it is only ± 70 kilometers from Jakarta. However, the condition of the road to Muara Gembong is poorly, causing road trip access from Jakarta to Muara Gembong to take ± 3 hours (Figure 4.2). This worsens when some areas are only accessible by motorbike. Another option that can be taken apart from land travel is sea transportation which only takes about ± 45 minutes.

Figure 4.2: Access road in the Muara Gembong area

Muara Gembong coast has a sloping topographic condition. Most of the area has a height of 0-5 meters above sea level with a flat surface. Flat and watery topography causes acidity of the soil which can then be categorized as acid. Soil pH ranges from 4.5 to 5.5. The low pH value is due to the high ferrite content.

Muara Gembong district consists of beaches, rivers, and ponds which are generally hot with temperatures of 29^{O} to 32^{O} C during the day and 25^{O} to 27^{O} C at night. Furthermore, Muara Gembong has an average rainfall of around 1360 mm, with the highest rainfall occurring in January and February. This level of rainfall affects the salinity of the ponds in Muara Gembong.

Most of the Muara Gembong district is, passed by the Citarum River with 4 tributaries that empty into the Java Sea. The condition of the river is quite wide between 30 meters to 80 meters, with weak currents and an average depth of 3 meters. The colour of the river is muddy or brown-coloured rivers especially in the rainy season. Currently, rivers in Muara Gembong are the main transportation infrastructure for its residents. The three large estuaries that allow entry into the District of Muara Gembong by boat are Muara Bendera, Muara Mati and Muara Bungin.

In Muara Gembong district, there are five villages in the coastal area which is directly bordered the Java Sea, such as Pantai Bahagia village, Pantai Mekar village, Pantai Sederhana village, Pantai Bakti village and Pantai Harapan Jaya village. The table 4.1 describes a set of geographic data for those villages.

Table 4.1: Geographic Data for five villages in Muara Gembong
Source: BPS (2018)

Num	Villages	Area	Topography	Rainfall and Temperature	Village Height from Sea Level
1	Pantai Bahagia Village	30.10 km^2 or around 18.75% of the total area of Muara Gembong District	Generally coastal land with an elevation of 0-5 degrees and a height of ±0.74 m	Rainfall reaches 1,695mm per year and temperatures range from 18-32^oC	2.0 Above Sea Level
2	Pantai Mekar Village	4.57 km2 or around 9.08% of the total area of Muara Gembong District	Generally coastal land with an elevation of 0-5 degrees and a height of ±0.74 m	Rainfall reaches 1,695mm per year and temperatures range from 18-32^oC	1.0 Above Sea Level
3	Pantai Bakti Village	34.42 km2 or around 21.44% of the total area of Muara Gembong District	Generally coastal land with an elevation of 0-5 degrees and a height of ±0.74 m	Rainfall reaches 1,695mm per year and temperatures range from 18-32^oC	4.0 Above Sea Level
4	Pantai Sederhana Village	12.00 km2 or around 7.47% of the total area of Muara Gembong District	Generally coastal land with an elevation of 0-5 degrees and a height of ±0.74 m	Rainfall reaches 1,695mm per year and temperatures range from 18-32^oC	2.0 Above Sea Level
5	Pantai Harapan Jaya Village	51.94 km2 or around 32.35% of the total area of	Generally coastal land with an elevation of 0-5	Rainfall reaches 1.695mm per year and temperatures range from 18-32^oC	4.0 Above Sea Level

Num	Villages	Area	Topography	Rainfall and Temperature	Village Height from Sea Level
		Muara Gembong District	degrees and a height of ±0.74 m		

3. Initial Observations of the Study Area

Field observations were carried out during the initial research period in January 2020, before the introduction of social restrictions due to COVID-19. On this occasion, an informal interview was also conducted to obtain a more detailed picture of the study area. Table 4.2 is a summary of the results of the observations made.

Table 4.2: Resume of Initial Observation of Study Area

Observed aspects		Explanation
Environment	Coastal Ecosystem Conditions	The condition of the ecosystem in Muara Gembong district tends to be in a damaged condition as a result of the change in the function of mangrove land to ponds in the previous year.
Environment	Coastal Dynamics	The coastal area of Muara Gembong is very vulnerable to abrasion, sedimentation (shoreline change), the overflow of the Citarum river and the sea which always causes flooding.
Environment	Coastal Area Physical Condition	Muara Gembong district is the meeting point between the land and sea of the Java sea, and has a flat topography. Muara Gembong is crossed by the Citarum river and several tributaries with turbid water

Observed aspects		Explanation
		characteristics which then empties into the Java Sea.
Social Economy	Social conditions of the Community	In Muara Gembong, there is structural poverty caused by the influence of the socio-economic structure of the community, the availability of development incentives or disincentives, the availability of development facilities, the availability of technology, and the availability of natural resources. In addition, the level of community education is quite low.
Economy	Economic Activities	The economy of the Muara Gembong community relies on marine products, most of their activities are catch fishermen, fishery product processing and fish cultivators.

4. Analysis of Land Change in Muara Gembong

Based on the results of initial observations in the study area as presented in table 4.2, it is known that the environmental conditions in Muara Gembong were of concern even before the oil spill occurred. The problems faced by Muara Gembong are annual tidal flooding, seawater intrusion, and increased abrasion (Maulani et al., 2021). Due to these environmental conditions, the impact experienced by coastal areas of the oil spill incident in the Java Sea was exacerbated. Therefore, to reduce the risk of future disasters, the land use aspect needs to be analysed as land use information can be an essential input for a spatial growth strategy to direct development away from disaster-prone (ADB, 2016).

Land change is a logical consequence that cannot be avoided due to society's socio-economic structure's growth and transformation. In some cases, changes in land use and land cover have led to changes in environmental quality such as loss of soil resources (Liping et al., 2018). Muara Gembong is one of the coastal areas that has experienced land changes often. According to Oktaviani and Imran (2019), in 1943 the area of mangrove forest in Muara Gembong was 10,082 ha (71.39%). However, decreased drastically in 2000 with an area of 398 ha (2.99%). In contrast, residential land increased 91 ha (0.64%) to 399 ha (3%) in the same period. The same condition also occurred in the designation of ponds which increased from 1,051 ha (7.44%) to 8,814 ha (66.97%) in the same period. With the significant changes that have occurred, several parties have linked the erosion and sedimentation that occurred in the area as a result of changes in area use. Given that erosion, sedimentation, or the abrasion caused by land changes can worsen conditions on the coast of Muara Gembong when an oil spill occurs, it is important to discuss land changes.

Based on the land changes that occurred in Muara Gembong this then led to the desire to manage the area in a sustainable manner where every activity, development, or utilization of the coastal area must be carried out by considering the inter-social balance, economic and ecological interests. This consideration needs to be applied so that areas designated as protected or cultivated areas are in accordance with the biophysical conditions of the area and their ecosystem is guaranteed (Yonvitner et al., 2007).

To provide a clearer picture of the land changes in Muara Gembong, analyses were carried out on land use patterns in Muara Gembong district in 2000, 2010, and 2020. Satellite image interpretation was carried out to identify changes in the land area consisting of several land use categories. Multi temporal data were obtained from three Landsat images from three time periods, namely 2000, 2010 and 2020 as shown in Table 4.3. The three time periods were chosen with the consideration that the 10 year time interval is expected to reflect land changes that have occurred. Landsat imagery for the Muara Gembong coastal area was obtained from the site of the USGS Centre for Earth Resources Observation and Science.

Table 4.3: Landsat Images Data

Year	Satellite Sensor	Acquisition Date
2000	Landsat 7 ETM+	3 December 2000
2010	Landsat 7 ETM+	21 May 2010
2020	Landsat 8 OLI/TIRS	28 August 2020

Image processing begins by making geometric corrections to the Landsat 7 and Landsat 8 image with reference to the Rupa Bumi Indonesia (RBI) topography map at a scale of 1: 25,000 of Bekasi Regency. The implementation of geometric correction shows that the average RMS Error value obtained in this geometric correction meets the requirements ≤ 1 pixel. The process is summarized in Figure 4.3. As a result, the percentage of land area per land use category identified from the imagery in Muara Gembong is presented in Table 4.4.

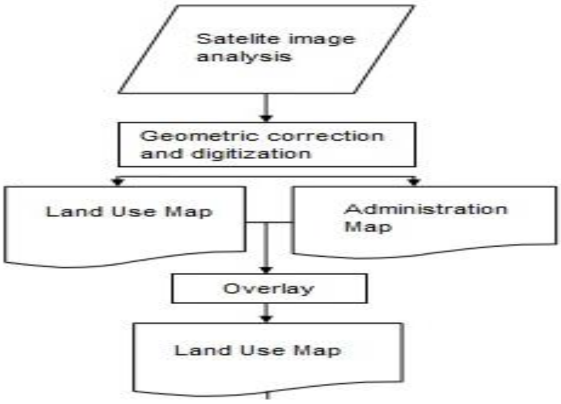
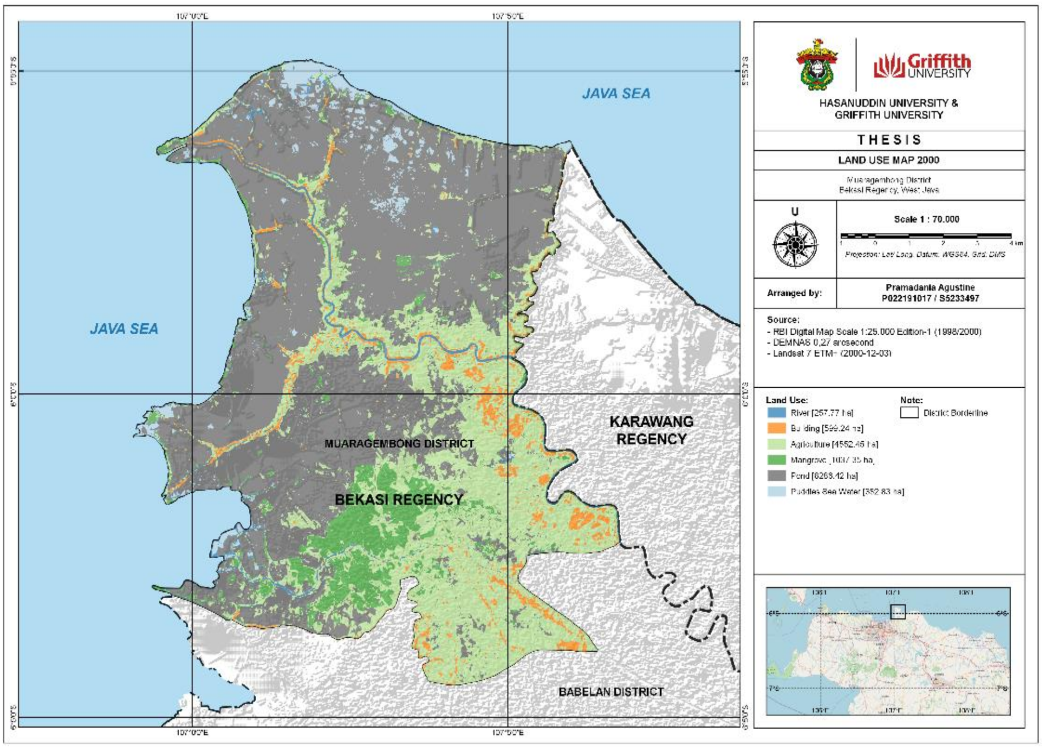


Figure 4.3: Framework for compiling land-use maps

Table 4.4: Percentage of land use area in Muara Gembong District (2000, 2010, and 2020)



						%
Buil vaca						5.19
Agri garc						7.02
Mangrove (Mangroves, swamps)	1037.35	7.17	535.46	3.76	638.67	4.96
Ponds (Fish Pond, Salt Pond)	8286.42	57.24	8635.18	60.68	6798.66	52.83
Total	14,475.46	100%	14,231.46	100%	12,869.70	100%

Figure 4.4: Land Use Map 2000

Based on the land use map 2000 as shown in Figure 4.4, the Muara Gembong area is widely used as ponds (57.24%). Agriculture (31.45%) also received a large portion of land use. However, what is of concern in this era is the number of mangroves and swamps which were only around 7.17% of the total area. Based on figure 4.5, it can be seen that mangroves were left only on the coast in 2010. This data confirms research conducted by Suwargana (2010), which stated a decrease in the number of mangroves from 1990 to 2007. The decline that occurred was about 1.66 hectares during those 17 years. The study found that the conversion of mangrove land to ponds, settlements, and paddy fields was an anthropogenic factor that contributed significantly to the decline in mangrove ecosystems' function on the balance of coastal areas (Oktaviani & Imran, 2019).

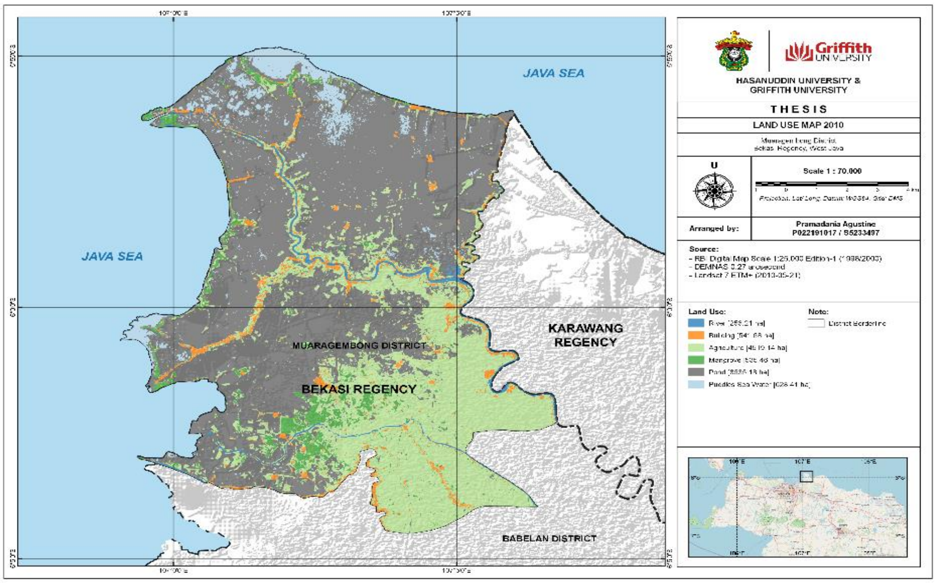
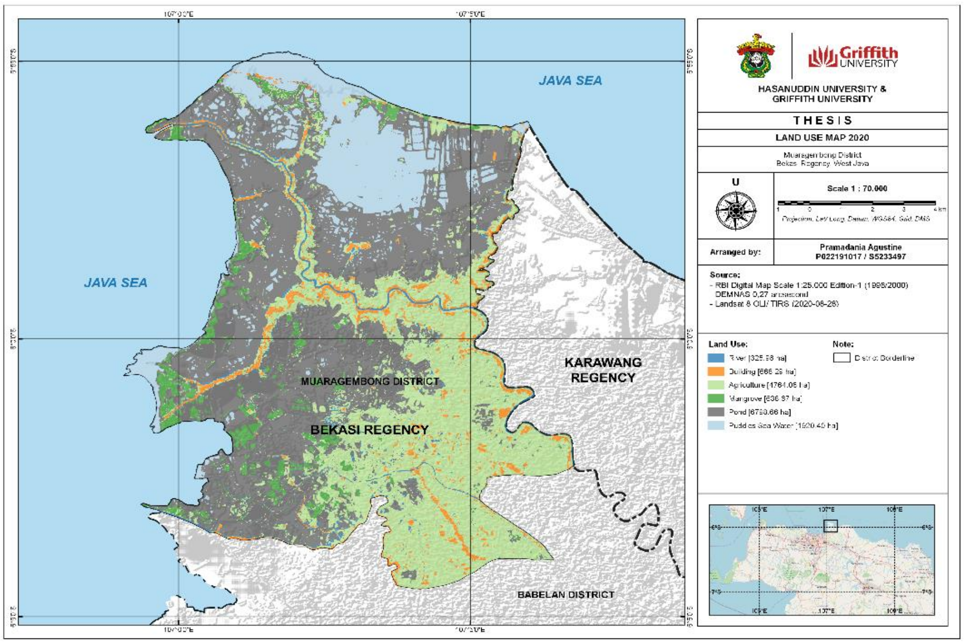


Figure 4.5: Land Use Map 2010

From 2000 to 2010, there minor changes in land use in Muara Gembong (see Figure 4.5). Ponds and rice fields still dominated the land use in Muara Gembong. A unique phenomenon occurred in mangroves during this decade. In the early 2000s, the number of mangroves had decreased. Oktaviani and Imran (2019), found that the number of mangroves in Muara Gembong reached 140 ha. The decline in the number of mangroves occurred until 2007 (Eddy et al., 2017). This situation then improved in the following years, and the area of mangroves and swamps reached 535.46 ha in 2010.

This improvement is thought to be due to increased public awareness of the importance of mangroves (Oktaviani & Imran, 2019). This increase in public awareness is an indirect response to Presidential Regulation Number 73 concerning the National Strategy for Mangrove Ecosystem Management which mandates the establishment of a National Mangrove Working Group. After the issuance of the regulation, mangrove care groups began to appear that were aggressively pushing for the rehabilitation of mangrove forests.

Similarly to the previous decade, in 2010-2020, Muara Gembong was still dominated by fishponds and agricultural land (see Figure 4.6). The



mangroves area had not changed significantly compared to the previous era, although in this decade, many mangrove rehabilitation projects were intensively carried out. The unavailability of mangrove thematic maps to support mangrove planting causes mangrove rehabilitation activities to be not evenly distributed, resulting in abrasion and damage at several points in the area (Hanan et al., 2020).

Figure 4.6: Land Use Map 2020

Based on the results of map analysis in 2000, 2010, and 2020, Muara Gembong has different total areas, including 14,475.46 ha in 2000, 14,231.46 ha in 2010, and 12,869.70 ha in 2020 (see Figure 4.6). The existence of abrasion and accretion influences the difference in the total area. According to Nugraha et al. (2019), from 1978 to 2018, there has been abrasion with a total area of up to 718.033 ha and accretions with a total area of up to 671.448 ha. Pantai Bahagia village is the most affected area, with a total area affected by abrasion reaching 482,945 ha while the total area affected by accretion reaches 330,460 ha. Ekaputri et al. (2014) show that the average area of coastline in each coastal village decreased within a range of 346.54 ha to 349.56 ha, from 2010 to 2012. This highlights the fact that the use of the Muara Gembong area is not oriented towards sustainable development characterized by development based on its capability.

B. Impact Assessment

The oil spill in the Java Sea in July 2019 is believed to have caused environmental damage and harmed marine and coastal land ecosystems. As stated by Fingas (2012), oil spills in the ocean can be hazardous as wind, waves, and ocean currents can spread most of the oil spill over a large area within a few hours in the open ocean. Although the oil spill did not occur in January or November, which are estimated to be the times with the highest wind values, the sea waves' direction towards the coast occurs throughout the year (A. Alimuddin & Aryanti, 2020). These oceanographic factors are suspected to be the cause of the extensive oil spills, which caused problems for the coastal area of Muara Gembong.

1. The Study of Environmental Impact

When the oil reaches the shoreline, organisms that are susceptible to oils such as crabs, anemones, mollusks, and others will experience growth retardation, even death (Mukhtasor, 2007). Bishop (1983) summarizes the effects of oil spills on the ecosystem, as follows:

- Reduced beach aesthetics due to the smell from the cover of oil material. Dark-coloured residues stranded on the beach will cover rocks, sand, plants, and animals. Tar formed in the weathering process will be washed away and stranded on the beach.

- Biological damage can be a lethal effect and a sub lethal effect. The lethal effect is a reaction that occurs when physical and chemical substances disrupt the cell or sub cell process in living things to the possibility of death. Sub lethal effects that affect physiological and behavioural damage but do not cause death directly. Coral reefs will experience lethal and sub lethal effects where recovery takes a long time due to the complexity of the community.

- The stunted growth of marine phytoplankton due to the presence of toxic compounds in petroleum components, as well as toxic compounds formed from the process of biodegradation. If the number of phytoplankton decreases, the population of fish, shrimp, and shellfish will also decrease though humans need these animals because they have economic value and high protein content.
- Declining algal and protozoan populations due to contact with the poison slick (oil layer on the surface of the water). Also, death of sea birds. This is because the slick makes the sea surface calmer and attracts birds to perch on it or dive for food. Upon contact with oil, oil seeps into the feathers and damages the water-forwarding and insulation systems, so that the birds will go cold and eventually die.

a. Ecosystem Analysis in Oil Pollution Areas

Based on the results of the analysis of geographical data with the interpretation of Landsat imagery in December 2019, information was obtained about the distribution of ecosystems around the coast of Muara Gembong (Figure 4.7). The results of this analysis are in accordance with information from the Bekasi Regency Fisheries and Marine Office that there are only mangrove ecosystems and no seagrass beds and coral reefs in the coastal area and waters around Muara Gembong.

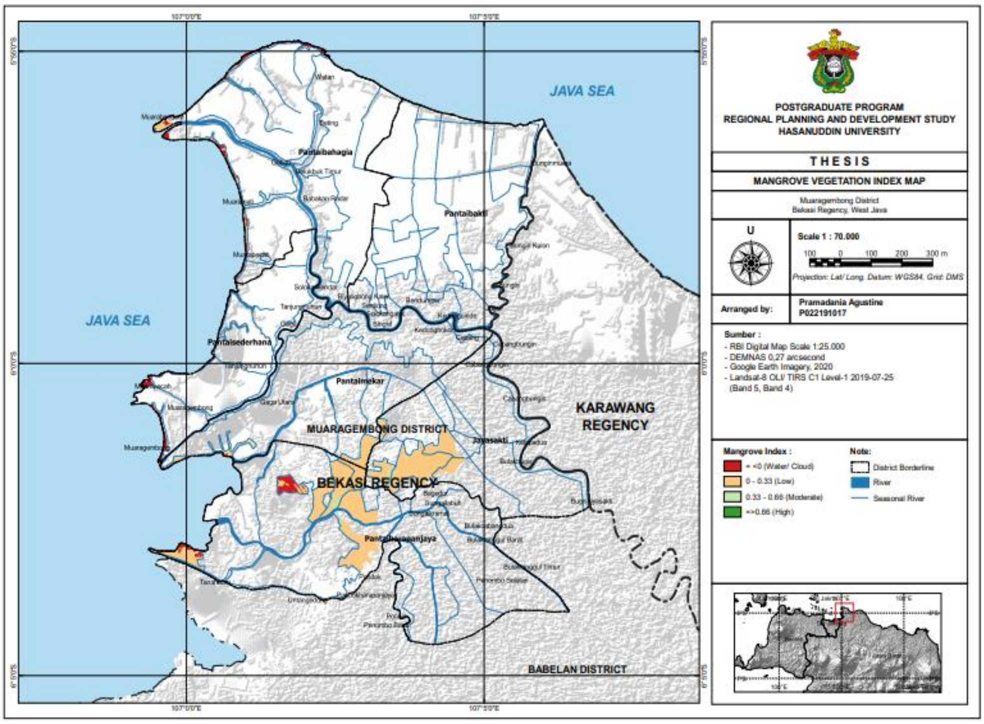


Figure 4.7: Mangrove Vegetation Index Map

In 1943 the coast of Muara Gembong was filled with mangrove forests and functioned as a protector of land from wind, currents and sea waves. According to Jamil (2007), in 1943 the area of mangrove forests in Muara Gembong was 10,082 ha (71.39%) and then drastically reduced in 2000 with an area of 398 ha (2.99%). A more alarming result was reported by Marsudi et al. (2018) where the conversion of mangrove land in Muara Gembong reached 93.5%. This causes ecological disasters for the coast of Muara Gembong such as abrasion/accretion of the coastline to the intrusion of adverse flooding times as it damages ponds and disrupts the economic activities of the Muara Gembong coastal community. However, until now there has been no recent information related to changes in mangrove area. The current status of the total area of mangroves on the coast of Muara Gembong District reaches 706.85 ha (BRPSDI, 2018).

Mangrove areas in Muara Gembong district are spread from the coast of Harapan Jaya Village, Pantai Mekar Village, Pantai Sederhana Village, Pantai Bahagia Village, and Pantai Bakti Village. Some types of mangroves that still survive are *Avicennia Alba, Avicenia marina, Rhizophora mucronata, R. apiculata* and *Sonneratia caseolaris, Excoecaria agallocha* (mangrove minor) *Achanthus ebracteatus* and *Acrosticum aureum.*

Mangroves in the Muara Gembong area are not only useful in supporting pond fisheries, but also support the life of other ecosystems such as birds. Based on information from the Fisheries and Maritime Affairs Office of Bekasi Regency, there are several species of birds associated with the mangrove ecosystem. Table 4.5 shows some types of coastal birds that can be found around the mangrove area in Muara Gembong:

Table 4.5: Coastal Birds in the Mangrove Ecosystem

Num	Type of Birds (Indonesian)	Type of Birds (English)	Type of Birds (Latin)
1	Kuntul Besar	Great egret	*Egretta alba*
2	Kowak Malam Kelabu	Black-crowned night heron	*Nycocoras nycticorax*
3	Blekok Sawah	Javan Pond Heron	*Ardeola speciosa*
4	Kuntul Karang	Pacific reef heron	*Egretta sacra*
5	Cangak Merah	Purple heron	*Ardea purpurea*
6	Raja Udang Kalung Biru	Blue-banded kingfisher	*Alcedo euryzona*
7	Dara Laut Sayap Hitam	Sooty Tern	*Sterna fuscata*
8	Pecuk-Ular Asia	Oriental darter or Indian darter	*Anhinga melanogaster*
9	Pecuk-Padi Hitam	Little black cormorant	*Phalacrocorax sulcirostris*
10	Kokokan Laut	Striated heron	*Butorides striata*
11	Cangak Abu	Grey heron	*Ardea cinerea*
12	Kipasan Belang	Malaysian pied fantail	*Rhipidura Javanica*
13	Tekukur Jawa	Spotted Dove	*Streptopelia chinensis*

Num	Type of Birds (Indonesian)	Type of Birds (English)	Type of Birds (Latin)
14	Remetuk Laut	Golden-bellied Gerygone	*Gerygone sulphurea*
15	Kerakbasi Ramai	Clamorous reed warbler	*Acrocephalus stentoreus*
16	Cipoh Kacat	Green iora	*Aegithina viridissima*
17	Layang-layang Batu	Pacific Swallow	*Hirundo tahitica*
18	Bondol Jawa	Javan Munia	*Lonchura leucogastroides*
19	Kuntul Peking	Scaly-breasted munia or spotted munia	*Lonchura punctulata*
20	Trinil Pantai	Common sandpiper	*Tringa hypoleucos*
21	Cici Padi	Zitting cisticola	*Cisticola juncidis*
22	Dederuk Jawa	Island Collared Dove	*Streptopelia bitorquata*
23	Tikusan Merah	Ruddy-breasted Crake	*Porzana fusca*
24	Cabai Jawa	Scarlet-headed flowerpecker	*Dicaeum trochileum*
25	Raja Udang Biru	Cerulean Kingfisher	*Alcedo coerulescent*
26	Cekakak Sungai	Collared kingfisher	*Todiramphus chloris*
27	Cekakak Suci	Sacred kingfisher	*Todiramphus sanctus*
28	Kekep Babi	White-breasted woodswallow	*Artamus leucorynchus*
29	Trinil Ekor Kelabu	Gray-tailed Tattler	*Tringa brevipes*
30	Cerek Tilil	Kentish plover	*Chradrius alexandrinus*

Although there are not a great number of bird species, these birds have ecological and economic benefits. Ecologically, these birds play a role in the food chain while economically, the diversity of these birds can be a tourism potential that can bring economic benefits to the surrounding population.

b. Map of Oil Pollution Distribution

Oil pollution in the Java Sea waters near the Muara Gembong region is suspected to have occurred before the oil spill incident in July 2019, but the incident has worsened the condition of oil pollution considering the large amount of oil spilled. Previously, oil pollution could only be known from water quality chemical tests, with the incident, the spread of oil pollution could be captured by satellite imagery. Figure 4.8 is a map of the distribution of oil spills processed from satellite imagery from July to December 2019.

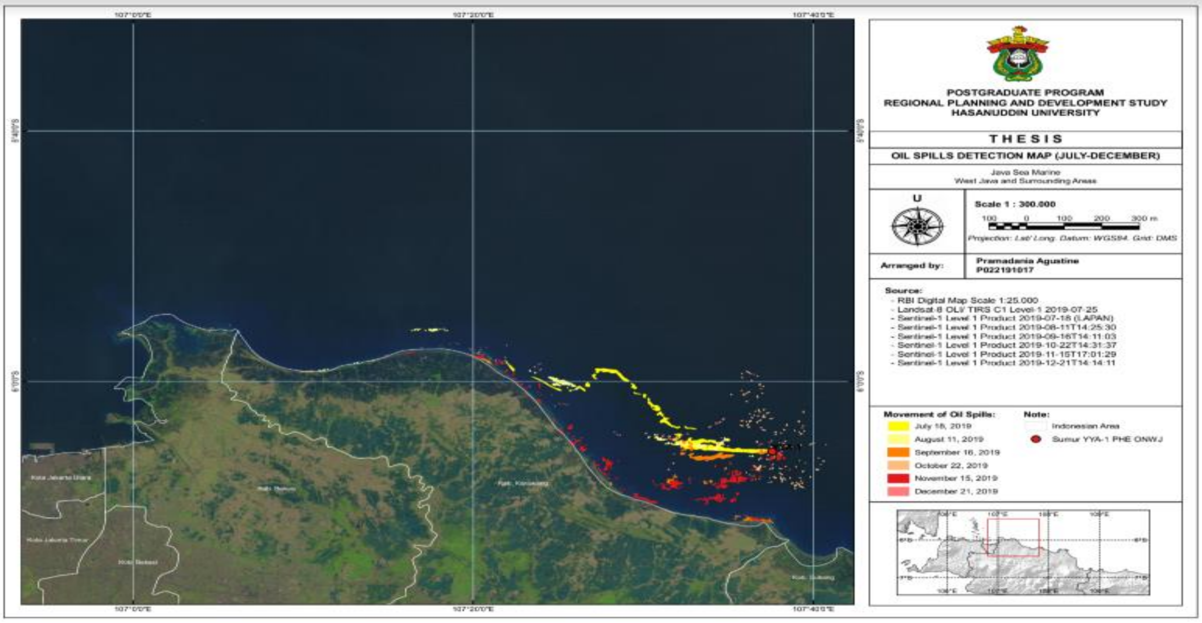


Figure 4.8: Oil Spills Detection Map (July-December 2019)

Detection of oil spills in the Karawang and Bekasi regions and in July to December 2019 used Sentinel 1 data and is supported with information from Landsat 8 data, table 4.6 informs the data specifications used.

Table 4.6: Data Specification for Mapping the Oil Spill

Num .	Satellite Image	Class	Time of Acquisition	Geographic Projection	Duratio n
1	Landsat-8	OLI/ TIRS C1 Level-1	2019-07-25	WGS-84, Lat-Long	-
2	Sentinel-A	Interferometric Wide Swath Level 1 Product	2019-07-06T14:06:02	WGS-84, Lat-Long	0.884 s
3	Sentinel-A	Interferometric Wide Swath Level 1 Product	2019-08-11T14:25:30	WGS-84, Lat-Long	1.163 s
4	Sentinel-A	Interferometric Wide Swath Level 1 Product	2019-09-16T14:11:03	WGS-84, Lat-Long	0.795 s
5	Sentinel-A	Interferometric Wide Swath Level 1 Product	2019-10-22T14:31:37	WGS-84, Lat-Long	0.763 s
6	Sentinel-A	Interferometric Wide Swath Level 1 Product	2019-11-15T17:01:29	WGS-84, Lat-Long	0.729 s
7	Sentinel-A	Interferometric Wide Swath Level 1 Product	9-12-21T14:14:11	WGS-84, Lat-Long	1.269 s

The initial analysis carried out was the detection of the presence of oil spills from Landsat 8. By using the composite RGB Red-Green-Blue-Coastal/Aerosol (321) and Red-Green-Blue (432), oil spills could be seen. Based on the location of the oil spill, it can be estimated where an oil spill occurred marked by the presence of dark colored objects in the waters. The results of the detection of oil spills from Landsat 8 optical images, then used as information to make detection using Synthetic Aperture Radar (SAR) data. The use of SAR data shows clearer oil spills compared to using optical data. Waters that have oil spills will look darker than waters that are not affected by oil spills. In summary, the oil spill mapping method is described in the Figure 4.9:

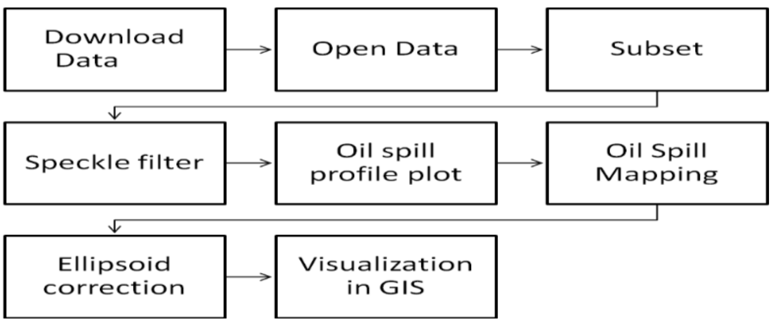


Figure 4.9: Research Flow Detection of Oil Spills in the Sea

Based on the results of the mapping of the distribution of oil spills as shown in Figure 4.8, it is known that the distribution of oil reaching the Muara Gembong region is not as much as the number of spills reaching the coastal area in Karawang. However, even though the number of oil spills reaching the coast of Muara Gembong is less, it has an impact on coastal communities, especially in September 2020, as illustrated in Figure 4.10.

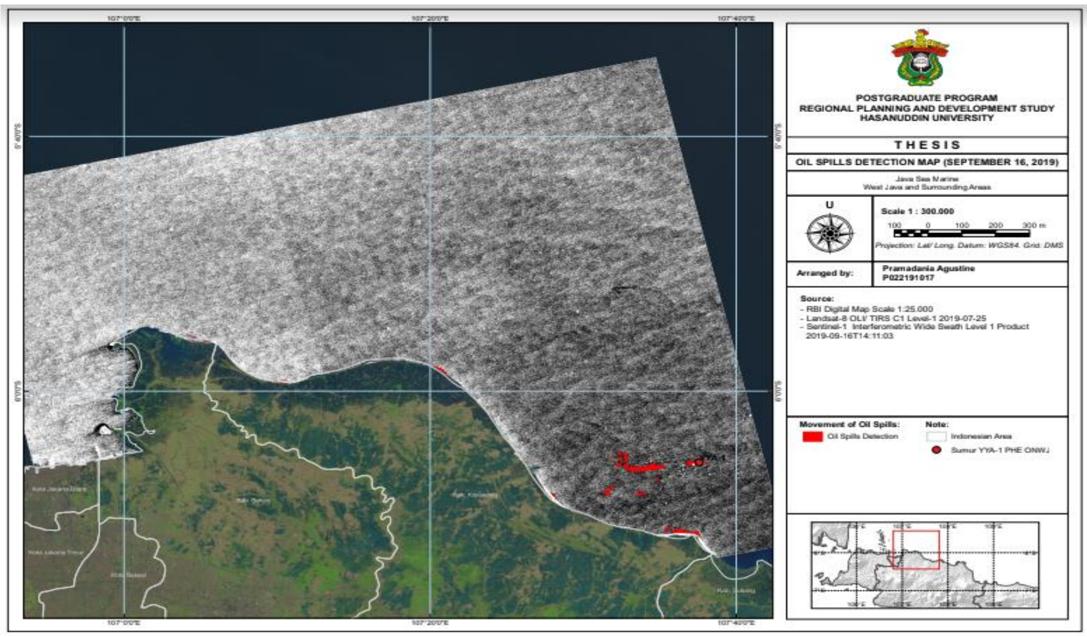


Figure 4.10: Oil Spills Detection Map in September 2019

In this study, ground truth was not carried out, because it was assumed that during the data collection period, oil spills were no longer present in the waters. However, this research data was validated using documentation data belonging to the National Institute of Aeronautics and Space of the Republic of Indonesia (LAPAN). The data used is Information on the Distribution of Oil Spill Areas in the North Java Waters which was published through LAPAN's social media on August 7, 2019.

c. Ecosystem Damage

Based on the news in various media and strengthened by direct observation and interviews with the Fisheries and Maritime Affairs of Bekasi Regency, information was obtained on numerous damages to the mangroves and coastal sand ecosystems due to oil pollution.

- Mangroves

  According to chairperson of Alipbata, Sonaji, quoted by Republika.co.id (2019), 300,000 mangrove trees in mangrove forests on the North coast were affected by PHE ONWJ's oil spill. The number of mangrove trees was obtained after Alipbata conducted a survey and data collection directly to locations impacted by oil spills. These locations include Muara Bungin Beach and Beting Beach, Pantai Bahagia Village, Muara Gembong District. From observations at the site, tree trunks were found in a torn, peeled condition, until the blister was exposed to oil heat and the mangrove leaves wither and dry out. This is because at night, when the tide comes in, the mangrove leaves are entirely submerged in seawater that has been contaminated with the oil spill.

  Meanwhile, from field observations at a coastal location at Muara Gembong, traces of oil spills are still visible on mangrove trees after the pollution event. The indication of mangrove damage can be observed by looking at the drought experienced by the mangrove ecosystem. According to Setiawan (2017), all coastal areas in Muara Gembong have almost similar physical characteristics of the beach, the mangrove beach type. The function of mangroves as sediment traps causes oil spills to be stuck in deep vegetation, making it difficult to clean (Figure 4.11).

Figure 4.11: The condition of mangroves affected by oil spill

- <u>Fish</u>

  The oil spill has an impact on capture fisheries and fish in ponds. Based on an in-depth interview with the local fishers, it is known that from July to September 2019, there was a decline in fish catch. The fishers suspect that the condition was caused by the reduction in the number of fish in their catchment area, which is estimated to move to other areas that are not polluted or die due to oil contamination.

  Regarding fish ponds, oil spills that enter the waters have a significant impact on the survival of fishermen and pond cultivators. According to one of the breeders interviewed, sea water contaminated with oil has a negative impact on some of the residents' ponds that are located on the seashore where sea water is a source of irrigation for the pond. As a consequence, some farmers have experienced a decrease in their fishpond yields and significant economic losses.

- <u>Coastal areas</u>

  Crude oil waste in the form of crust and black like asphalt pollutes the beach at Muara Gembong. In August-September 2019, traces of oil spills are often found on the coast (Figure 4.12). It certainly reduces the visual aesthetic of the beach. The impact that arises is the loss of the function of the beach as a place to play around children.

Figure 4.12: Beach sand polluted with oil

2. The Study of Social Impact

The social impact referred to here is the impact due to loss or damage to social functions (DNV, 2011). It is undeniable that the oil spill that occurred in the Java Sea harmed various communities living around the coast of the Java Sea, especially in the Muara Gembong and Karawang regions. For the Muara Gembong region itself, oil spills have an impact on fishers and coastal residents.

a. Impact on Fishers

Fishers were the communities most affected by oil spills. They experienced not only individual impacts such as health impacts, but also economic impacts. To explore this information, observations and in-depth interviews were conducted to find out more about the negative impacts of oil spills experienced by fishers. The following are some of the impacts experienced by the fishers:

- Decline in Catches of The Fishers

  The fishery sector is one of the sectors that supports the economic activities of the Muara Gembong community. Many residents of Muara Gembong work as traditional fishers with a simple type of fishing gear and season-dependent income.

  Based on interviews with the fishers, although no dead fish were found, the catch of fishers after the oil spill in Muara Gembong has decreased by 90 percent. The fishers suffered losses since they could only catch 1 kilogram of fish, compared to the usual 6-7 kilograms per day.

- Increased operational costs for fishing

  The scarcity of fish in the catchment area indirectly forced some fishers to expand the fishing area. As fishing mileage increased, so did the operational costs of fishing. The increase in operating costs was due to the fact that fishermen had to prepare more fuel and equipment to clean the boats, such as kerosene and coconut husks.

- The loss of fishing opportunities

  According to the fishers, for approximately 2 months they did not go to sea. The reasons for this are calls from local governments not to go to sea and concerns about potential damage to ships due to oil pollution. There is concern among fishers that the oil in seawater could damage their boats.

- The damage of fishing equipment

  Based on interviews with fishermen groups, information was obtained about damage to fishing equipment. Several fishing nets were damaged. The net was so soaked with oil and difficult to clean that it cannot be reused.

b. Impact on Coastal Residents

Coastal areas and the ecosystem therein may experience a significant impact from oil pollution (Bejarano & Michel, 2016). When there is offshore oil extraction that is not far from the coast, coastal residents must be prepared for spills and other forms of damage caused by exploration and pipeline-related activities such as those undertaken by residents of the Louisiana wetlands (Theriot, 2011). According to Janjua et al. (2006) and E. R. Gundlach (2013), coastal residents affected by the oil spill experience health-related social problems related to the skin, respiratory tract, eyes and nervous system. This also happened to the people of the coastal area of Muara Gembong. They experience bad impacts on health, such as skin health problems because they have helped clean up the oil waste spilled in the sea. In addition, the location of the residential area of coastal communities which is also close to the location of the oil spill has resulted in a strong odour from the oil waste. It didn't just stop there, the incident of the oil spill has also exacerbated the problem of water availability on the coast of Muara Gembong. Prior to the oil spill, the coastal residents of Muara Gembong had experienced problems of difficulty/scarcity of clean water. The water they usually use is brackish water. The need for clean water for cooking is usually met by buying clean water to the Cilincing area, North Jakarta. With the oil spill, the problem of the water crisis is getting worse. Residents even become increasingly unable to rely on existing well water.

C. Analysing the Extent to Community Perceptions of Risk and Preparedness Regarding Oil Spill Incident

In this study, the statistical tests used included descriptive analysis, normality test, linearity test and hypothesis testing using the SPSS 23 application. The data for this statistical analysis are based on the results of a survey of the coastal residents of Muara Gembong. The results of this analysis will show the extent to which the community has perceptions and readiness for the oil spill incident.

1. Descriptive Analysis

Descriptive statistics are used to provide an overview of the subject under study, or the characteristics of the sample being reviewed (Table 4.7).

Table 4.7: Descriptive Analysis

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Risk	30	12	48	60	54.60	.682	3.738
Preparedness	30	15	126	141	134.17	.805	4.411
Valid N (listwise)	30						

The results of the descriptive analysis show that the minimum value of the risk variable is 48, the maximum value is 60, and the mean value of the risk variable is 54.6. For the preparedness variable, the minimum value is 126, the maximum value is 141, and the average value is 134.17. The results of the descriptive analysis indicate that there is a fairly large variation regarding the understanding of risks and preparedness for oil spill incidents among residents of the coastal area of Muara Gembong as indicated by the range of differences between the minimum and maximum values. A value of "std deviation statistic" that is greater than the value of "mean std error" indicates the data tends to vary quite much or is not really capable of explaining the whole data.

2. Normality Test

The normality test is important because it is a requirement if the data are to be processed by regression analysis. Data can be considered normally distributed if the p value is greater than a significance level of 0.05 (Table 4.8).

Table 4.8: Data Normality Test

Data Normality Test

		Unstandardized Residual
N		30
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	4.40989000
Most Extreme Differences	Absolute	.102
	Positive	.063
	Negative	-.102
Test Statistic		.102
Asymp. Sig. (2-tailed)		.200[c,d]

The results of the normality test are determined by looking at the significance value of the variable. Rangkuti (1998) states that a variable is considered to have passed the normality test if the sig. p value > 0.05. The test results show that the p value is 0.2. This value is greater than 0.05, which means that the variables are normally distributed.

3. Linearity Test

A linearity test is used to observe the relationship between two variables. Linearity is considered proven if the p value is smaller than the significance level of 0.05, whereas if the p value is greater than the significance level of 0.05, the two variables are not linear (Table 4.9).

Table 4.9: Linearity Test

Linearity Test

			Sum of Squares	df	Mean Square	F	Sig.
TOTAL_Y * TOTAL_X	Between Groups	(Combined)	310.417	12	25.868	1.733	.146
		Linearity	.200	1	.200	.013	.909
		Deviation from Linearity	310.217	11	28.202	1.889	.115
	Within Groups		253.750	17	14.926		
	Total		564.167	29			

The results of the linearity test calculation show that the value of derivation from linearity has a significance value of 0.115. This value is greater than 0.05, so the relationship between the two variables taken is not linear. These results will have an impact on testing the effect of variables X and Y.

4. Correlation Test

Table 4.10: Correlation Test

Correlation Test

		TOTAL_X	TOTAL_Y
TOTAL_X	Pearson Correlation	1	.019
	Sig. (2-tailed)		.921
	N	30	30
TOTAL_Y	Pearson Correlation	.019	1
	Sig. (2-tailed)	.921	
	N	30	30

Rangkuti (1998) states that this variable has a display that has a sig p value <0.05. The results showed that the sig. p value of 0.921 (Table 4.10). This value is more than 0.05, therefore it can be stated that there is no relationship between risk perception and disaster preparedness.

5. Hypothesis Test

Hypothesis testing in this study are:

- Ha: There is an influence of Disaster Risk Perception on Disaster Preparedness in the Coastal Coast of Muara Gembong District
- H_0: There is no effect of Disaster Risk Perception on Disaster Preparedness in the Coastal Areas of Muara Gembong District

Table 4.11: Hypothesis Test

Hypothesis Test

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.200	1	.200	.010	.921[b]
	Residual	563.967	28	20.142		
	Total	564.167	29			

a. Dependent Variable: Disaster preparedness

b. Predictors: (Constant), Perception of Risk

The results in Tables 4.10 and 4.11 showed that a sig. p value of 0.921. This value means that there is no influence of risk perception variables on disaster preparedness. In addition, the F value is 0.010, which means that 10 % of the disaster preparedness variable can be explained by the model, while 90 % is determined by other variables outside the model.

The hypothesis of Zero (H_0) is accepted, suggesting that the independent variable (X) has no effect on the dependent variable (Y), so there is no effect of Disaster Risk Perception on Disaster Preparedness in the Coastal Areas of Muara Gembong District. If H0 is rejected, it means that there is an influence of Disaster Risk Perception on Disaster Preparedness in the Coastal Coast, Muara Gembong District. The results of this study differ from those of Yong et al. (2017) which states that there is an effect of risk perception on disaster preparedness. The difference between the results of this study and previous studies is because the oil spills have not been considered a disaster that has a significant impact on society, in contrast to floods or tsunamis, which are considered more dangerous to humans than oil spills. The results from this research should be followed up by the stakeholders, thus the understanding of oil spill risk perceptions can be improved so that there are systematic, large-scale and structured efforts to tackle potential oil spills.

D. Formulating Recommendations of Policy Implications That Can Be Implemented to Protect the Coastal Area

To formulate the initial recommendations for oil pollution management, the strategy which will be used for this research is a combination of Strength-Weakness-Opportunity-Threat (SWOT) analysis and Analytical Hierarchy Process (AHP). This technique has been used in a number of environmental studies (Eslamipoor & Sepehriar, 2014; Masozera et al., 2006). However, this technique has been rarely used to formulate policies for coastal areas prone to oil spills.

For this research, a Strategy Analysis Framework was formulated based on the standards proposed by David and David (2013) with some adjustments.

- For stage 1 (The Input Stage), the internal and external factors were identified related to the study area.

- For stage 2 (The Matching Stage), SWOT matrix is constructed based on the identification of internal and external factors.

- For stage 3 (The Decision Stage), some adjustments were made for this stage. This stage was conducted after assessment of the results of the SWOT Matrix. Also, in this stage, QSPM was replaced by AHP. The SWOT-AHP model in some ways is similar to the QSPM (Dekiawan & Subagyo, 2018).

Data was collected between January and February 2020 by conducting face-to-face interviews with 30 people consisting of the local government officers, NGOs personnel and coastal residents of Muara Gembong.

1. Identification of Internal and External Factors

Based on observations, interviews and the results from processing of collected data, there were 10 internal factors (Strength-Weakness) and 6 external factors (Opportunity-Threat) identified.

- Strength

Five points identified as the strengths in the management of the coast of Muara Gembong related to the risk of oil pollution (see Table 4.12).

Table 4.12: List of Identified Strength

Num.	Strength	Consideration
S1	Strategic location	The Java Sea is not only the main sea for Indonesia, but also the core sea for Southeast Asia (Houben, 1992)
S2	The existence of fishers and the community	Based on data from the Bekasi Regency Marine and Fisheries Service, there are more than 2200 residents of Muara Gembong who work as fishers. These fishers and fish farmers can help the economic system both for Bekasi Regency and the fishers themselves.
S3	There are several active NGOs working in the environmental field.	There are several active NGOs that focus on social issues and environmental conservation efforts in the Muara Gembong. One of the many NGOs is Alipbata which is engaged in protecting mangrove ecosystems.
S4	Having an abundance of captured fisheries and suitable regional conditions for aquaculture	Muara Gembong district has large number of captured fisheries and aquaculture products. These products can help increase the income of fishers and fish farmers.
S5	Research and conservation potential	There are many activities carried out along the coast that can affect the function of the ecology so that many things can be investigated in the area around the Java Sea.

- Weakness

Five points were identified as the weakness in the management of the coast of Muara Gembong related to the risk of oil pollution (Table 4.13).

Table 4.13: List of Identified Weaknesses

Num.	Weakness	Consideration
W1	Access to transportation and infrastructure in the Muara Gembong Region is inadequate.	Poor access to and from the District of Muara Gembong and the lack of adequate transportation facilities indirectly inhibits all activities that occur in Muara Gembong.
W2	Low awareness and community participation	The role of the community in managing and maintaining coastal areas and waters is vital since the community experience the direct impact of pollution that occurs in the waters of the Java Sea. The more polluted waters will cause the waters to become unhealthy, and this will have an impact on the fish catch.
W3	The condition of the water is polluted by oil	Besides oil spill incidents, the shipping activity is suspected as one of the causes of oil pollution in the Java Sea Waters.
W4	The occurrence of abrasion on the Muara Gembong Coast	Excessive conversion of mangroves has caused environmental degradation that affects the productivity of the area and finally resulted in increased abrasion.
W5	Limited use of technology	The local government has not yet optimized the use of technology-based applications in planning regional management. For example, when oil spills occur, the local government has not optimized the application of technology to predict oil distribution.

- Opportunity

Three points were identified as opportunities in the management of the coast of Muara Gembong related to the risk of oil pollution (Table 4.14).

Table 4.14: List of Identified Opportunities

Num.	Opportunities	Consideration
O1	Investment Opportunities	The location of Muara Gembong District, which is close to the country's capital, allows the Muara Gembong area to be developed into a tourist attraction or other form of business.
O2	Ecotourism Potential	Muara Gembong district has several regional spots that can be used as ecotourism sites that contain mangrove ecosystems.
O3	Economic potential	Muara Gembong district has an abundance of captured fisheries and aquaculture products.

- Threat

Three points were identified as threats in the management of the coast of Muara Gembong related to the risk of oil pollution (Table 4.15).

Table 4.15: List of Identified Threats

Num.	Threats	Consideration
T1	Land use conflicts	Varying interests among coastal area stakeholders tend to raise the conflicts in coastal spatial use, such as environmental vulnerability and increased industrialisation.
T2	Declining quality of water and coastal areas	The intensity of activities in the waters and coastal areas can cause pollution to marine ecosystems
T3	Overexploitation	The large number of land conversion into ponds has caused the decline in mangrove ecosystems.

2. SWOT Matrix

The SWOT matrix is used to clearly describe how the external factors, faced in the management of coastal areas related to oil pollution in Java Sea waters, can be adjusted according to the internal factors. This matrix produces four sets of possible strategic alternatives. Thus, strengths and opportunities can be increased and weaknesses and threats can be overcome. The four sets of possible strategies in Table 4.16 are called the S-O Strategy, the W-O Strategy, the S-T Strategy and the W-T Strategy.

Table 4.16: SWOT Matrix

internal / external	Strength (S1, S2, S3, S4 and S5)	Weakness (W1, W2, W3, W4, and W5)
Opportunities (O1 and O2)	**S/O Based Strategies** 1. Improving the expertise of surrounding communities related to handling oil pollution so that they can help maintain the economic potential (S2, S3, O3)	**W/O Based Strategies** 1. Developing regional infrastructure (W1, O1). 2. Payment of environmental taxes by the users of environmental services to the relevant stakeholders whose task it is to preserve the local environment (W3, O1)
Threats (T1, T2 and T3)	**S/T Based Strategies** 1. Mapping coastal sensitivity to oil (S5, T2) 2. Handling the issue of spatial use conflicts by making land suitability maps (S5, T1, T2). 3. Improving integration and coordination between related institutions (S3, S5, T1, T3) 4. Improve pollution control mechanisms (S2, S3, T2)	**W/T Based Strategies** 1. Recommendations for building a Wave Breaking Building to protect the coastal area (W4. T2) 2. Recommendations for the use of technological tools to predict the distribution of oil pollution (W5, T2)

- <u>S/O Based Strategy (Strength-Opportunity)</u>

The S/O strategy is a strategy that uses power to take advantage of opportunities. There is one S/O strategy that can be implemented in the management of coastal development regarding oil pollution, such as:

- Improving the expertise of surrounding communities in managing oil pollution (S2, S3, O3)

To minimize the potential impact of oil pollution on the coast, it is necessary to strengthen the understanding of the surrounding community about how to deal with oil pollution.

- W/O Based Strategy (Weakness-Opportunity)

W/O strategy is a strategy that minimizes weaknesses to take advantage of opportunities. There are two strategies that can be implemented in the management of coastal development regarding oil pollution in Muara Gembong, such as:

- Developing regional infrastructure (W1, O1)

  The government should develop regional infrastructure as economic activity in the Muara Gembong area is not limited only to fisheries activities.

- Payment of environmental taxes by the users of environmental services to the relevant stakeholders whose task it is to preserve the local environment (W3, O1).

  By providing these obligations to business actors related to oil pollution in the Java Sea, it is expected to be able to maintain the preservation of the Java Sea waters and tax revenues can be utilized for regional development.

- S/T Based Strategy (Strength - Threat)

The S/T Strategy is a strategy that utilizes power to prevent threats. There are four S/T strategies that can be implemented in the management of coastal development with regard to oil pollution in Muara Gembong, such as:

- The mapping of coastal sensitivity to oil (S5, T2)

  Maps of coastal sensitivity to oil are essential in the planning of coastal environmental policies, conservation and protection of coastal habitats/resources, pollution control and mitigation planning to deal with sea disasters, environmental rehabilitation and restoration, and for strategic environmental impact assessments.

- Handling the issue of spatial use conflicts by making land suitability maps (S5, T1, T2).

  The conflict of land-use is enough to affect the living conditions of people in coastal areas. For example, the rise in conversion of mangroves into ponds causes a reduction in the level of protection of the coastal regions that have been supported by mangroves. In the event of oil pollution, these conditions caused polluted seawaters to easily inundate coastal residential areas. Therefore, to minimize these impacts in the future, it is necessary to map the suitability of land use and then restore the land use according to its purpose.

- Improve integration and coordination between related institutions (S3, S5, T1, T3)

Regulations and policies should also be made to prevent behaviour by people and businesses which can damage the environment. Governments should employ law enforcement agencies or impose sanctions on polluters, so that they can be used as examples to prevent similar actions recurring.

- Improve pollution control mechanisms (S2, S3, T2)

  Government should provide strict supervision of the environment, especially the environment directly related to the waters bordering the Java Sea, in order to protect the sustainability of the ecosystems contained in the region.

- W/T Based Strategy (Weakness – Opportunity)

W/T strategy is a strategy that minimizes weaknesses and prevents threats. There are two W/T strategies that can be implemented:

- Recommendations for building a protective construction to protect the coastal area (W4. T2)

  About 3 % of the total area of Muara Gembong district is a residential area, which is located in coastal areas. To protect human settlements from coastal abrasion, especially if the waters are polluted, an effective and integrated treatment is needed.

- Recommendations for the use of technological tools to predict the distribution of oil pollution (W5, T2)

Predicting the distribution of oil pollution will facilitate the handling process so that the potential impact can be minimized. GNOME is a technological tool that can simulate the movement of oil that is affected by wind, currents, tides and the distribution of oil spills.

E. Assessment of Each Recommendation

From the SWOT analysis, six management strategies were obtained. To ensure that the strategies are feasible, further analysis using strategies such as GIS analysis will be carried out. Table 4.17 lists each recommendation for policy implication and the type of assessment or analysis.

Table 4.17: Types of assessments for formulating strategies

Recommendation for Policy Implication	Type of Assessment or Analysis	References
Mapping coastal sensitivity to oil pollution	ESI map	(Adler & Inbar, 2007; Sriganesh et al., 2015)
Predicting oil pollution distribution	GNOME	(Samuels et al., 2013; Zafirakou et al., 2018)
Handling the issue of spatial use conflict	Land use or suitability map	(Hernawan & Risdianto, 2018; Omodanisi, 2013)
Improving synergy and coordination between related agencies	Analysis based on literature review	(Daura, 2000)
Strengthening the control mechanism of oil pollution	Analysis based on literature review	(Daura, 2000)
Constructing protective building	GIS analysis	(Hartati et al., 2016)

1. Handling the Issue of Spatial Conflicts

Spatial conflict is often associated with a particular use of space that arises from space use or the intention to change its use (Cieślak, 2019). Cieślak (2019) added that a common example of spatial conflict arises from the need for economic development and the need to protect the natural environment's value. Generally, there are three groups of spatial conflicts, including problems that endanger the ecological stability of the landscape (including endangering biodiversity and nature conservation areas); problems that endanger natural resources (especially land, forests, waters); and problems that directly harm the human environment (stress factors in residential and recreational areas) (Izakovičová et al., 2018). Furthermore, Santorineou et al. (2010) stated that changes in land use inevitably create spatial conflicts. Therefore, it is necessary to handle spatial conflicts with land use planning by paying attention to land capability and suitability so that the final decision can be made to support sustainable development (Hollingsworth, 2020; Santorineou et al., 2010).

a. Land Capability Analysis

As discussed in the analysis of land-use change in the Muara Gembong area in section 3.1.4, the results of this analysis highlight the fact that the use of the Muara Gembong area is not oriented towards sustainable development characterized by development based on land capability. This is indicated by the change of mangrove land to ponds in the early decades of observation (Jamil, 2007). The reduction in mangrove land in Muara Gembong ultimately causes land loss due to abrasion (Oktaviani & Imran, 2019). Therefore, for future land use to be carried out optimally while maintaining ecological sustainability, it is necessary to analyse determining the capacity of the land as an initial stage in land utilization and management (Hollingsworth, 2020). Figure 4.13 displays the land capability of Muara Gembong.

Land capability analysis was conducted based on an approach outline in the Minister of Environment Regulation No. 17 (2009), entitled Guidelines for “Determination of Environmental Carrying Capacity in Regional Spatial Planning”. In this document, land capability is categorized into eight classes. Table 4.18 outlines the classification of the land capability.

Table 4.18: Classification of Land Capability by Class Level Based on the Minister of Environment Regulation No. 17 (2009)

Class	Criteria	Use
I	• There are no or few obstacles that limit its use • Suitable for a variety of uses, especially agriculture • The land characteristics include: almost flat topography, low threat of erosion, deep effective depth, good drainage, easy processing, good water holding capacity, fertile, not threatened by flooding	Agriculture: • Seasonal agricultural crops • Grass plants • Forests and nature reserves
II	• There are several barriers or threats of damage that reduce the choice of their use or require moderate conservation action	Agriculture: • Annual crops • Grass plants • Pasture • Production forest

Class	Criteria	Use
	• Need to be careful in management including conservation measures to prevent damage	• Protected forest • Nature preserve
III	• There are some serious constraints that reduce land use options and require special conservation measures • These constraints limit the length of use for annual crops, processing times, crop choices or a combination of these constraints • There is a barrier heavier than class II and if it is used for crops, it is necessary to have soil management and conservation measures to be more difficult to implement	Agriculture: • Annual crops • Plants that require tillage • Grass plants • Meadow • Production forest • Protected forests and nature reserves Non-agricultural
IV	• The resistance and threat of soil damage is greater than class III, and the choice of crops is also limited • Need careful management of annual crops, conservation measures are more difficult to implement	Agriculture: • Annual crops and agricultural crops in general • Grass plants • Production forest • Pasture • Protection forest and nature reserve Non-agricultural
V	• Not threatened with erosion but has other barriers that are not easily removed, thus limiting the choice of its use • There are barriers that limit the choice of types of use and crops • Located on a flat topography - almost flat but often affected by flooding, rocky or unsuitable climate	Agriculture: • Grass plants • Pasture • Production forest • Protection forest and nature reserve Non-agricultural
VI	• There are serious inhibiting factors that cause very limited use of land	Agriculture: • Grass plants

Class	Criteria	Use
	because it has a threat of damage that cannot be eliminated • Generally located on steep slopes, so that if used for grazing and production forests must be managed properly to avoid erosion	• Pasture • Production forest • Protected forests and nature reserves Non-agricultural
VII	• There are inhibiting factors and serious threats that cannot be eliminated, therefore its use must be of a conservation nature. If used for pasture or production forest, heavy erosion prevention must be carried out	• Meadow • Production forest
VIII	• Should be left naturally • The boundaries and threats are very serious and conservation action is impossible, so they need to be protected	• Protected forest • Nature recreation • Nature preserve

The first two classes (class I and II) is land that is suitable for agriculture and the last two classes (class VII and VIII) is land that needs to be preserved or land for conservation purposes. Class III, IV, V, and VI can be used for other functions. As a result, the land in class III and IV can still be used as agriculture lands. Land classes I to IV include land suitable for agriculture and land classes V to VIII are categorized as unsuitable for agriculture, as the management of the land will be costly (Hardjowigeno, 2007). Based on the evaluation results, there are four classes of land capability in Muara Gembong, those are class II, III, IV and VIII (See Table 4.19).

Table 4.19: Classes of land capability in Muara Gembong

Land capability class	Land capability subclass	Area (ha)	Percentage (%)
II	II (t)	3859,12	27
III	III (w)	1957,19	13,70
IV	IV (b)	6187,09	43,30
VIII	VIII (t)	2286,39	16
		14289,79	

Note: according to the Minister of Environment Regulation number 17 of 2009, land capability classes (class II to class VIII) can be broken down into sub-classes based on four inhibiting factors, such as slope (t), inhibition of plant roots (s), erosion level/erosion hazard (e), and puddle (w).

Land in classes I to IV are suitable for a range of uses, while classes V to VIII are suitable for specified uses only. Based on the evaluation results, plantation crop development can only be carried out on land classified as class III and IV. These classes are depicted in Figure 4.13.

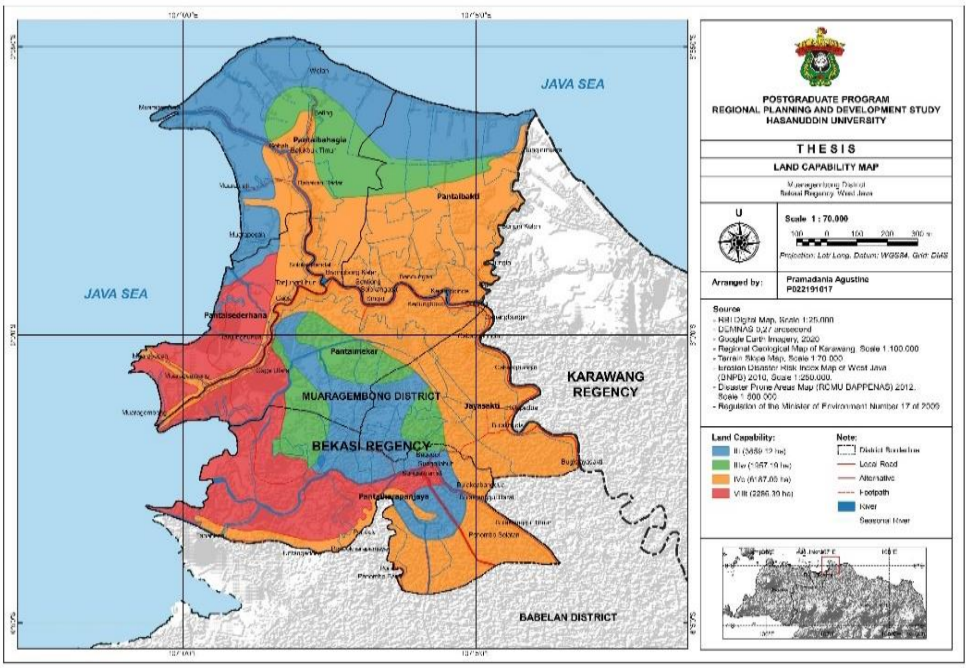


Figure 4.13: Land Capability Map of Muara Gembong

b. Land Suitability Analysis

Land suitability analysis was carried out to assess land suitability using GIS. The application of GIS for land suitability evaluation will simplify and speed up the data analysis process, because GIS has the ability to input, edit and analyse data (graphic data and attribute data) accurately (Hanna et al., 1998). For this research, this land suitability analysis was carried out only for the three main uses in Muara Gembong, such as settlements (residential), fishpond, mangrove and swamp.

- The Suitability for Residential

  Churchill and Lowe (1999) stated that the development of a residential area in an unsuitable area will endanger the surrounding environment and even human souls as residents of the settlement area. There are three basic parameters used in this land suitability analysis, including slope, soil type, and rainfall intensity.

  The analysis of the suitability of residential land was carried out by overlaying the land capability map and land use map. Figure 4.14 shows the results of this analysis:

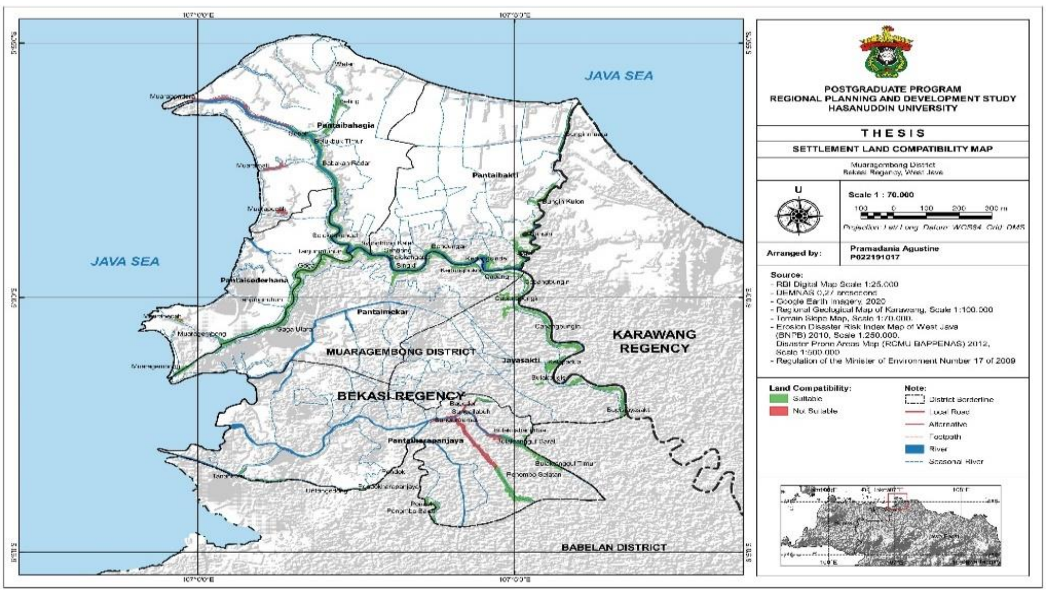


Figure 4.14: Settlement Land

Based on Figure 4.14, land allocated for residential areas was mostly being used appropriately (marked with green lines). Most settlement patterns followed the river flow that empties into the Java Sea. Those areas which are not being used in accordance with their designation, should be returned to their designated use according to the land capacity. For example, areas with a red line in the Jayasakti Village area should have been returned to a protected forest or nature reserve.

- The Suitability of Fishpond Area

  The analysis of the suitability of the fishpond area was carried out by overlaying the land capability map and land use map as shown in Figure 4.15.

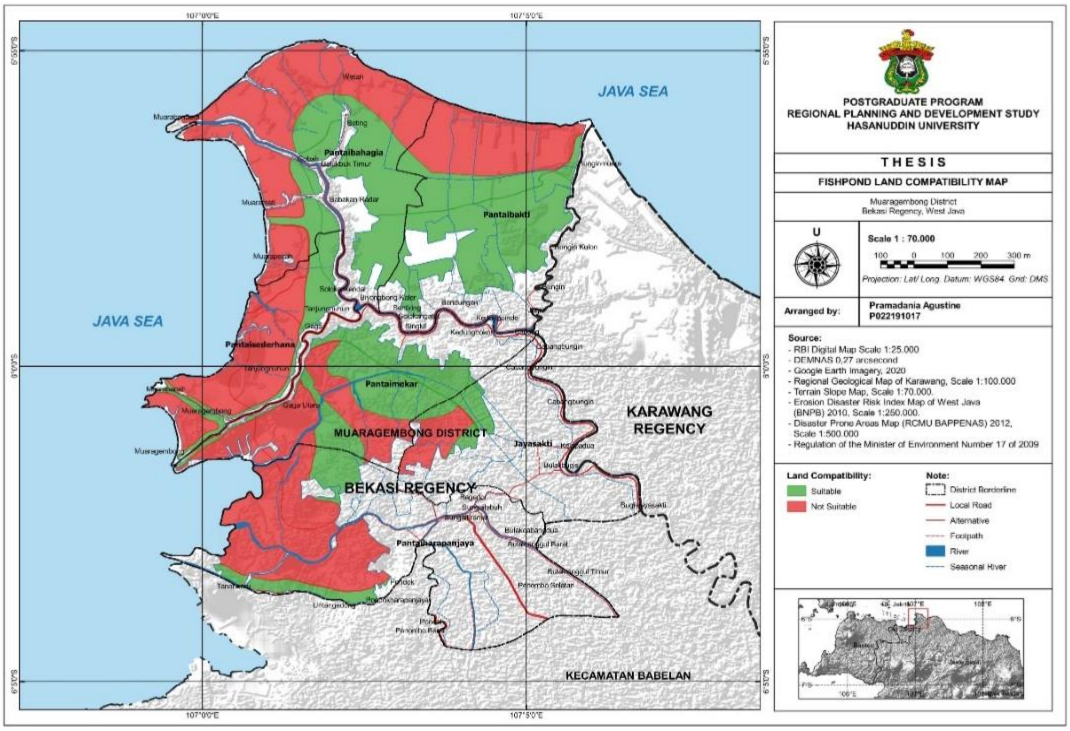


Figure 4.15: Fishpond Land

These results indicated that the land allotment for fishponds is not in accordance with its actual designation (marked in a red). The ongoing conversion of mangroves into ponds, especially in coastal areas has made the area more vulnerable to disasters, which would have been minimized by the presence of mangroves along the coastline. In relation to oil-polluted seawater, this vulnerability was demonstrated in July 2019 when there was an oil spill around the area. The ponds were contaminated by sea water which was contaminated with oil and eventually caused the death of a significant number of fish. Therefore, to minimize these incidents in the future, authorities need to reconsider existing land use by changing land functions in accordance with its capacity.

- The Suitability of Mangrove and Swamp Areas

  The analysis of the suitability for Mangrove and Swamp areas was carried out by overlaying the land capability map and land use map. Figure 4.16 indicates the results.

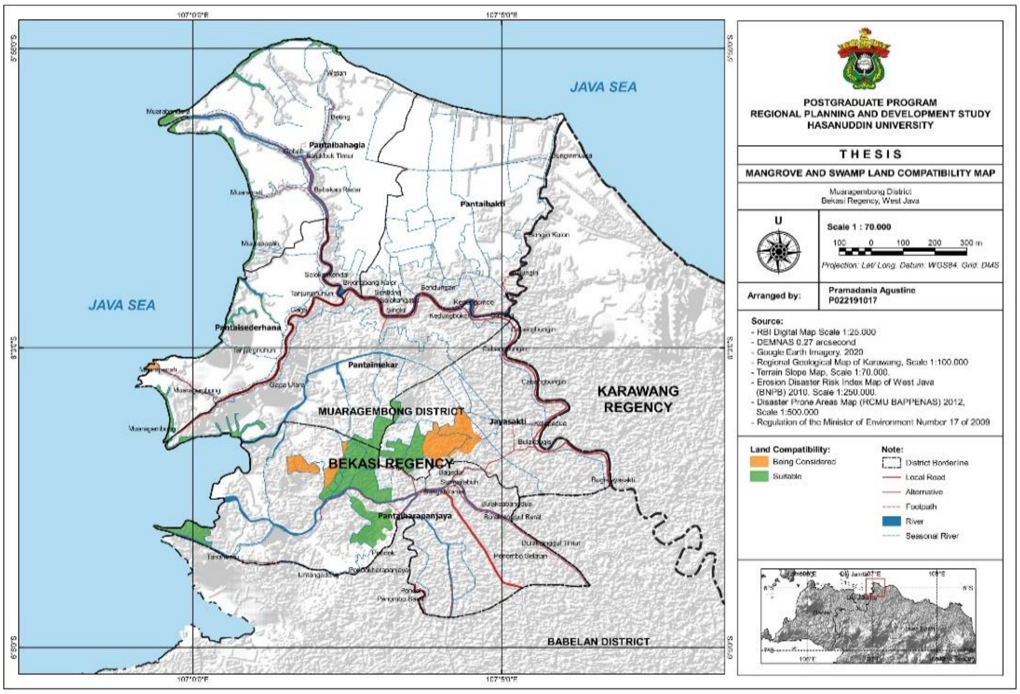


Figure 4.16: Mangrove and swamp

According to the analysis of land capability based on the Minister of Environment Regulation No. 17 (2009), the designation of the Muara Gembong coastal area is as a protected forest or nature reserve, specifically for mangrove conservation. However, there are several areas, other than the Muara Gembong coast, that can be used as mangrove forests or swamps (those being considered marked in yellow; suitable areas marked in green). This can be a recommendation for future regional development.

2. Construction of Protective Buildings & Beach Reinforcement

The conversion of land functions in coastal areas causes a potential increase of erosion or abrasion, since the coastal area loses its protection (Dugan et al., 2008). Coastal erosion and/or abrasion causes the surrounding community to be flooded causing economic and health impacts (Depledge et al., 2017), especially if the sea water that enters residential areas is contaminated with oil (ITOPF, 2011). Therefore, the analysis about protective buildings & beach reinforcement was carried out to determine alternative buildings for abrasion control that occurs at Muara Gembong Beach. This analysis is important as the existing coastal protection structures in Muara Gembong are currently in poor condition and cannot protect the coastal area when an oil spill occurs (Figure 4.17).

Figure 4.17: Existing embankments in the Muara Gembong area

One of the approaches used in determining the appropriate protective structure for the coastal area of Muara Gembong is by analyzing each choice of coastal protection structure type. The selection of the type of coastal protection building depends on the condition of the beach, the basic condition of the protected beach, the availability of materials, and the equipment to make the building (Triatmodjo, 1999). Table 4.20 illustrates the comparison.

Table 4.20: Comparison of Various Coastal Protection and Reinforcement Structures
(MoPW, 2020; Triatmodjo, 1999)

Num	Type	Function	Material	Placement
1	Seawall	The function of the sea wall is as a reinforcement in the coastal profile and a barrier to relatively high wave forces	Natural or artificial stone, masonry, concrete, concrete sheeting, steel sheeting, or wooden sheet piles	Built in the direction parallel to the coast or almost parallel to the coast with the aim of protecting the coast against the crashing waves
2	Revetment	Protecting a shoreline cliff or slope surface, which as a whole has a role to increase the stability of the coastline or protected embankment shoulders	Empty masonry, concrete slabs, concrete blocks, and gabions	Parallel to the coast or almost parallel to the coastline that limits the land area with the sea
3	Break water	• Serves as a protection for the harbor water pond that is located behind it from wave attacks • Waves that spread on a wave-absorbing building part of its energy will be reflected (Reflection), • The share of the reflected wave energy, destroyed and transmitted depending	Masonry / concrete, or non-massive types in the form of piles of stones, concrete blocks or tetrapod	Upright or almost perpendicular to the beach

Num	Type	Function	Material	Placement
		on the characteristics of the incoming wave (period, height, water depth), • Less wave energy in a protected area will reduce sediment delivery in the area		
4	Groyne	Regulating the direction of ocean currents; Enlarge the bending radius of the sea channel which is too sharp so that the alignment of the sea is better; Reducing the speed of ocean currents along sea cliffs; Controlling sea cliff erosion by reducing the velocity of flow attacking sea cliffs; Speed up sedimentation; Closing the sea channel branches (on the braided river) so that the ocean currents go to the desired channel; Ensuring the safety of embankments or cliffs against scouring; Concentrate flow; Deepening sea lanes; Directs the flow at low discharge conditions; Protect other marine structures.	Blank stone, masonry, or concrete block, steel or concrete trim	Upright or almost perpendicular to the beach

To determine the right type of seawater retaining structure, a descriptive analysis was carried out from various related literatures. Table 4.21 reviews several alternatives:

Table 4.21: Alternative Coastal Protection
(Alamratri & Sarwono, 2017; MoPW, 2020)

Num	Type	Advantages	Disadvantages
1	Groyne	• Easy to obtain materials, such as wood, river stone • Can use equipment from the direction of the beach • Can hold longshore sediment transport and hold sediment in the planned position • Does not change the surf zone	• There is frequent erosion downstream • Cannot be used on beaches with high mud content • Interfering with boat landing activities to the beach
2	Revetment	• The ability to absorb waves is very good as the structure is right along the coastline so that the existence of the coastline can be protected optimally. • Work and maintenance can be done easily because the building is on land	• As it is built along the coastline, it requires a considerable volume of material • Not effective in areas that have a sloping base. As it can cause severe erosion if the foundation is in shallow water • The top elevation of the building is high
3	Breakwater	• The beach looks natural without protection • There is an increase in land area • Retains the sediment rate towards the sea	• Construction requires special construction tools and methods and is relatively more difficult than other methods • Requires a certain processing time, namely waiting for the buttons to occur and cuspate (salient) • Interferes with shipping
4	Seawall	• The ability to absorb waves is better • The use of material is relatively less than the revetment • Fast job execution • The probability of damage during execution is small • Low maintenance costs • Able to withstand large waves	• Can lead to considerable erosion if the foundation is located in shallow water • Peak elevation tall building • Difficult to fix if broken • Heavy equipment required for construction

Based on a literature review comparing several coastal protection and reinforcement structures that can be built on the coast of Muara Gembong, the construction of a breakwater can be an appropriate option. The consideration that underlies this conclusion is that in addition to the breakwater holding the sediment flow away from the sea, the breakwater does not reduce the beauty element from a beach aspect. Although it requires special techniques and a longer period of time, in the long term this option can slow down damage to the coastline. According to Alimuddin (2015), simulations using Genesis predict a slowdown in shoreline change. In addition, the breakwater can withstand the onslaught of sea waves so that it can protect the coastal area behind it, especially protecting from oil-contaminated sea water.

When compared with other options, the breakwater has the advantage of holding sedimentation behind the building. Groynes can cause sedimentation in the upstream areas, and can results in the cessation of sediment supply in the downstream areas and results in abrasion, while a seawall is less effective in holding sediment transport, meaning shoreline damage is likely to occur at the end of the building.

3. Mapping of Coastal Sensitivity to Oil-Polluted Seawater

To compile a Coastal Sensitivity Map, several sensitivity criteria were identified from various sources. The parameters or criteria used in analysing the coastal sensitivity index are compiled based on the collected data and concept modelling previously compiled and developed (NOAA, 2000; Setiawan, 2017) (See Table 4.22).

Table 4.22: Environmental sensitivity criteria in the sensitivity index analysis

Criteria	Sensitivity level					Reference
	Not sensitive (1)	Less sensitive (2)	Medium (3)	Sensitive (4)	Very sensitive (5)	
Type of Coastal Area	Cliff beach		White sandy beach		Mangrove beach type	(Sloan, 1993)
Slope Level from the Coastal Area (%)	< 15.1	10.1 - 15.0	5.1 - 10.0	3.1 - 5.0	< 3	(Hayes et al., 1992)
The degree of influence of wave energy and tidal currents	High sea waves (h> 1m) and strong tidal currents throughout the season		Ocean waves and tidal currents have a seasonal pattern		Ocean waves and tidal currents are protected by coastal morphology	(Setiawan, 2017)
Mangrove density (Ind / Ha)	<600	600 - <900	900 - <1200	1200 -1500	>1500	Decree of the Indonesian State Minister for the Environment. Number: 201 of 2004
Dominance of mangrove species	*Bruguiera*	*Lumnitzera, Xylocarpus, Scyphiphora*	*Rhizophora, Ceriops*	*Sonneratia, Excoeceria*	Avicennia	(NOAA, 2000)
The habitat of marine animals is protected	unavailable				available	(Damar et al., 2013)
Place of importance	Port	Settlement	Cultivation	Fish catching	Tourism	(Sloan, 1993)

a. Type of Coastal Area

Based on satellite images and confirmed by the random field observations, the type of coastal areas in Muara Gembong are mangrove beaches. This type of beach has a substrate that is generally flat and high in organic matter. The soil texture tends to be muddy, but there is grassy or woody vegetation. If oil-polluted sea water enters this beach, cleaning efforts can actually cause significant ecosystem damage and have long-term impacts (Sanjarani et al., 2016). Therefore, these beaches are considered to have high sensitivity (Sloan, 1993).

b. Slope Level from the Coastal Area

Based on satellite image processing, it can be seen that the slope level along the entire coastal area of the Muara Gembong coast is less than 3 %. According to Sloan (1993), beaches with this level of slope can be considered as beaches with a high level of sensitivity to oil pollution. Figure 4.18 displays the terrain slope map.

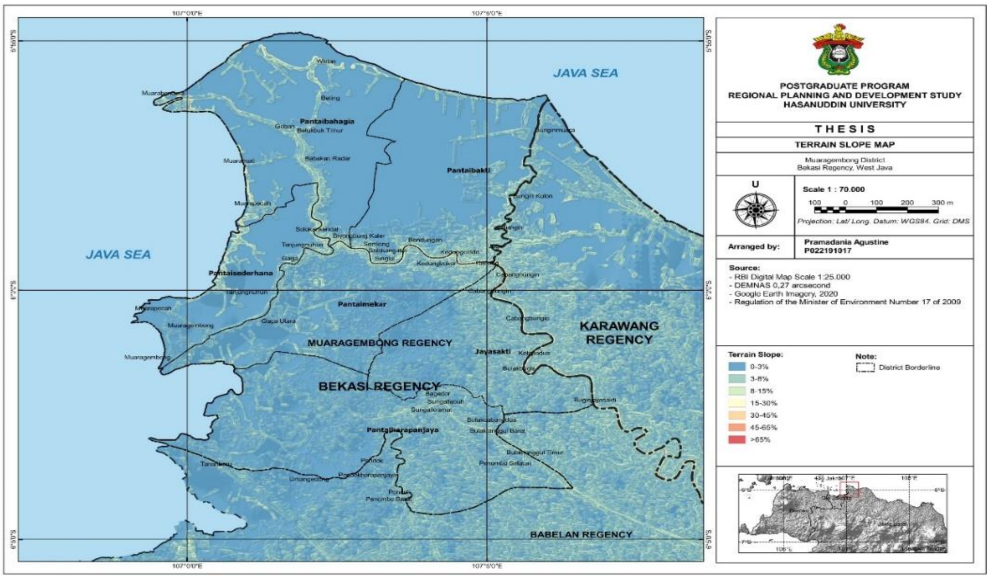


Figure 4.18: Terrain Slope Map

c. The Degree of Influence of Wave Energy and Tidal Currents

The level of sensitivity of the coast to oil can also be seen from the tidal patterns that occur (Hayes et al., 1992). From the tidal information (Figure 4.19), it can be considered that that the tidal wave in the waters of the Muara Gembong area is a mixed type with a tendency to a single daily.

The coastal areas of Muara Gembong is also very sensitive to oil spills because the coast of Muara Gembong is overgrown with mangroves (Hayes et al., 1992). The position of the mangroves does protect coastal residential areas from current and tidal waves, but when an oil spill occurs, mangroves are the first to be affected.

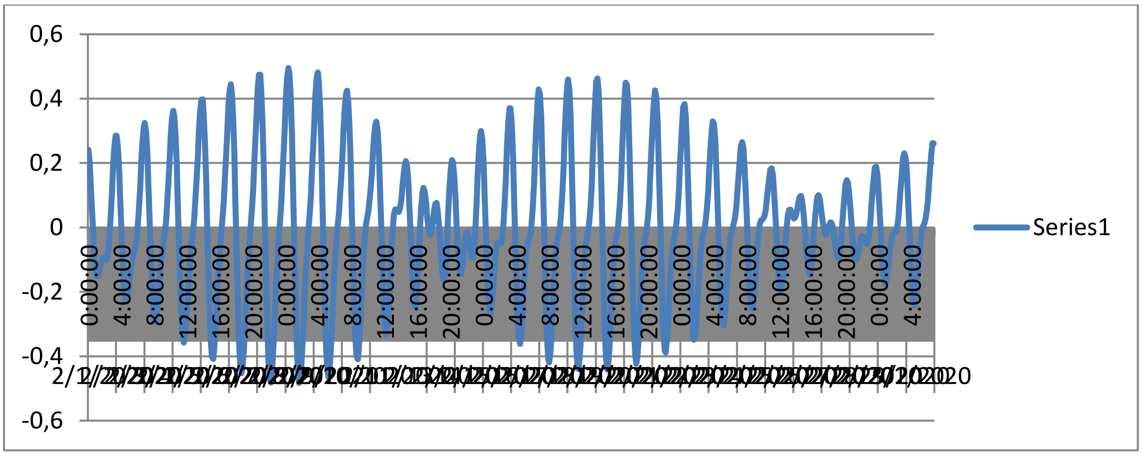


Figure 4.19: Tidal data of West Java Sea Waters

d. Mangrove Density

According to the Minister of Environment Decree No. 201 of 2004, mangrove density levels can be used to measure the level of sensitivity of coastal areas to oil (Table 4.23). The higher the mangrove density in an area, the higher the sensitivity level. Furthermore, in addition to density, the dominance of mangrove species determines the level of sensitivity. According to NOAA (2000), mangroves of the Avicennia sp are the most sensitive to oil.

Table 4.23: Mangrove Sensitivity Level based on Density and Species Dominance

Location	Dominance of mangrove types	Mangrove Density (N/Ha)	Reference of Previous Research	Level of Sensitivity to Oil (Minister of Environment Decree No. 201 of 2004)
Pantai Mekar Village	*Avicennia sp, Rhizopora sp*	2633	(Pribadi et al., 2017)	Very Sensitive (>1500 N/Ha)
Pantai Harapan Jaya Village	*Sonneratia sp, Avicennia sp, Rhizopora sp*	8733	(Pribadi et al., 2017)	Very Sensitive (>1500 N/Ha)
Pantai Bahagia Village	*Avicennia sp, Rhizopora sp, Sonneratia sp,*	1650	(Marsudi et al., 2018)	Very Sensitive (>1500 N/Ha)
Pantai Bakti Village	Avicennia sp, Rhizopora sp, Sonneratia sp,	1300	(Rachmawati et al., 2014)	Sensitive (1200 – 1500)
Pantai Sederhana Village	Sonneratia sp, Avicennia sp,	2240	(Rachmawati et al., 2014)	Very Sensitive (>1500 N/Ha)

e. Habitat for Protected Animals

Muara Gembong is one of the areas designated as a habitat for animals protected by the state. In Muara Gembong, there is Javan langur, whose population declines every year and is vulnerable to extinction (Ramdhan, 2018). Table 4.24 lists the protected animals in the region.

Table 4.24: List of Protected Animals in Muara Gembong

Location	Types of animals that are protected	Level of Sensitivity to Oil
Pantai Mekar Village	None	1
Pantai Harapan Jaya Village	None	1
Pantai Bahagia Village	Javan langur	5
Pantai Bakti Village	None	1
Pantai Sederhana Village	heron	5

f. Place of importance

With the presence of mangroves along the coast, actually the Muara Gembong area has the potential to become a conservation area and nature reserve. However, based on field observations, there are still many areas that are used for other uses, such as settlements and ponds. Table 4.25 shows the range of land utilization that occurs in Muara Gembong based on field observations.

Table 4.25: List of Place of importance

Location	Designation type	Level of Sensitivity to Oil
Pantai Mekar Village	Settlement	2
Pantai Harapan Jaya Village	Settlement	2
Pantai Bahagia Village	Tourism	5
Pantai Bakti Village	Settlement	2
Pantai Sederhana Village	Fish catching	4

g. Map of Coastal Sensitivity in Muara Gembong

The results of the mapping of the sensitivity of the Muara Gembong coastal area to oil-polluted seawater are shown in Table 4.26. Table 4.27 displays the Environmental Senstivity Index and category ranking. As for the results from Table 4.26, the distribution of the sensitivity of the coastal area is depicted in Figure 4.20.

Table 4.26: Environmental Sensitivity Index analysis table (Modified from Setiawan (2017))

Villages	Sensitivity Value			Ecological Value		Socio-Economic Value	Environmental Sensitivity Index*)	Category **)
	Type of Beach	Beach Slope	Effect of Wave Energy & Tidal Current	Mangrove Density & species	Protected Marine Animal Habitat	Place of Important Value		
Pantai Mekar Village	5	5	5	5	1	2	40	Sensitive
Pantai Harapan Jaya Village	5	5	5	5	1	2	40	Sensitive
Pantai Bahagia Village	5	5	5	5	5	5	166,6667	Very Sensitive
Pantai Bakti Village	5	5	5	4	1	2	33.3333	Sensitive
Pantai Sederhana Village	5	5	5	5	5	4	133.3333	Very Sensitive

Notes: *) ESI = SV*EV*4/3SEV (IPB, 2009). The portion determined by the Ministry of Environment is that the weighting for the vulnerability index and the ecological index are the same, equal to 0.30 ($\alpha = \beta = 0.30$), while the socio-economic index is determined as 0.4 ($\gamma = 0.40$).
**) According to IPB (2009), there are five categories of environmental sensitivity index as described in Table 4.26.

Table 4.27: Environmental Sensitivity Index Classification

ESI	Category
1	Not sensitive
2-8	Less sensitive
9-27	Medium
28-64	Sensitive
65-125	Very sensitive

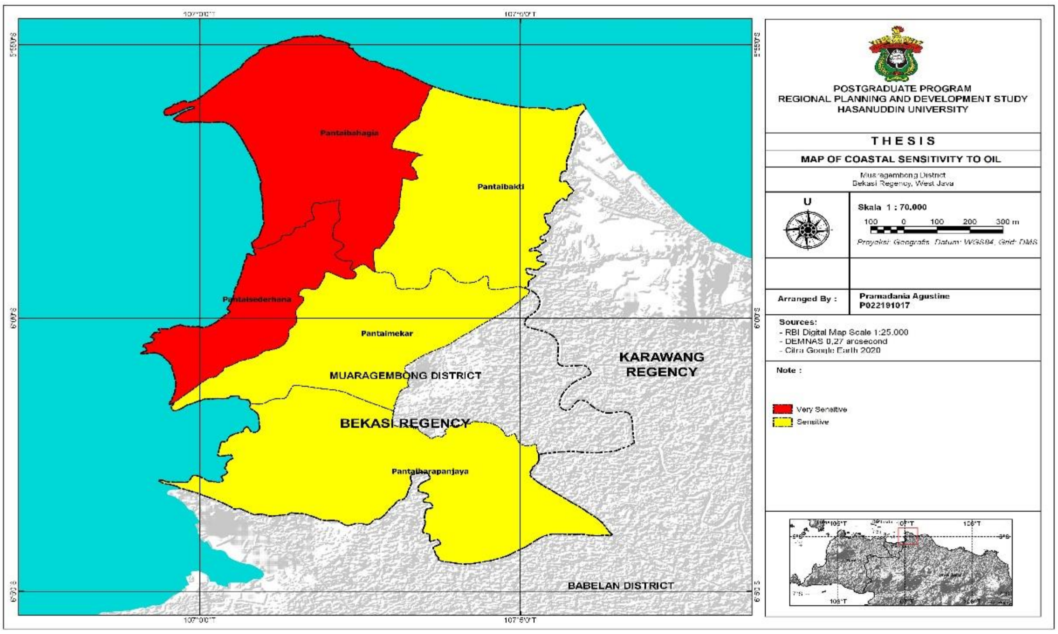


Figure 4.20: Map of Coastal Sensitivity to Oil

4. Prediction of Oil Distribution

Based on the results of discussions with the Marine and Fisheries Office of Bekasi Regency, one of the reasons for the lack of readiness of the local government in dealing with the oil spill incident in July 2019 was that technological tools were not used. Advanced technological tools could predict the direction of the oil spill. Therefore, in this study a simulation of the distribution of the oil spill was carried out with the point of origin of the distribution, PHE ONWJ's offshore location.

Before carrying out the simulation, documentation of the direction of the distribution of the Pertamina oil spill in 2019 was reviewed. The documentation time is from July 2019 to December 2019.

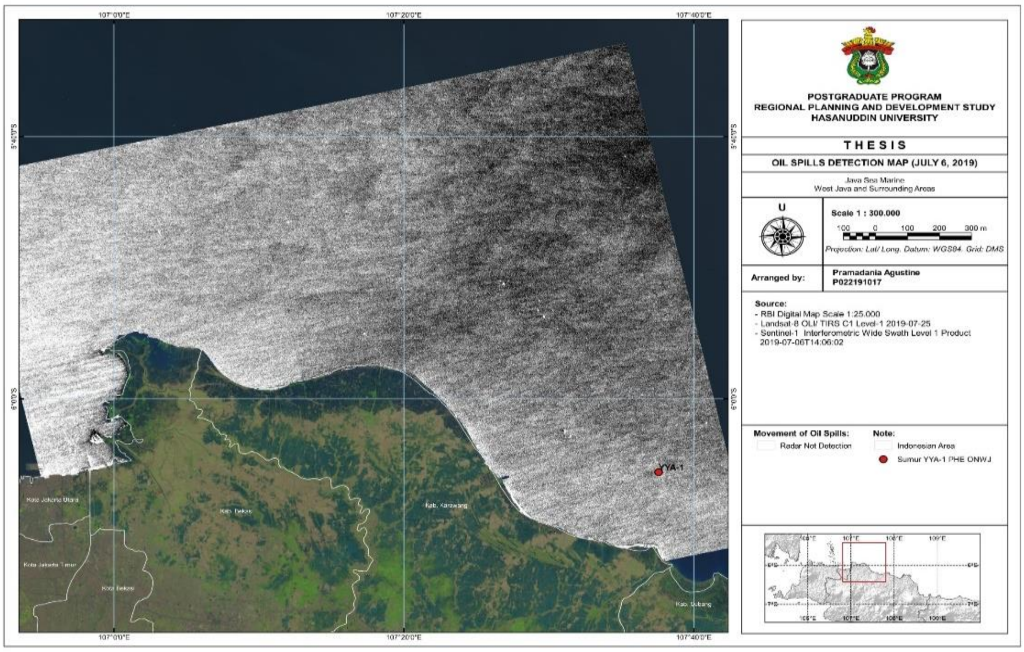


Figure 4.21: Oil Spill Detection Map (July 2019)
(see also Figure 4.10 for September 2019)

Figure 4.21 is the image before the Pertamina oil spill. The location of the incident is marked with a red dot. It is clear that from the satellite imagery, no oil spill in the Java Sea has been detected.

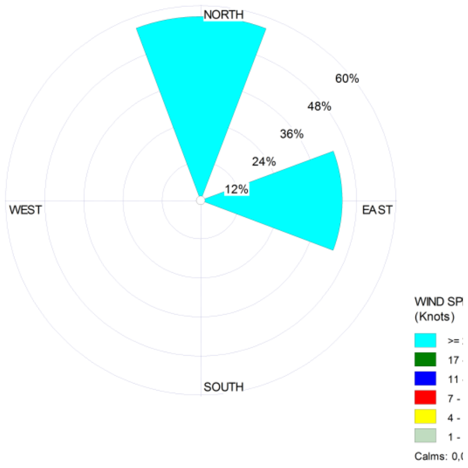
After the Pertamina oil spill occurred on July 12, 2019, oil began to be very clearly detected in satellite images on July 18 2019 (Figure 4.21). When the oil spill occurred, it was seen that the distribution of oil spread with a thin layer of oil, mostly only in the waters of the Karawang Regency. The oil spill distribution pattern in this condition has a shape like a trajectory that was still connected. In August 2019, the oil spill began to spread westward and reached the coastal area of Muara Gembong. However, satellite images on September 16, 2019 shows the movement of the spill tended to return to the east towards the origin of the spill. Furthermore, in October and November 2019, the satellite imagery depicts the oil spill had unusual movement dynamics (Figure 4.8). It is estimated that this is an effect of PHE ONWJ's activities to handle the oil spill.

From that analysis, it is clear that the movement of oil in the sea is strongly influenced by hydro-oceanographic conditions. Thus, understanding hydro-oceanographic components such as wind conditions and ocean wave currents are very helpful in predicting the distribution of oil in the sea. By predicting the distribution of an oil spill, it becomes easier to determine the direction of handling the oil spill.

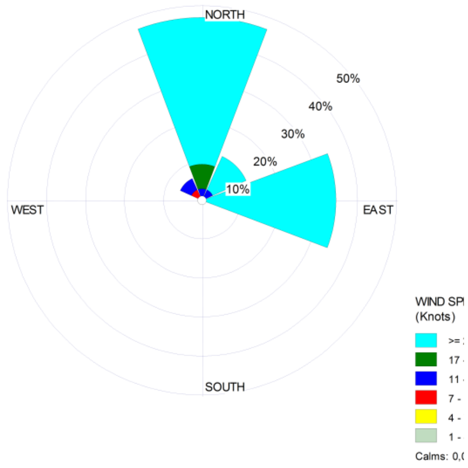
a. Wind Conditions

The spread of oil spills is influenced by the presence of wind. Wind can affect the movement of currents on the sea surface. Wind movement can affect the speed and direction of oil distribution.

The movement of the wind in the north of Java is influenced by the seasons that occur around the world. The wind movement in the West Monsoon (December-January) in the north of Java moves predominantly to the east. This is evidenced by the European Center for Medium-Range Weather Forecasts (ECMWF) data for the Bekasi District as shown in Figure 4.22 the wind moves in the north and east. By contrast, during the east monsoon the wind moves towards the west and south.



a.



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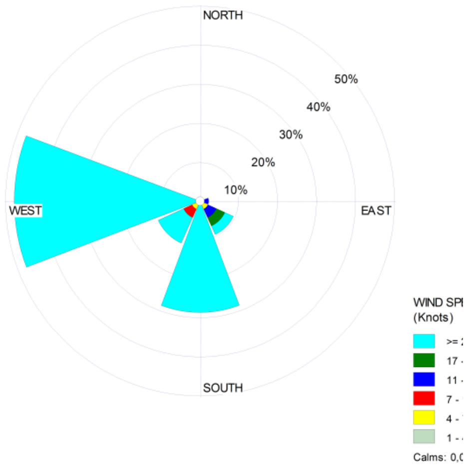

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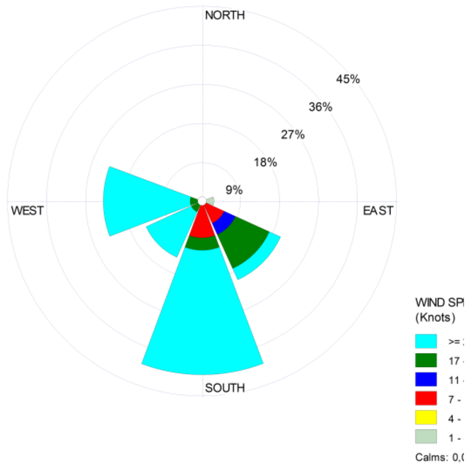

d.

Figure 4.22: Seasonal Wind Pattern
(a. West Season b. Transitional Season I c. East Season. d. Transition season II)

The North Coast of Java is in the Northern Hemisphere (NH) weather pattern. Direction patterns and wind speeds are influenced by monsoons. The West Monsoon (North season) in the Northern hemisphere lasts from October to April and the peak takes place from December to January while the East Monsoon (South season) lasts from April to October and the peak takes place from June to August (Prawirowardoyo, 1996).

b. Tidal Currents

Tides are one of the components used to model hydrodynamics. The difference in the intervals at the water level causes the current to move from the higher water level to the lower water level. Figures 4.19 and 4.22 show that the waters of the Java Sea, including the Muara Gembong region, have mixed prevailing diurnal winds and tidal variations. The oil spill event occurred on July 12, 2019, which according to the division of the season is the eastern season. In the east monsoon, the dominant current moves from the east and southeast to the west and northwest.

c. Oil spill distribution simulation

The research location is at PHE ONWJ, West Java. Grid width is made from the Jakarta Bay to Karawang. The source location displayed in Figure 4.23. Because the location file of Indonesia is not facilitated in the standard GNOME mode, the simulation is carried out using the Diagnostic Mode. Indonesia's loc files can be provided from the polygon map of the area under study. Polygon maps are created in BNA (Atlas Boundary File) format. Furthermore, for data and sea wind direction, historical wind data in Muara Gembong during 2020 is used from the site www.worldweatheronline.com. The limitation in this simulation is that this simulation only uses wind data information as a determinant factor due to the limitations of researchers in obtaining other data such as current and tide.

For this simulation, it is assumed that the type of spilled oil is medium crude oil of 10000 barrels. The simulation is clearly depicted in Figures 4.23 to 4.35. These figures are the simulation results of the oil spill model that occurred at PHE ONWJ from January to December 2020. The direction of the oil distribution model is influenced by wind conditions in the sea. The little dot shows the initial location of the oil spill.

Figure 4.23: The source location, PHE ONWJ

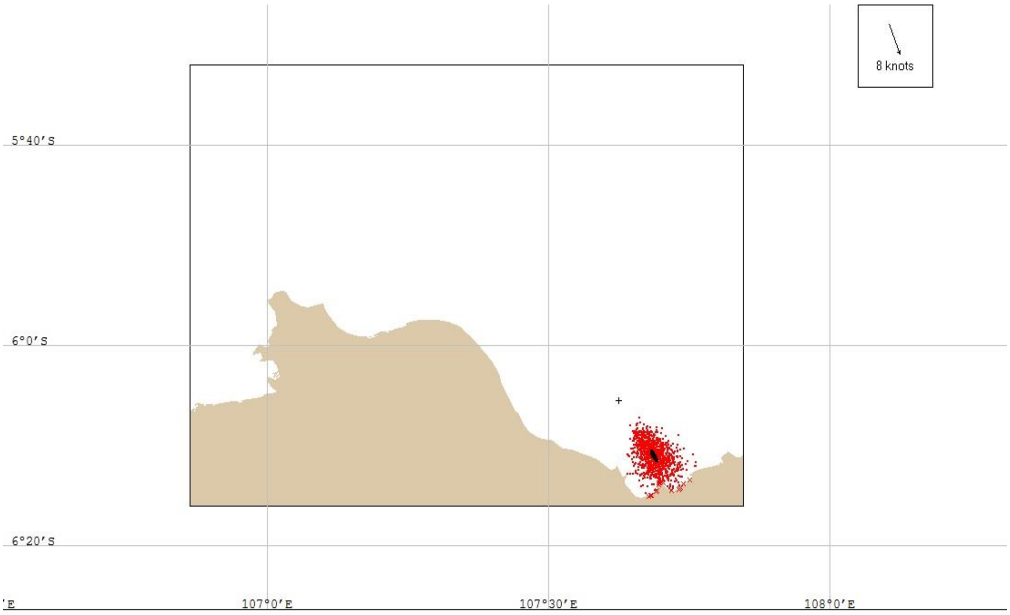

Figure 4.24: Oil spill in January

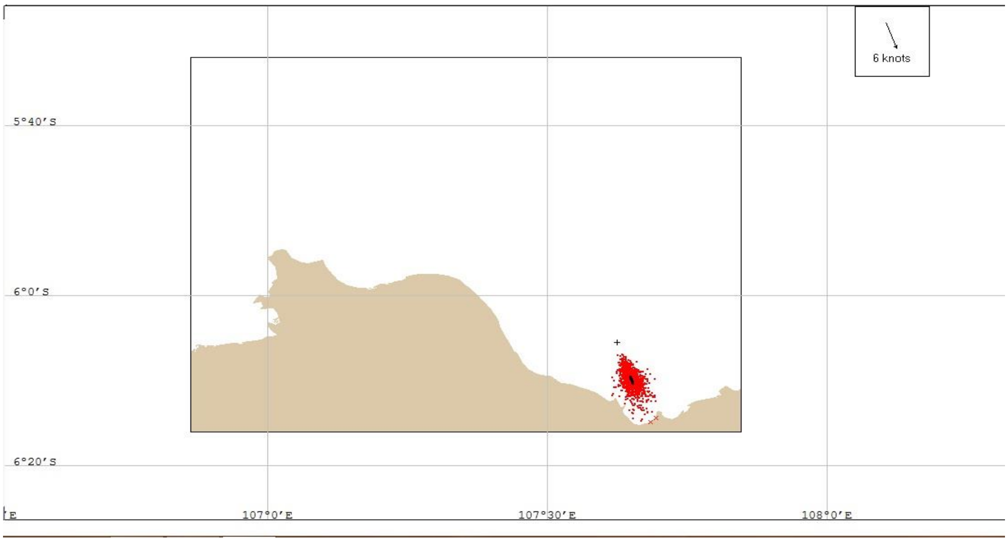

Figure 4.25: Oil spill in February

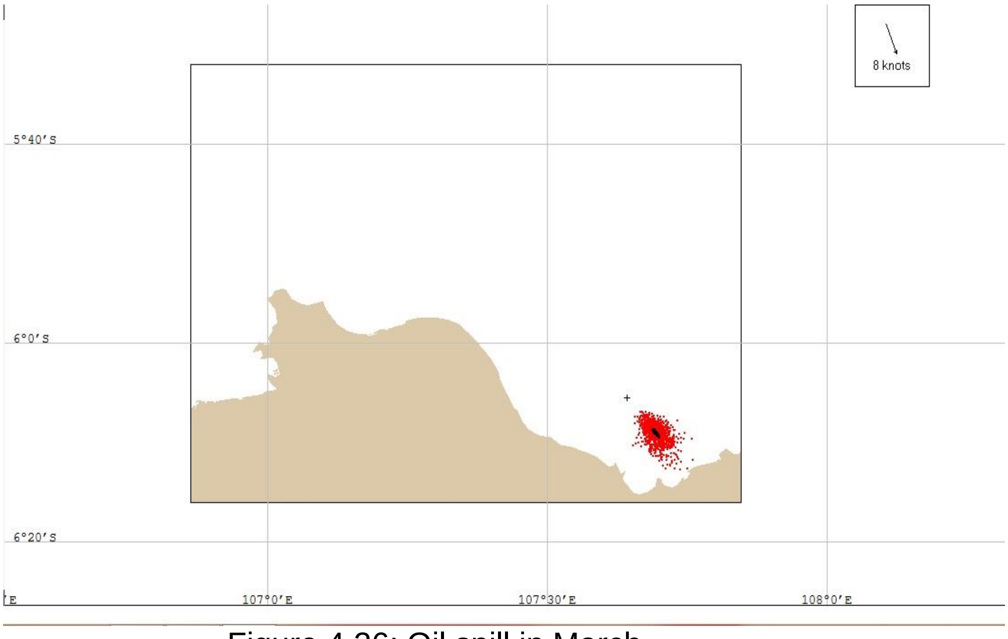

Figure 4.26: Oil spill in March

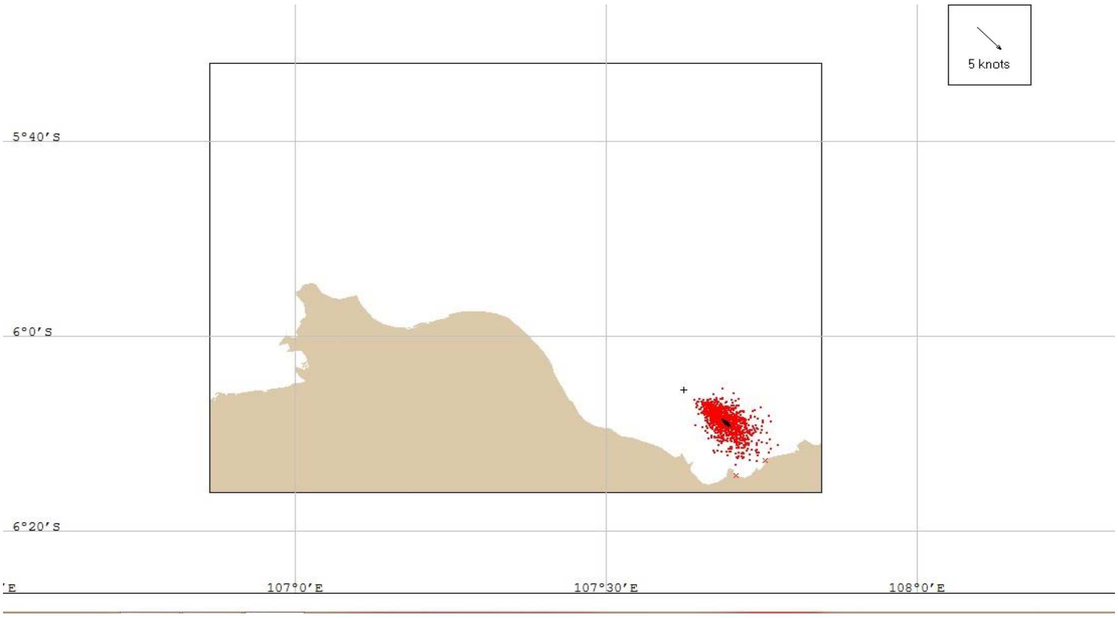

Figure 4.27: Oil spill in April

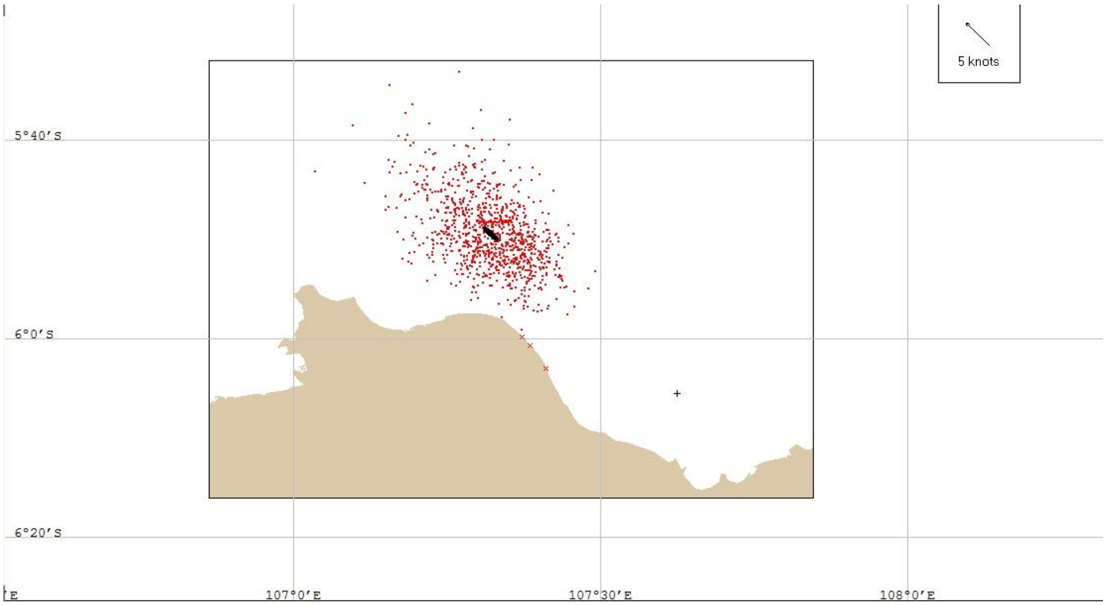

Figure 4.28: Oil spill in May

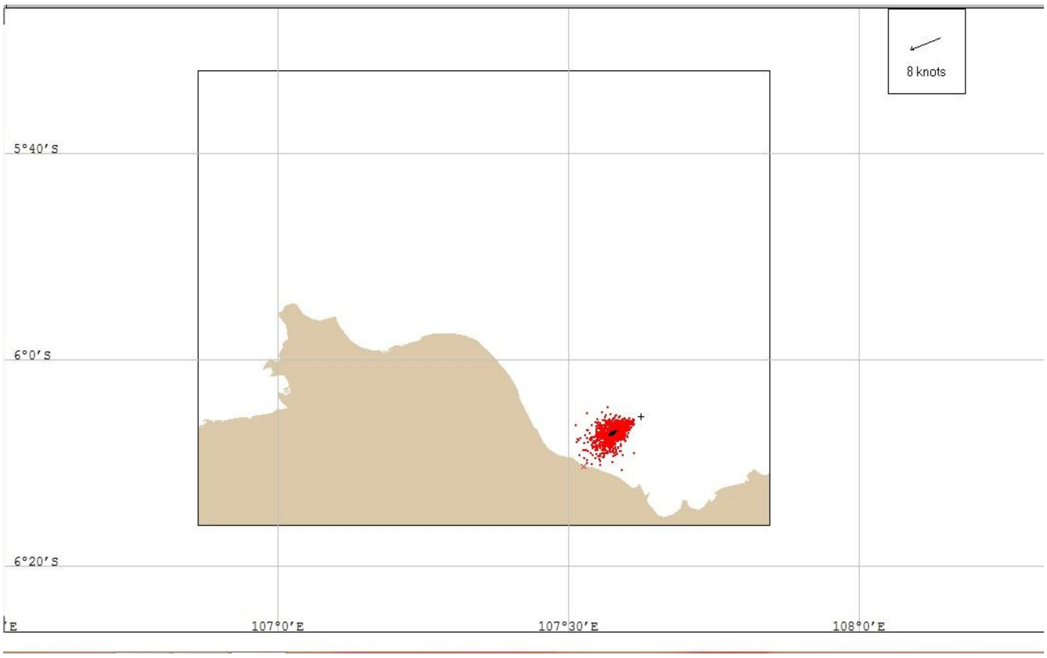

Figure 4.29: Oil spill in June

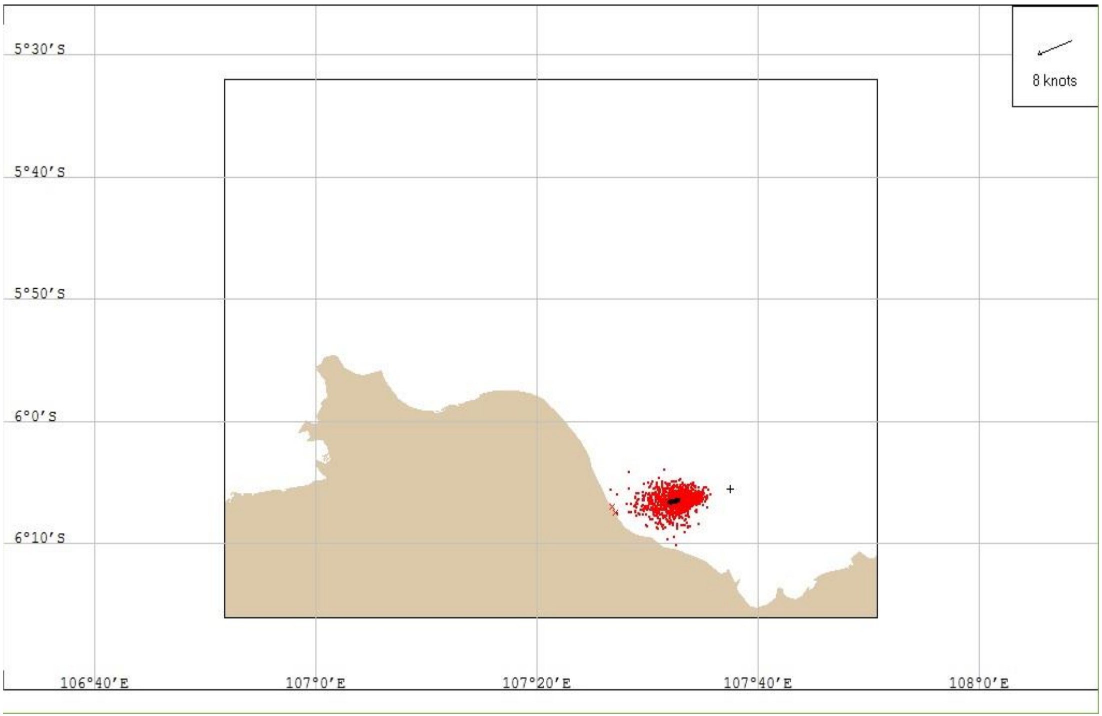

Figure 4.30: Oil spill in July

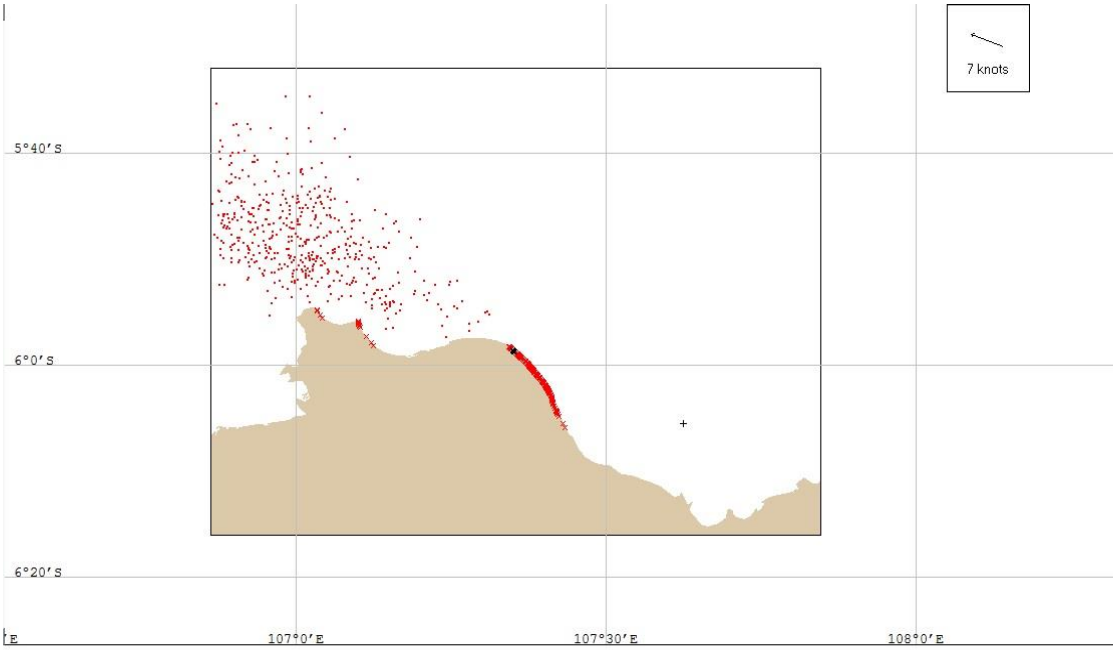

Figure 4.31: Oil spill in August

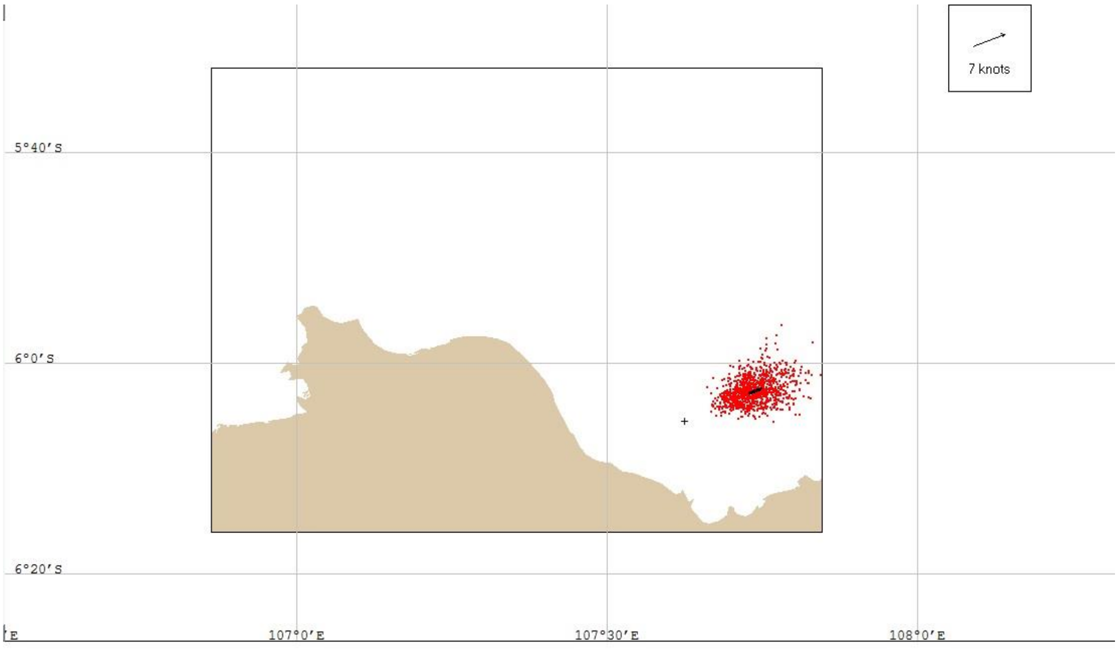

Figure 4.32: Oil spill in September

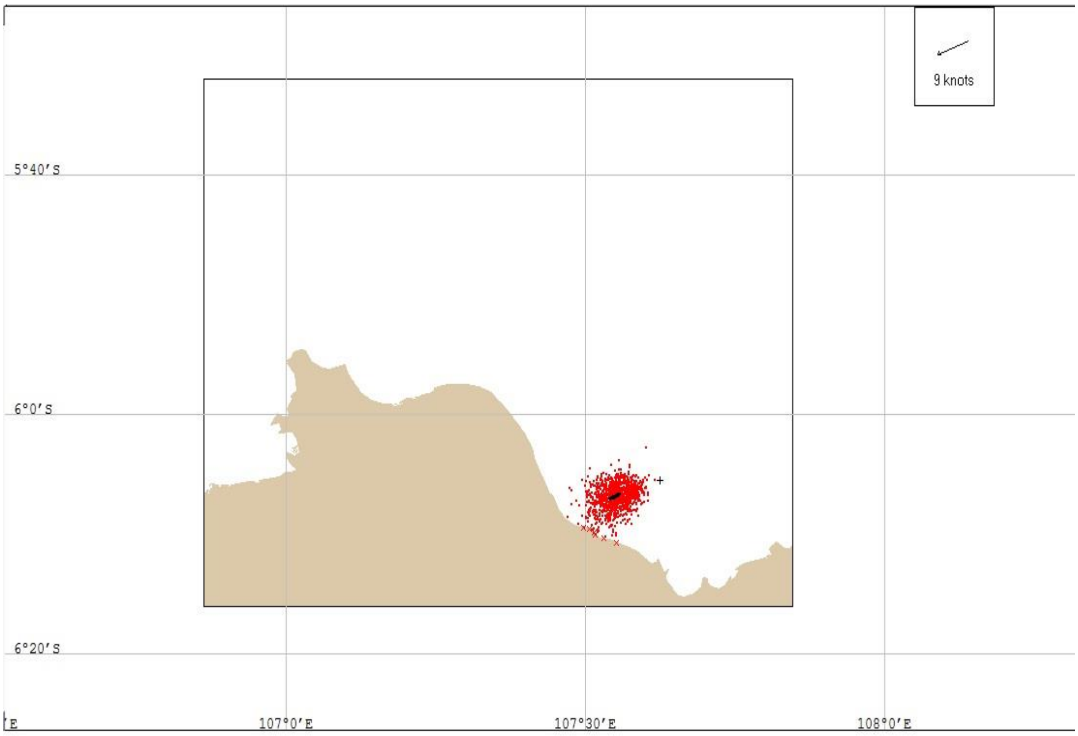

Figure 4.33: Oil spill in October

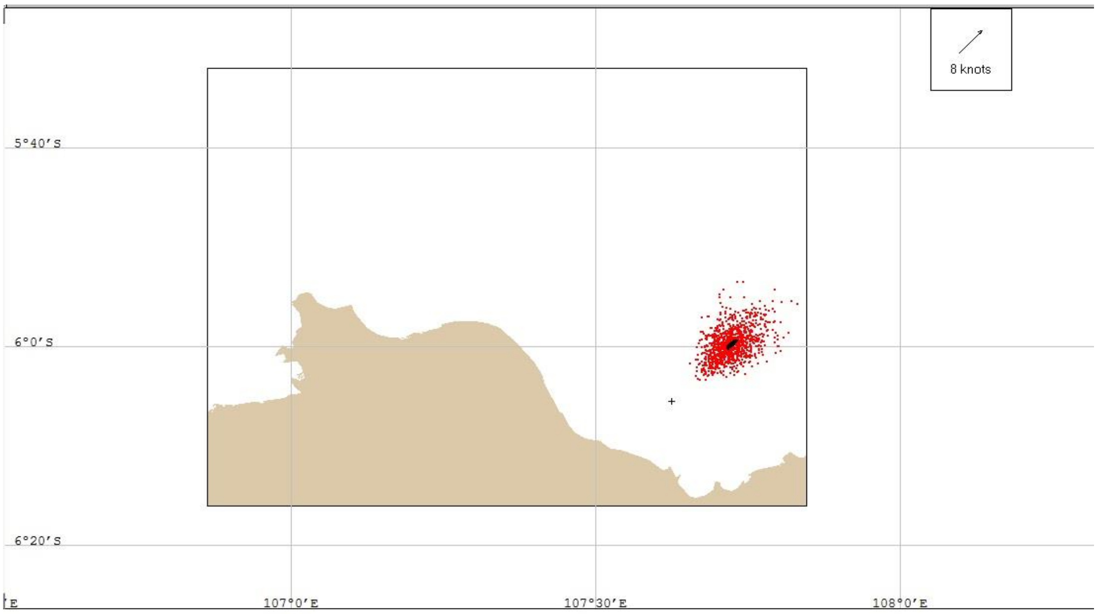

Figure 4.34: Oil spill in November

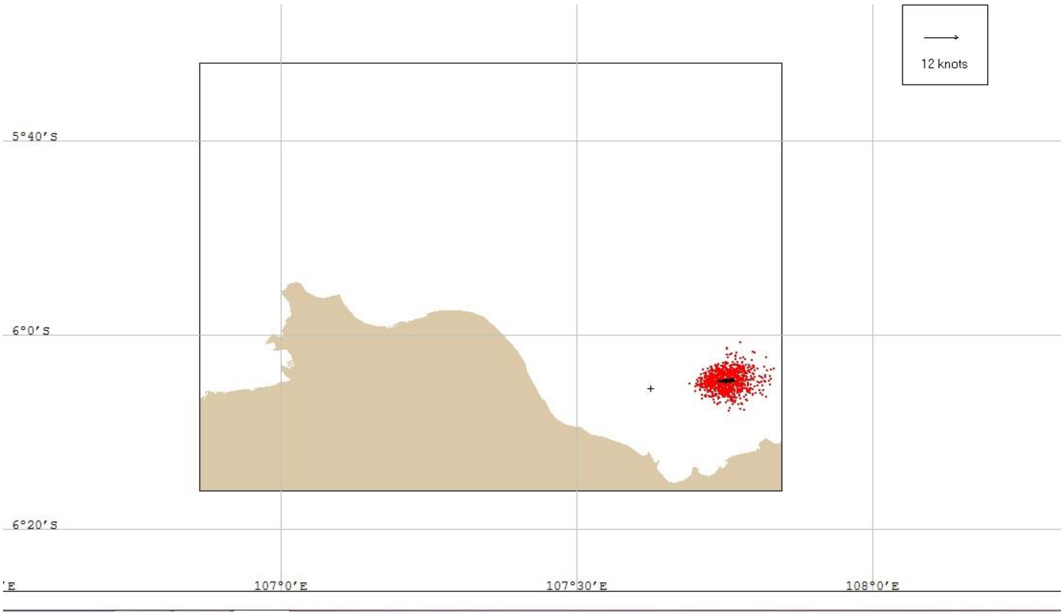

Figure 4.35: Oil spill in December

Based on the results of the GNOME simulation shown in figures 4.24 to 4.35, it is known that if an oil spill occurs in 2020, the areas that have the greatest potential to be polluted by oil spills are the Karawang and Subang districts. From January to April 2020, it is very clear that the movement of the oil spill tends to the north towards the coastal area in Subang Regency. The coastal area of Muara Gembong has the potential to be affected if a spill occurs in May and August, because this month, the wind direction tends to be northwest. Furthermore, based on the simulation results, the coastal area of Karawang Regency has the potential to be affected by an oil spill if an oil spill occurs in May, June, July, August and October. If the oil spill occurs in September, November and December, the chance to pollute the Java Sea coast is getting smaller because the direction of distribution tends to move away from the Java Sea coast and towards the northeast.

5. Improving Synergy and Coordination Between Related Agencies

Coordination has become an important subject in organizational studies as coordination can help shape organizational relationships (Alexander, 1995). Coordination is considered an important factor for the effective functioning of systems. Evaluating the occurrence of an oil spill can demonstrate the importance of developing coordination between organizations (Kinner & Merten, 2006). Therefore, there must be increased coordination between local government and stakeholders to respond to incidents effectively (Sydnes & Sydnes, 2011).

6. Strengthening the Control Mechanism of Oil Pollution

One of the input recommendations for the management strategy of the Muara Gembong coastal area to avoid oil-contaminated seawater is to improve the monitoring mechanisms for related aspects. The government is expected to play a more active role in responding to oil spills. One of the things that can be done to prevent oil spills in Indonesian waters is to create a Standard Operating Procedure (SOP) for tightening surveillance in domestic maritime areas.

Based on observations of this series of oil spill handling processes, in addition to optimizing the performance of the Bekasi Regency Marine and Fisheries Service, the role of the Ministry of Maritime Affairs and Fisheries as a Government Unit that plays a role in marine issues in Indonesia is also expected to be more intensive in the future. The role that is currently being carried out is actually quite good, the KKP has issued several regulations/policies related to handling oil spills, such as The Presidential

Regulation of The Republic of Indonesia Number 109 Of 2006 concerning Emergency Management of Oil Spill in The Sea and Decree of the Minister of Maritime Affairs and Fisheries Number: 54/KEPMEN-KP/2016 concerning the Team for Mitigating the Impact of an Oil Spill on the Marine and Fishery Resources. One thing that might need to be done is to optimize the performance of the "Pulbaket Team" so that the process of handling oil spills can be better in the future.

F. Determining the Right Management Strategy to Protect the Coastal Areas from Oil Pollution

The management strategy to protect the Muara Gembong coastal area from sea water contaminated with oil is prepared by using a hierarchical structure analysis or AHP. There are three priorities for this analysis such as interested actors, utilization aspects and strategic alternatives (Mujahidawati et al., 2018). This model will describe a multi-factor problem or complex multi-criteria criteria into a hierarchy (Yusuf et al., 2016).

1. Priority of Actors

The actors related to coastal management in the Muara Gembong area include; the Local Government, NGOs, Academics, Tourism Managers and Communities. The five main actors are expected to work together in any planning activities for the management of the Muara Gembong coastal area, especially in the case of oil pollution entering the coastal area of Muara Gembong. AHP analysis of the five groups of actors or stakeholders is shown in Figure 4.36.

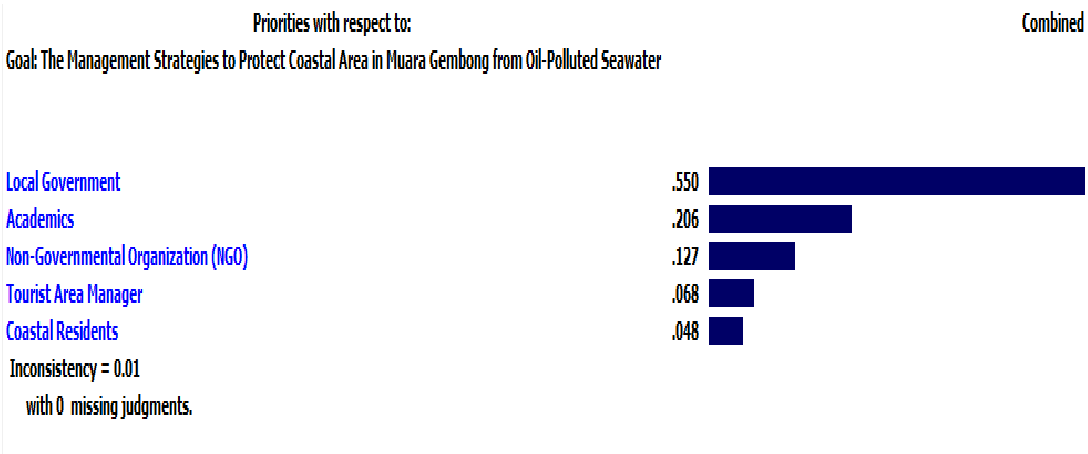

Figure 4.36: AHP Analysis of Actors Priorities (Stakeholders)

Local Government is the most important actor in the management strategy design of the Muara Gembong coastal area from oil pollution with a weighting of 0.550. The second rank is Academics with a weighting of 0.206. The third rank is NGOs with a weighting of 0.127. The fourth rank is Tourist Area Manager with a weighting of 0.068 and the last rank is Coastal Residents with a weighting of 0.048. From the AHP results, with the condition that the consistency ratio is less than 0.1, the combined results for the actors which comes from the three experts consist of local government officer, academics and NGOs officer, produce a consistency ratio value of 0.01. The consistency ratio value of 0.01 is smaller than 0.1, hence it can be said that it has met the consistent requirements of the three experts in assessing actors.

2. Priority of Utilization Aspect

The resource utilization aspect is one of the evaluation criteria in determining a coastal area management strategy in an effort to prevent oil-polluted seawater from entering the coastal area. In general, there are 4 (four) main utilization, such as fishery business, tourism, conservation and sea transportation. Figure 4.37 shows the AHP analysis output for the criteria for utilization aspects:

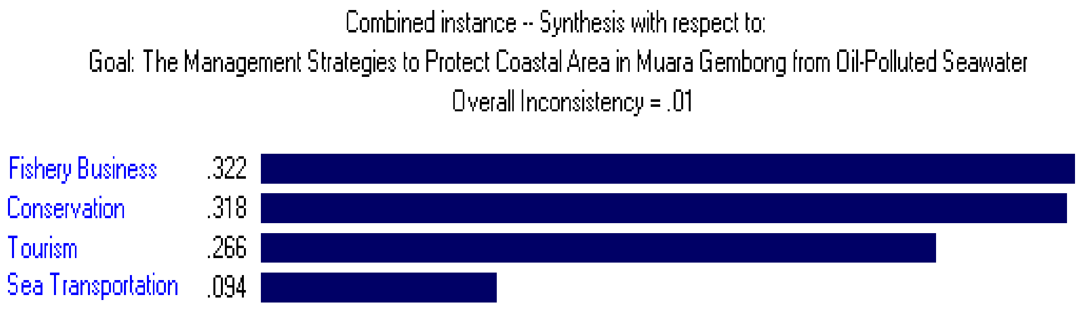

Figure 4.37: AHP Analysis of Utilization Aspects

The fishery business sector is the most important aspect in the strategic design of the management of the Muara Gembong coastal area from oil pollution with a weighting of 0.322; the second rank is Conservation with a weighting of 0.318, the third rank is Tourism with a weighting of 0.266; and the last rank is Sea Transportation with a weighting of 0.094. From the AHP results, with the condition that the consistency ratio is less than 0.1, the combined results of the three experts for the aspect produce a consistency ratio value of 0.01. The consistency ratio value of 0.01 is smaller than 0.1 so that it can be said that it meets the consistent requirements of the three experts in assessing aspects. The high weighting value for the fisheries business utilization aspect is due to the level of resource sensitivity to oil-polluted seawater. Oil spills can disrupt marine ecosystems and can even cause fishery business to stop.

3. Priority of Management Strategy

The alternative coastal management strategy of Muara Gembong is an implementative strategy in an effort to protect the coastal area of Muara Gembong from oil-polluted seawater. There are 3 main strategies derived from the results of the SWOT analysis that has been carried out. Figure 4.38 shows the AHP analysis output for management strategy priorities:

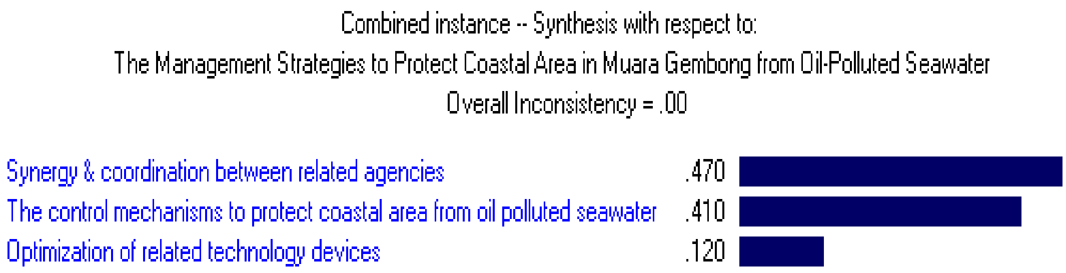

Figure 4.38: AHP Analysis of Management Strategy

Synergy and coordination between related agencies is the most important strategy in the design of a strategic management strategy for the Muara Gembong coastal area from oil pollution with a weighting of 0.470; the second rank is the control mechanisms to protect the coastal area from oil polluted seawater with a weighting of 0.410; and the last ranking is Optimization of related technology devices with a weighting 0.120. From the AHP results with the condition that the consistency ratio is less than 0.1, the combined results of the three experts for the aspect result in a consistency ratio value of 0.00. The consistency ratio value of 0.00 is smaller than 0.1 so that it can be said that it has met the consistent requirements of the three experts in assessing the strategy.

CHAPTER V

DISCUSSION

As stated in the initial chapter of this thesis, this research aimed to develop a coastal area management plan or strategy to minimize the impact of oil spill events that may occur in the future. The analysis involves and pays attention to various related aspects. A series of analyses carried out included analysis of environmental, social, technology and policy strategies.

A. Overall Findings

The coastal area of Muara Gembong is located in the Java Sea. The Java Sea is known to be one of the busiest shipping lanes in Indonesia and is one of the locations for offshore oil mining. This makes the Muara Gembong coastal area one of the coastal areas prone to oil spills. Considering that the impact of an oil spill can harm the coastal environment, it is essential to formulate various efforts to anticipate the impact of an oil spill incident that may occur in the future (Santos & Andrade, 2009).

To determine an integrated planning and management action both technically and institutionally, a good understanding of the coastal area's condition is required (Setyonugroho et al., 2019). This understanding will make it easier to determine priority problem handling and develop better planning (Santos & Andrade, 2009). Based on this consideration, this study begins with an assessment of the Muara Gembong coastal area's environmental conditions. Based on the geographical analysis results, there have been significant changes in land use and cover during the last twenty years due to society's socio-economic structure's growth and transformation. The total area of land has changed from 14,475.46 ha in 2000 to 12,869.70 ha in 2020. One of the reasons for this change is the reduction in mangroves' number as an abrasion barrier. According to Oktaviani and Imran (2019) the number of mangroves in Muara Gembong has decreased significantly due to the conversion of mangrove land to other land uses such as ponds.

When an oil spill occurs in the sea, the main concern is how much of an impact the incident causes (Albert et al., 2018). To present data about the impact of the oil spill on the coast of Muara Gembong in July 2019, literature studies, geographic analysis and interviews with related parties were carried out. Based on a literature study and geographic analysis, it is known that the mangrove ecosystem has been the affected ecosystem and 300,000 mangrove trees in mangrove forests on the North coast were affected by PHE ONWJ's oil spill.

In addition to impacting the mangrove ecosystem, oil spills also cause a decline in fish catch. The fishers interviewed suspect that the oil spill caused the reduction in the number of fish in their catchment area. They predict the fish move to non-polluted areas or die due to oil contamination. Furthermore, local fishers provided information about the social impacts experienced by coastal communities, such as health problems. Coastal residents experienced skin health problems as they helped clean up the oil waste spilt in the sea. This finding is in line with research by P. C. Nwilo and

Badejo (2006) which demonstrated how oil spills significantly impact the environment, ecology and society.

Given the significant impact of oil spills on the coastal environment, this then increases awareness of efforts to control pollution and reduce the adverse effects of oil spills on the community (Albert et al., 2018). The chosen approach to describe efforts to minimize the impact of oil spills is a disaster preparedness measurement of the coastal community of Muara Gembong. Statistical analysis was carried out using adjusted variables from the research of Yong et al. (2017) and Sopaheluwakan (2006). Surprisingly, the analysis shows that despite the significant impact caused by the oil spill event, the coastal communities of Muara Gembong do not consider the incident as a disaster requiring preparedness, such as an earthquake or tsunami. This indirectly shows that people's understanding of the impact of oil pollution is currently still considered minimal. Therefore, a more active role is demanded of local governments better to socialise the dangers of an oil spill incident so that the community can be better prepared and the impact can be minimized.

In addition to the need to increase socialization efforts related to the impact of oil spills on coastal communities, local governments also need to formulate coastal management strategies that can minimize the impact of oil spills that may occur in the future. The initial method for strategy formulation that is recommended is a SWOT analysis. This analysis is based on internal and external factors to maximize strengths and opportunities and minimize weaknesses and threats (Rangkuti, 1998). Each point from the internal and external factors is identified directly from the relevant parties. This is followed by a matching stage to produce several sets of possible strategic alternatives. To ensure that the strategies are feasible, each strategy produced by SWOT analysis is assessed.

The first recommendation resulting from the SWOT analysis is handling the issue of spatial conflicts. This recommendation appears as a solution option to overcome the current physical condition of the coastal environment of Muara Gembong. It is expected that with a better physical condition of the coastal environment, the impact of the oil spill incident will be minimized. Further, as Santorineou et al. (2010) stated that changes in land use inevitably create spatial conflicts, therefore it is necessary to handle spatial conflicts with land use planning by paying attention to land capability and suitability (Hollingsworth, 2020; Santorineou et al., 2010). Land capability and land suitability are important to determine land use feasibility, which is the base of consideration in land use (Khadiyanto, 2005). Based on the results of land capability analysis using the formulation of the Minister of Environment Regulation No. 17 (2009), it is known that around 84% of land in the Muara Gembong area is suitable for a range of uses including agriculture and nature reserve. On the other hand, the remaining 16% are suitable for specified uses only, such as nature reserve and protected forest. In future, it is essential to protect especially the 16% area, so that it does not cause environmental damage. Analysis of land capability completed with land suitability analysis is required. The land suitability analysis in this study is devoted to providing a clearer picture of which areas are suitable for the three main uses in the Muara Gembong area, including settlements, aquaculture ponds and mangroves. Based on the results of the Land Suitability analysis, it is known that there are still many forms of land use that are not in accordance with their intended purpose, such as ponds. As depicted in Figure 4.15, almost all the ponds on the coast of Muara Gembong are unsuitable as they are located in coastal and river boundaries which are supposed to be protected areas. This is an important concern as land use that is not in accordance with its designation will increase the potential for land degradation (Soewandita, 2013).

According to Hartati et al. (2016), in principle, actions for the management and protection of beaches from abrasion/erosion consist of preventive measures by regulating land use in coastal areas and coastal protection. This is carried out by making non-structural structures, such as the Green Belt Area, or structural structures designed for “coastal reinforcement” purposes. As preventive measures have been described in the previous discussion regarding land use, the following discussion focuses on determining the appropriate form of coastal protection. Based on a literature review comparing several coastal protection and reinforcement structures that can be built on the coast of Muara Gembong, the construction of a breakwater can be an appropriate option. The breakwater can withstand the onslaught of sea waves so that it can protect the coastal area behind it, especially protecting from oil-contaminated seawater.

Effective and efficient pollution control measures can only be achieved if an efficient oil pollution control information system is available. Analysis of the index of environmental sensitivity to oil pollution can be valuable information to determine strategies for controlling oil pollution, so that the ecosystem in the area can be protected. The index of environmental sensitivity to oil pollution is formulated by analysing several factors such as type of coastal area, slope level, mangrove density, habitat for protected animals, the place of importance, wave energy and tidal currents (Setiawan, 2017). In this analysis, GIS is used as it provides reliable visualisation and evaluations of vulnerability from a spatial perspective (Matisziw & Grubesic, 2013). Based on the results of the analysis of five coastal villages in Muara Gembong District, it is known that the coasts in 3 villages are categorized as sensitive and the coasts in the other 2 villages are categorized as very sensitive to oil spills.

Another recommendation resulting from the SWOT analysis is the importance of predicting the distribution of oil spills when they occur. Knowing the projected trajectory of the spill is important information to determine further policies in dealing with the disaster, especially to save the environment by taking preventive measures and handling oil spills (Zafirakou et al., 2018). Without proper handling, the loss of environmental damage will have a long-term impact (Chang et al., 2014). To be able to accurately predict the movement of oil spills at sea is challenging, however not impossible to achieve. Mapping of the distribution of oil spills can be done using GIS analysis as GIS can trace the distribution of oil and record the characteristics of the spill (Matisziw & Grubesic, 2013). The initial data was complemented with other supporting data for distribution analysis, such as wind and tidal data. The distribution was simulated using the Gnome application software. The simulation results for 12 months show the distribution of oil tends to spread. Based on GNOME simulations, the areas that have the greatest potential to be polluted by oil spills are the Karawang and Subang districts. It is estimated that the Muara Gembong coast will only be directly affected by the oil spill if the oil spill occurs in May and August 2020.

In addition to the four previous strategic recommendations that are oriented towards the use of technological tools, a SWOT analysis also produces strategic recommendations that are oriented towards strengthening coordination and synergy and strengthening supervisory mechanisms. Furthermore, to determine the priorities of various alternative strategies, a process hierarchy analysis (AHP) was carried out. The results of the formulation of alternative strategies for managing coastal areas to minimize the impact of oil spills obtained several alternative strategies. The main priority of increasing synergy and coordination between related agencies with priority values reaching 47%, the second priority is increasing supervision efforts to protect the coastal area of Muara Gembong from oil-polluted seawater with a priority value of 41%, and the third priority is the use of technological tools with a priority value of around 12%. Overall, the implementation of this strategy is expected to contribute to efforts to minimize the impact of oil spills that may occur in the future.

B. Policy Implications

Based on the regional development plan for Bekasi Regency, the Muara Gembong area is included in Service Area II, North Zone (Jamil, 2007). This area is directed at the development of wet agricultural activities, one of which is for the use of pond land. This policy direction has more or less led to changes in land use during the last few decades (Oktaviani & Imran, 2019). Lack of supervision from coastal area managers has led to large-scale conversion of mangrove land into ponds. This then results in damage to the ecosystem and ultimately results in abrasion that endangers the inhabitants of coastal areas.

Conditions on the coast of Muara Gembong worsened after the oil spill. With the lack of ecosystems and coastal protection structures, oil polluted seawater can easily reach land and have a negative impact on coastal ecosystems, including health problems for coastal communities. Considering these conditions, it is appropriate that the Muara Gembong coastal area be managed better so that if an oil spill incident occurs again, the impact will not be worse than the previous incident. For this reason, local governments need to formulate a proper management strategy for the Muara Gembong Coastal Zone so that they are better prepared for oil spill incidents. Furthermore, the coastal area management strategy that will be formulated must pay attention to sustainability aspects in land use in addition to coastal oil spill mitigation.

To realize the expected conditions, the implementation of the results of this research strategy needs to be supported by several efforts or policy adjustments from the Regional Government, including:

1. Making adjustments to the direction of the development policy for the Muara Gembong coastal area, such as by stopping or minimizing the conversion of mangrove land to fish ponds or agriculture.

2. Restoring land functions according to the capacity of the land, especially for land that is designated as a conservation area.

3. Conducting outreach that aims to provide understanding to coastal communities about the dangers and impacts of an oil spill incident, so that the community will be better prepared when such incidents occur in the future.

4. Sharpen the role of local governments in drafting regulations related to pollution control. Regulatory instruments are controls for various stakeholders to prevent oil pollution in the aquatic environment.

C. Obstacles and Limitations

To carry out this research, the researcher identified several obstacles and limitations, as follows;

- This research focuses on environmental aspects and a little about social aspects of coastal communities. The discussion of economic aspects was not carried out in this study.

- In the subject of this study, many subjects have lower educational backgrounds, so researchers have to take a personal approach such as reading and explaining each statement and also helping to fill out the questionnaire. This reason is also why the survey cannot be conducted online.
- The oil pollution incident in July 2019 is still under investigation at the national level, thus access to some data and information is quite limited.
- Furthermore, due to the COVID-19 outbreak and social restrictions in the research area, the writer made several adjustments in the data collection stage and other stages that required direct visits to the research area, such as field surveys for image interpretation.

CHAPTER VI

CONCLUSION

A. Summary

Marine oil pollution in coastal areas is a multi-dimensional and complex problem with no single solution that can solve this problem. Discussing the development of coastal areas to prevent the impact of future oil spills cannot be separated from discussing how the area is currently being used. The fact that land use in Muara Gembong is not fully oriented towards sustainable development has created a desire to manage the area sustainably by considering the factors of land capability and suitability. It is expected that the sustainable development can reduce the potential for damage to coastal areas. Degraded coastal areas can exacerbate the impact on communities in the event of an oil spill incident.

Another aspect that must be considered in coastal development is the ingrained behaviour of various stakeholders and populations. Some stakeholders do not consider oil spills as a major disaster such as an earthquake. This is reflected in the results of the analysis on the effect of risk perceptions from oil spills on disaster preparedness, where the results show that the Muara Gembong community does not see any correlation between these two factors.

A series of analyses were carried out in this study. The vulnerability map of the Muara Gembong coastal area to oil is vital to observe. Of the 5 coastal villages observed, all coastal villages were categorized as sensitive to oil. This emphasizes the importance of making efforts to minimize the impact of future oil spills.

Among all the proposed strategies, the implementation of the strategy of utilizing technological mechanisms can be a tool to change the behaviour of the local government, which initially tends to be passive and does not seek many preventive measures. Local government is also expected to be more actively involved in efforts to protect the coastal environment and encourage all levels of society to contribute to the effort to prevent marine oil pollution. With a more active role from local governments in the case of oil spills, it is expected that the impacts that arise will be minimized.

B. Recommendations

1. The coastal areas in Pantai Bahagia village and Pantai Sederhana village need to be prioritized for protection considering that these areas are the areas with the most sensitive level of vulnerability to oil. In addition, these two areas have also been proven to be the two areas in Bekasi Regency that were most affected when the oil spill incident occurred in July 2019.

2. When an oil spill occurs again in the future, it is expected that the role and function of the Regional Government can be more active in efforts to deal with the oil spill event so that the impacts that occur can be handled more quickly or even minimized.

3. Participation in community support is needed to create participatory and more conducive coastal area management. The community can be more involved in efforts to rehabilitate and protect conservation lands in coastal areas. This involvement will be very useful in an effort to minimize the impact of oil spills that may occur in the future.

4. Supervision and enforcement are needed as part of the implementation of regulations (Law No.32 of 2009) which imposes strict sanctions on parties that cause environmental damage in the waters.

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APPENDIX

The Work Steps of Land Change Analysis

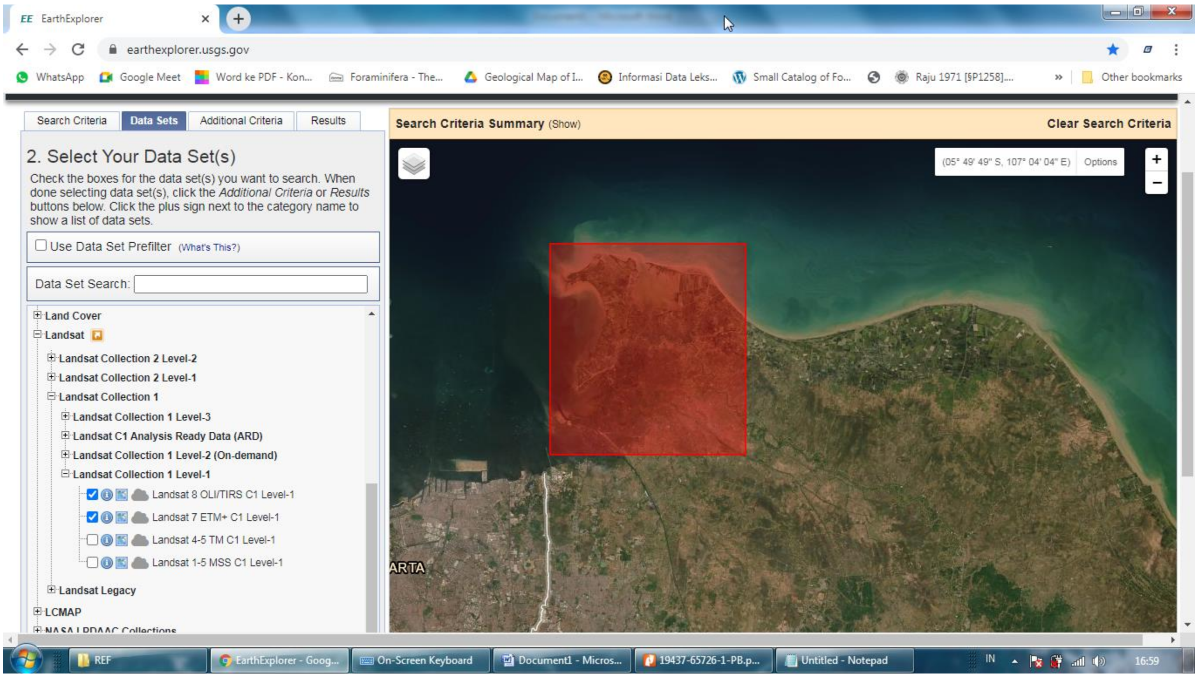
a. Methodology

The type of data used is quantitative data. Quantitative data is information data in the form of numeric or numeric symbols. Based on the number symbols, quantitative calculations can be made to produce a generally accepted conclusion in a parameter. This quantitative data is in the form of vegetation index value obtained from processing of Landsat satellite image data and the area in each classification class. The data used are secondary data in the form of Landsat 7 and Landsat 8 satellite imagery.

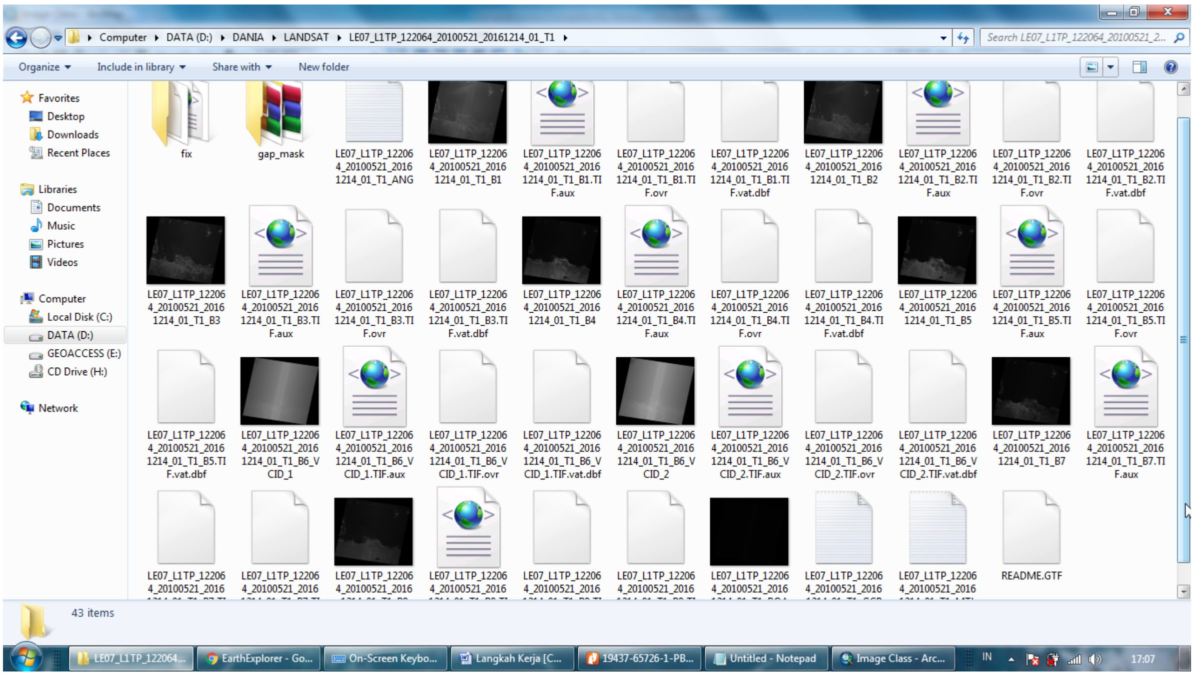
Changes in land cover can be identified by classifying the land cover. The land cover classification class consists of six, namely river bodies, constructed buildings, agriculture, mangrove forests, ponds, sea water / puddles.

b. Retrieval of Landsat Image Data

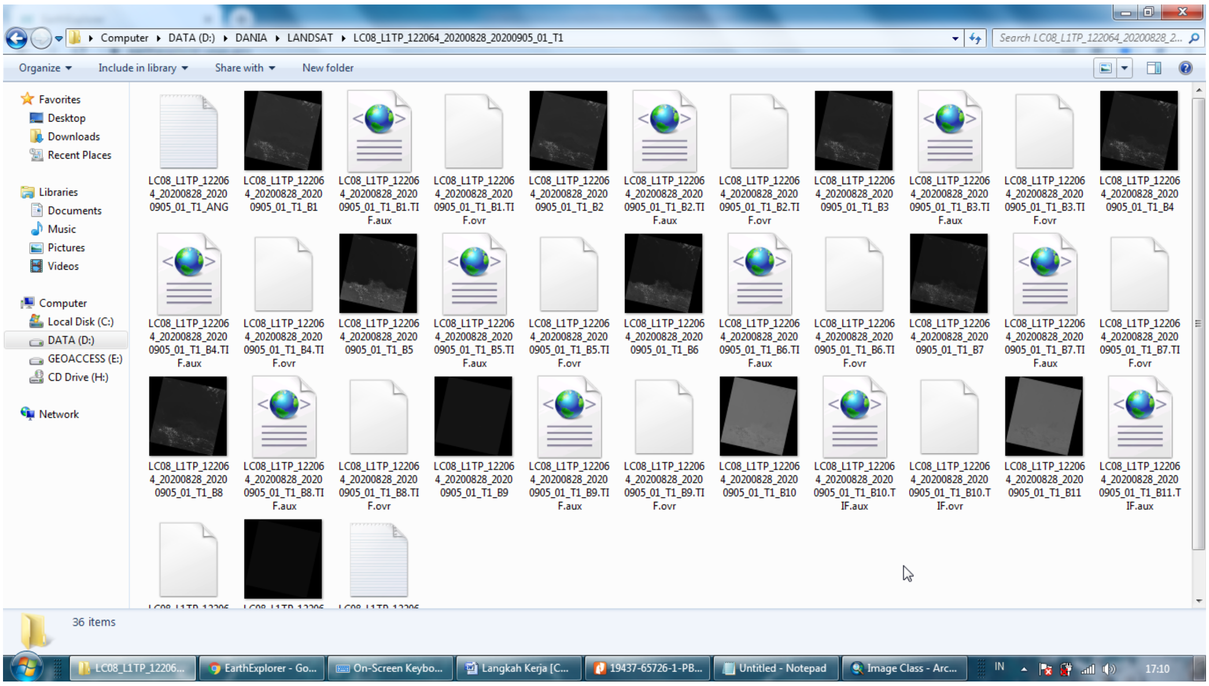
The selection of Landsat image data in this study is because the Landsat image data has a good spatial resolution of 30 meters and a temporal resolution of 16 days so that it is considered sufficient for use in land change. Landsat images in this study were obtained from the United States Geological Survey (USGS).



https://earthexplorer.usgs.gov/



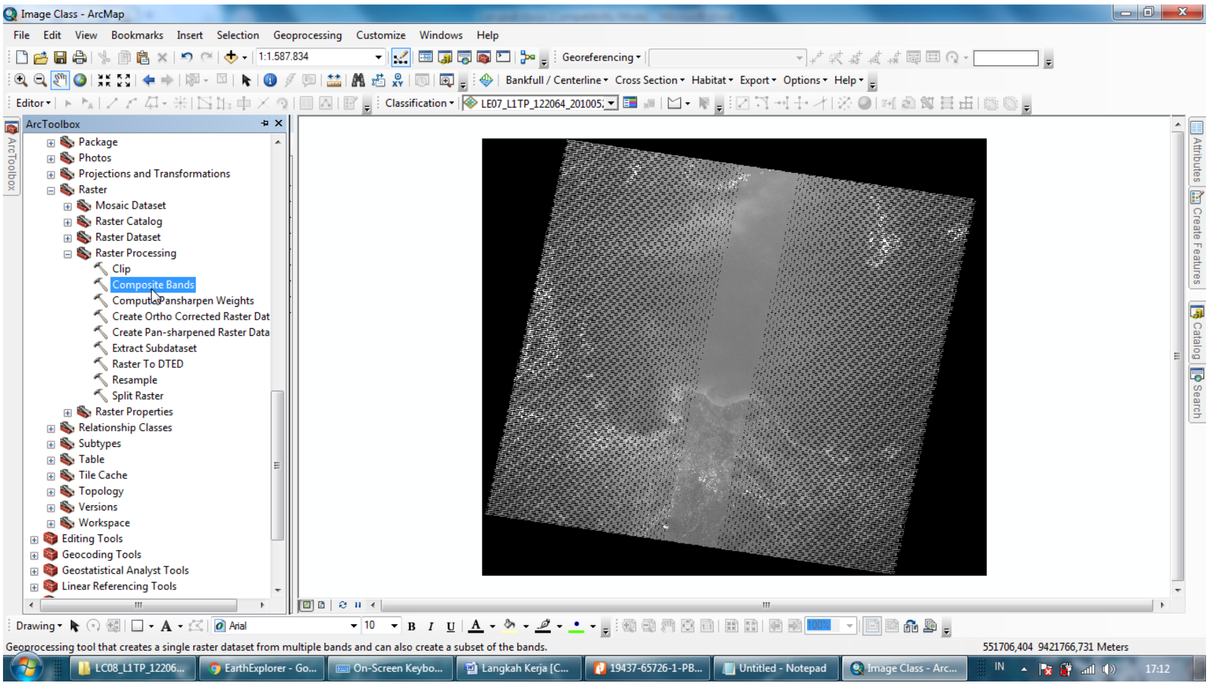
Landsat 7 has 8 Channel Bands [B1-B8]



Landsat 8 has 11 Channel Bands [B1-B11]

c. Land Cover Classification

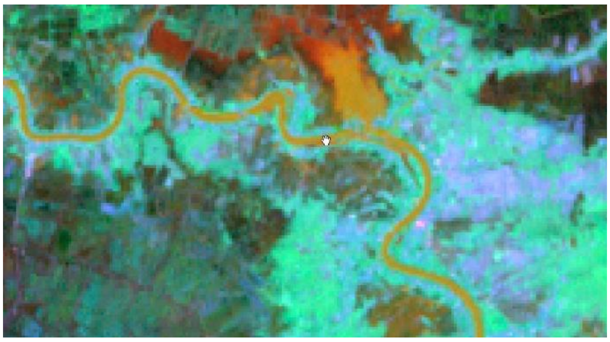
The land cover classification is carried out using the supervised classification method. This method uses a combination of RGB bands (Red, Green, and Blue). This combination of RGB bands is obtained from the composite results of band 1 blue, band 2 green, and band 3 red for Landsat 7 and band 2 blue, band 3 green, and band 4 red for Landsat 8 to get the original color (True Color). The results of the Supervised classification obtain land cover maps according to the Landsat data year.



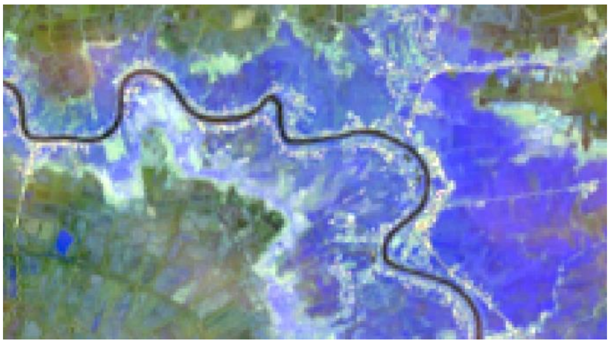
Composite All Channel Bands

True Color can use Composite Band 3,2,1 on Landsat 7

True Color can use Composite Band 4,3,2 on Landsat 8



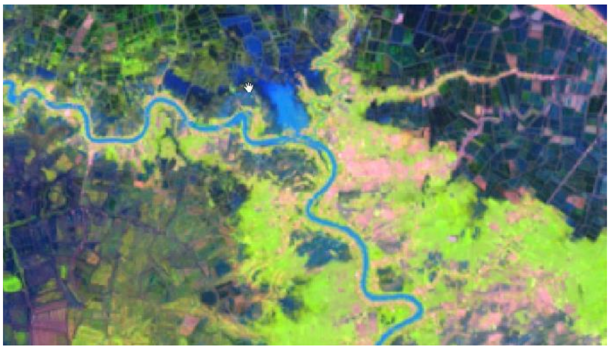
Composite Band 1,4,5 on Landsat 7 with brown color to identify water



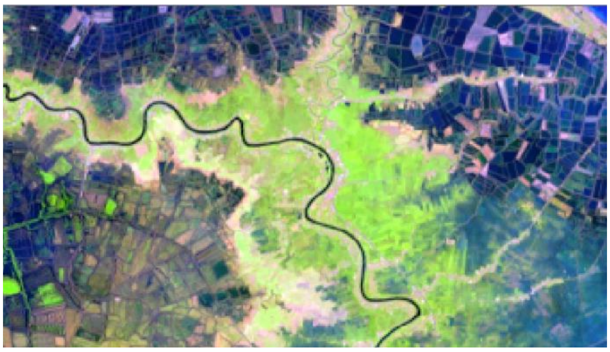
Composite Band 1,4,5 on Landsat 8 with dark brown color to identify water

Composite Band 3,2,1 on Landsat 7 with whitish brown color to identify buildings

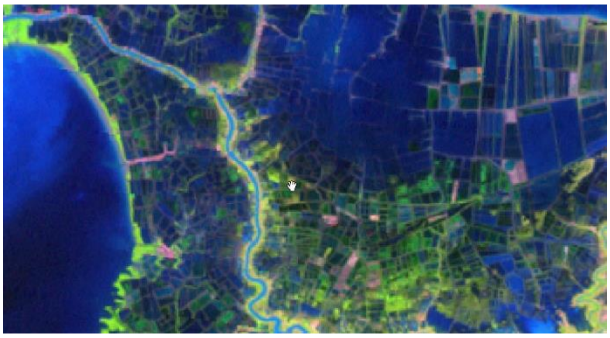
Composite Band 4,3,2 on Landsat 8 with whitish brown to identify Buildings



Composite Band 5,4,3 on Landsat 7 in green to identify agriculture

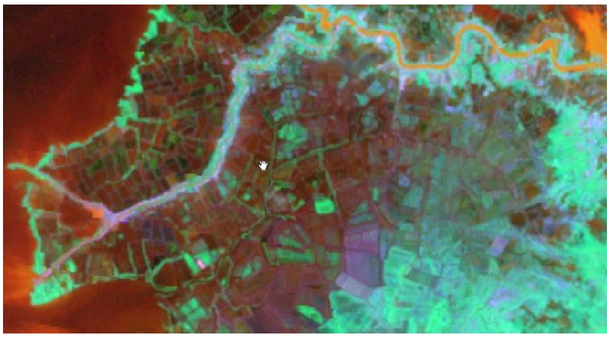


Composite Band 6,5,2 in Landsat 8 in green to identify agriculture



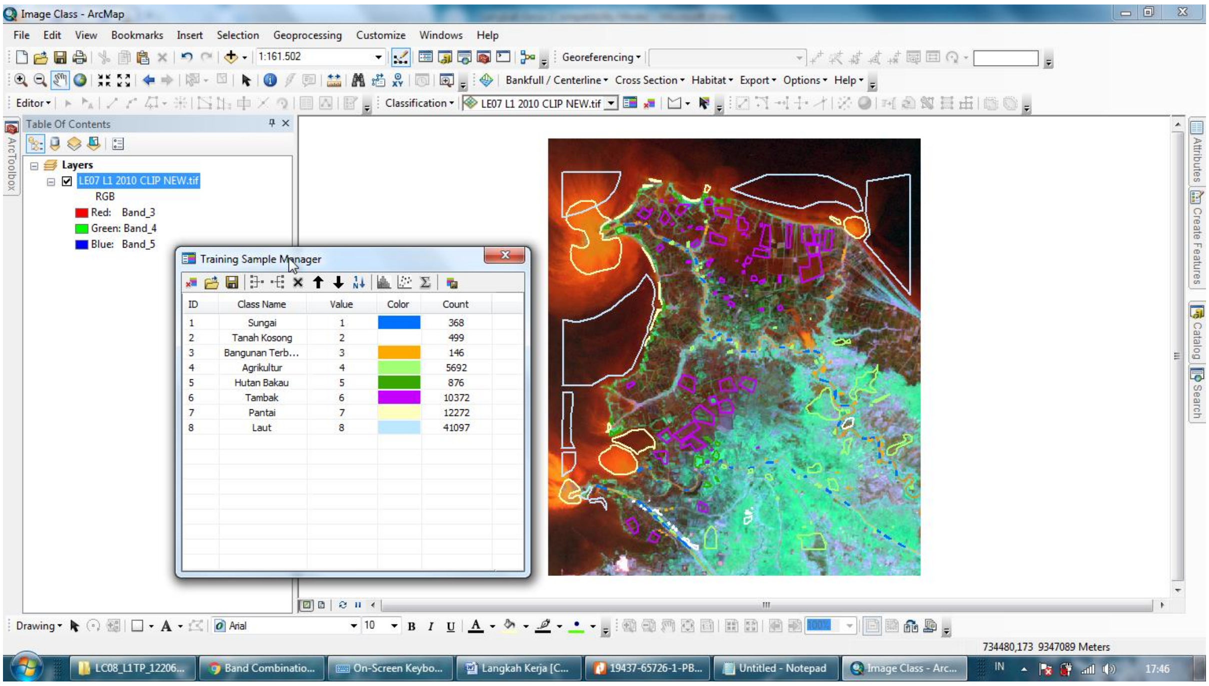
Composite Band 5,4,3 on Landsat 7 with blackish blue color to identify ponds

Composite Band 6,5,2 on Landsat 8 with blackish blue color to identify ponds

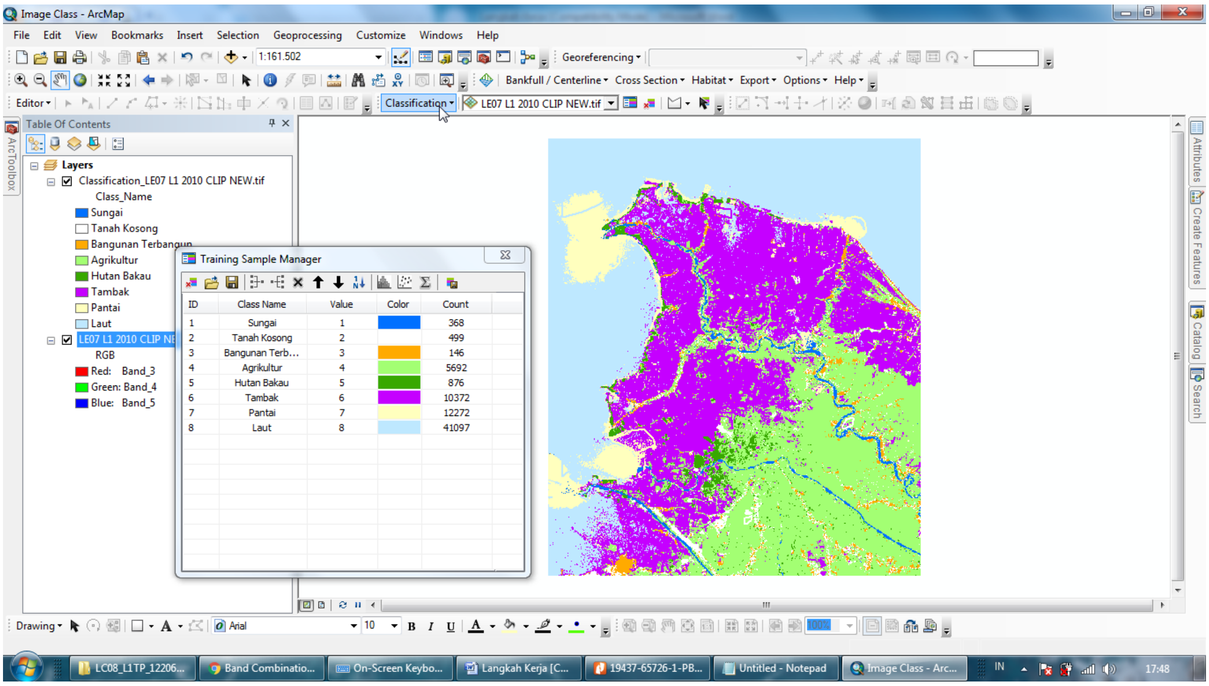


Composite Band 3,4,5 on Landsat 8 with green highlighter to identify mangroves

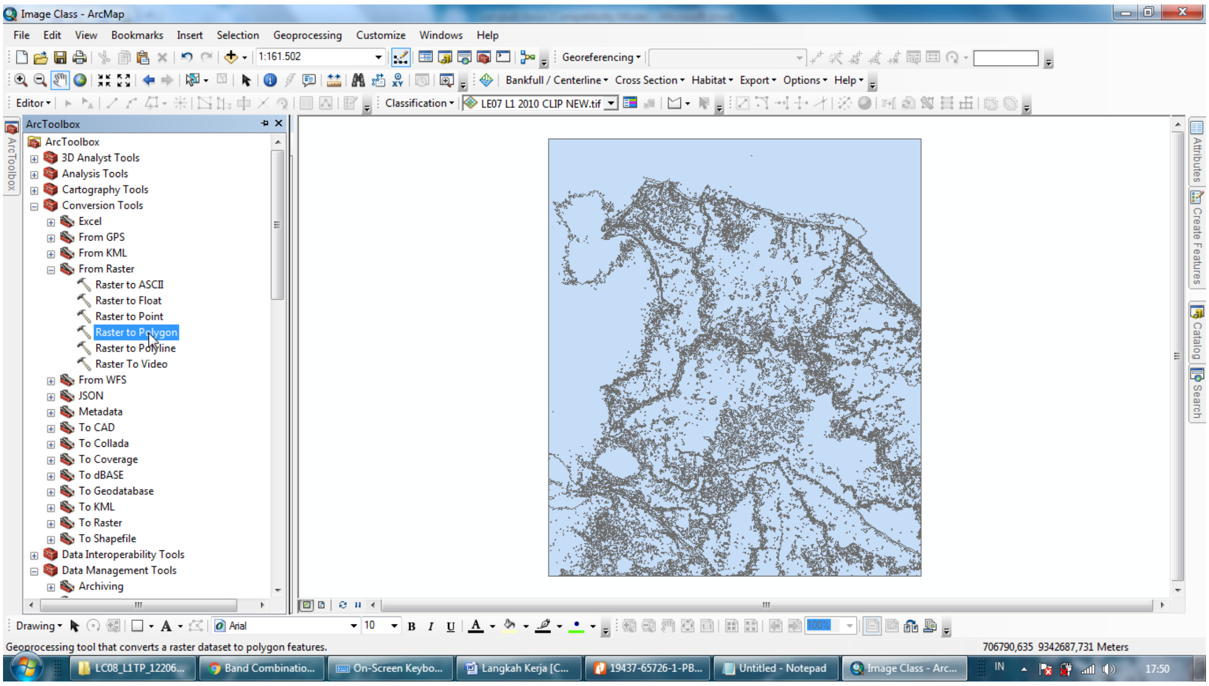
Composite Band 4,5,6 on Landsat 8 with green highlighter to identify mangroves



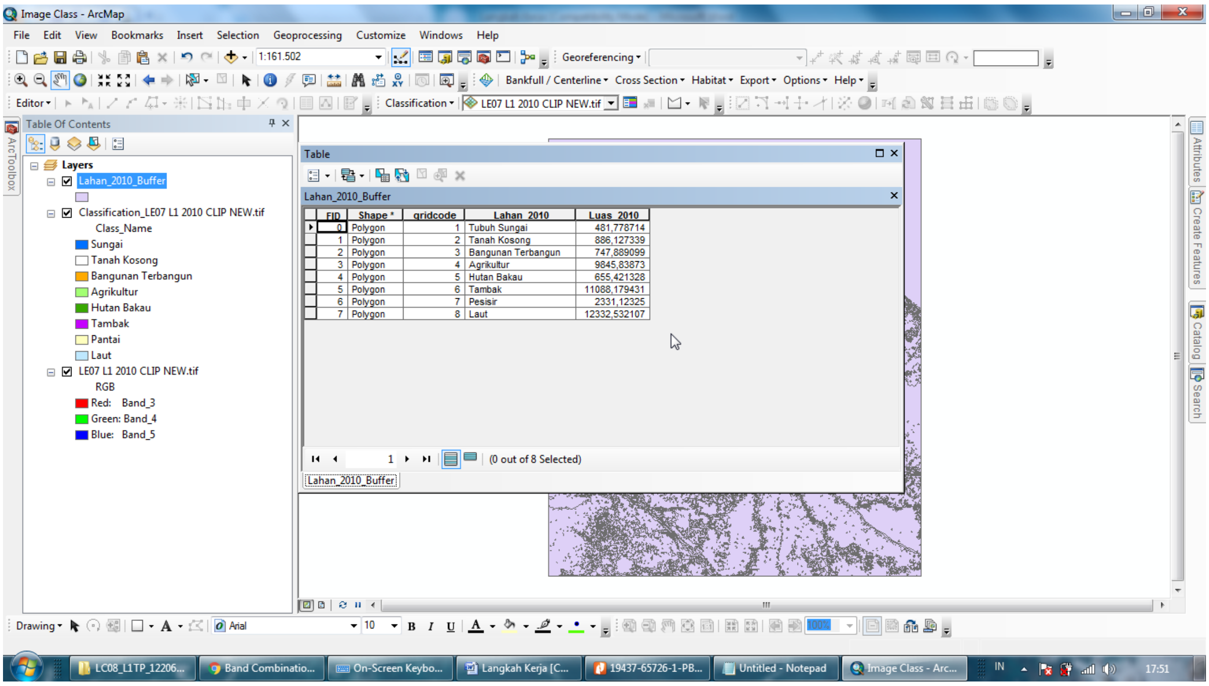
Perform a Training Sample on each land use that has been identified with the help of a composite band.



Land use is automatically classified based on the training sample carried out.



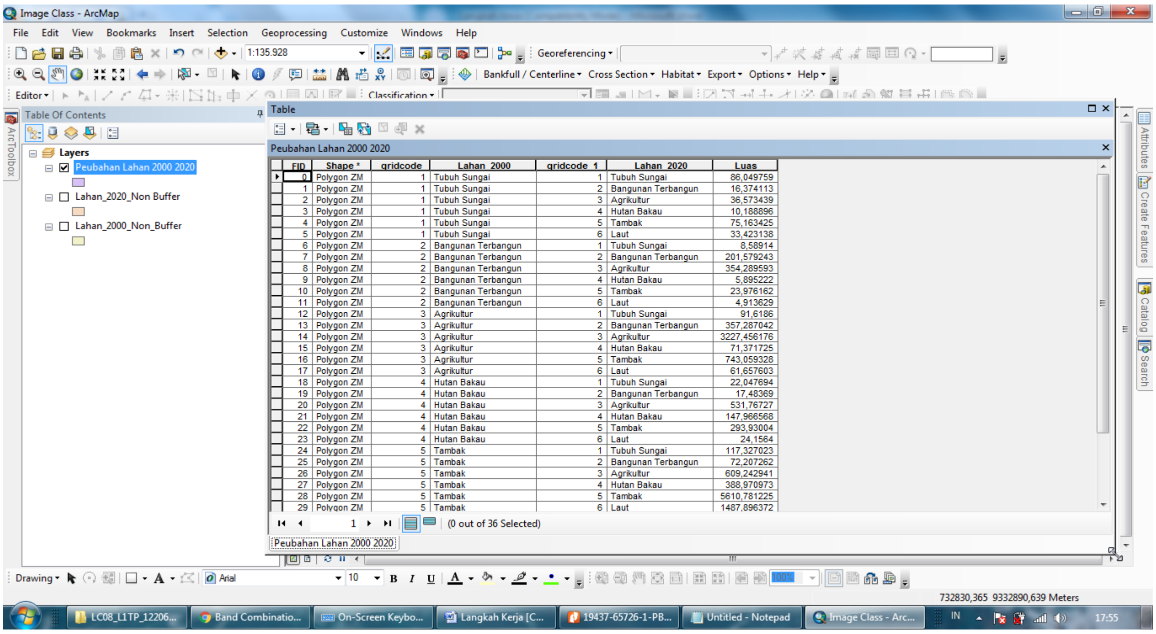
Convert Raster data to Polygon, then dissolve based on the same gridcode value.



Then the total area of each land use can be calculated

d. Seeing Changes in Land Cover

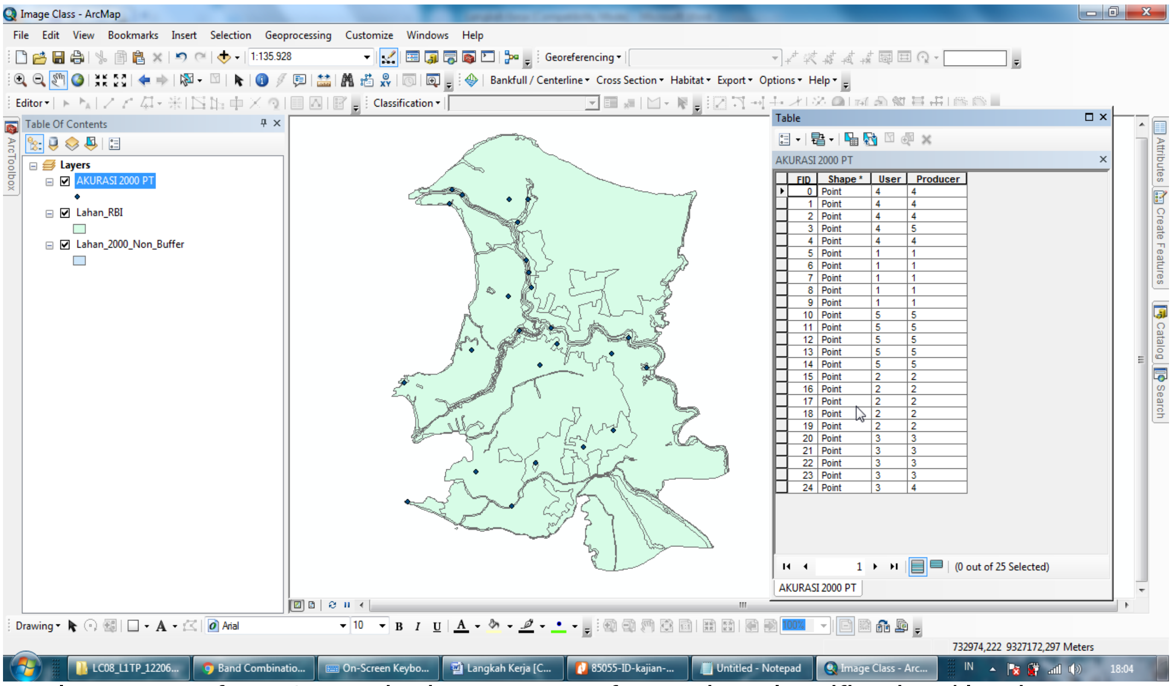
This can be done by conducting Geoprocessing (Union) of the period of land where changes will be known. Suppose that the change in order is



2000 vs 2020.

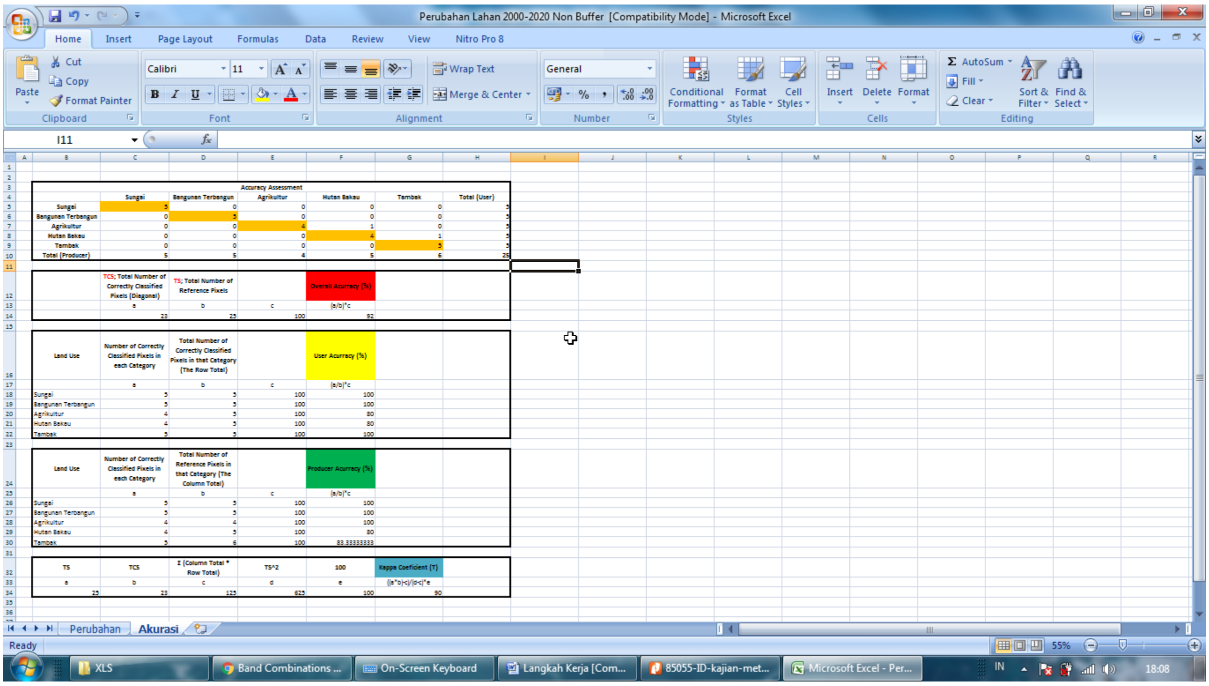
e. Classification Accuracy Assessment Analysis

The classification accuracy test stage is carried out by the accuracy test method using the Kappa coefficient method. The Kappa coefficient



value ranges from 0 to 1, in the process of mapping classification / land cover an acceptable accuracy value is 85% or 0.85 (Anderson, 1976). The Kappa coefficient is based on the consistency of the assessment by considering all aspects, namely producer's accuracy and user accuracy (commission error) obtained from the error matrix or confusion matrix.

Because in this study it was not possible to do a ground check, the data used for the producer test used the RBI Digital Scale 1 map data; 25,000 Edition-1 (1998/200) on the recording of Landsat 7 images in 2000. The accuracy test sample was taken five points randomly across the five identified land uses.


Perubahan Lahan 2000-2020 Non Buffer [Compatibility Mode] - Microsoft Excel
Accuracy Assessment
Perubahan
Akurasi

Questionnaire for Disaster Preparedness

IDENTITY OF THE RESPONDENT

1. Name...M / F
2. Age...
3. Number of dependents : □ 1 □ 2 □ 3 □ 4 □ 5 □ >5
4. Length of stay : □ More than 10 years □ 6 – 10 years □ 1 – 5 years □ 3 – 12 months □ < 3 months
5. Education: □ S1 □ S2 □ D1/D2/D3/D4 □ SMA /SLTA □ Others…………..
6. Occupation : ....

* Tick *checklist* (✓) to the columns provided, regarding your answers

As a respondent on this research, I declare that my answers in this survey are permitted to use by Pramadania Agustine (the Researcher) for her academic purposes only.

.................., ...2020

....

Part 1 Disaster Preparedness

Num	Statements	Strongly Disagree	Disagree	Kinda Disagree	Kinda Agree	Agree	Strongly Agree
1	I know that oil spills can occur due to human negligence and natural phenomena.						
2	Our family has motivation to prepare for an oil spill event						
3	Our families discuss safety measures that can be taken in the event of an oil spill						
4	Every family member knows guidelines regarding emergency response in the event of an oil spill						
5	Our family prepares to provide light medicines that the family can use, such as medicine for fever, diarrhea, flu and cough						
6	Our family provides disaster preparedness bags and supplies which is easy to carry						
7	One of the family members conduct training on disaster preparedness						
8	Our family ensures that they are aware of the signs (signs) of disaster danger by hearing the announcement from officer						
9	We know about sources of information for disaster warning from both traditional and local sources						
10	We have access to Disaster warning information						
11	We have preparedness materials disaster from the government						
12	Our family agreed to conduct an oil spill disaster preparedness simulation exercise						
13	I live in an area prone to oil spills						
14	Our family knows what to do when an oil spill occurs						

Part 1 Disaster Preparedness							
Num	Statements	Strongly Disagree	Disagree	Kinda Disagree	Kinda Agree	Agree	Strongly Agree
15	Keluarga kami tidak berpartisipasi dalam simulasi evakuasi						
16	Every family member has a role to play when the oil spill occurred						
17	Our family believes in an oil spill in the area where we live						
18	Our family prepared the battery reserve for emergency situations						
19	Our family has addresses of important facilities such as hospitals, firefighters, police, PAM, PLN, Telkom						
20	Our family can get information about the disaster from social media						
21	One of the family members attended a seminar on oil spill disaster preparedness						
22	Our family has a means of communication with which to contact family / relatives / friends						
23	Our family has a means of transportation for family evacuation						
24	Our family had an agreement on a place to meet when the oil spill happened						
25	Our family occupies the same house has building standards for areas prone to oil spill disaster						
26	Our family evacuated when a disaster occurs						
27	Our family has relatives / relatives / friends who provide temporary shelter disaster happened						
28	Our family has a practical food supply (no need to cook and it lasts long) to deal with emergencies						
29	Our family does not have telephone numbers for important facilities such as hospitals, fire engines, police, PAM, PLN, Telkom which can be contacted during conditions Emergency						

Part 1 Disaster Preparedness							
Num	Statements	Strongly Disagree	Disagree	Kinda Disagree	Kinda Agree	Agree	Strongly Agree
30	One of the family members has skills related to disaster preparedness						
31	We have savings or savings to deal with emergency conditions when a disaster occurs						
32	Families conduct training and simulation of disaster warning systems						
33	Our family is active in participating in all series of disaster preparedness training and simulations						
34	Our family provides alternative lighting tools for families in times of emergency (flashlights and emergency lamps)						
35	Our family has a first aid kit which is easy to carry						
36	The family has maps, evacuation routes family and family gathering place in case of an oil spill disaster						
37	I understand that shortly before the oil spill there was unusual activity of ships delivering oil or drilling for oil						
38	Our family has a supply of bottled drinks to deal with emergencies						
39	Our family knows that communication tools are needed in an emergency						
40	Our family is looking for information disaster preparedness						
41	Family members are involved in disaster preparedness seminars and training						
42	Our family monitors disaster preparedness bags regularly						

Part 2 Perception of Disaster Risk							
Num	Statements	Strongly Disagree	Disagree	Kinda Disagree	Kinda Agree	Agree	Strongly Agree
1	I think preparing for an oil spill disaster is my responsibility						
2	I feel that preparedness is useless to protect against an oil spill disaster						
3	I feel that science and technology help ensure that we are ready to face oil spill disaster						
4	In my opinion, schools or other community organizations should assist communities in learning preparedness against oil spill disaster						
5	A fate that will decide what I will be like when the oil spill disaster strikes						
6	I feel that planning effective preparedness for oil spill disasters is the responsibility of the government						
7	How much risk is received due to an oil spill disaster depends on what I do to minimize it						
8	I think the bad effects of an oil spill can be reduced with adequate preparation						
9	If an oil spill disaster has occurred recently, it is unlikely that it will happen again soon						
10	I feel that apart from property loss and death, the oil spill disaster has other negative effects						

Part 2 Perception of Disaster Risk							
Num	Statements	Strongly Disagree	Disagree	Kinda Disagree	Kinda Agree	Agree	Strongly Agree
11	I am more worried if the people closest to me are worried about the oil spill disaster						
12	I continued to follow directions from the government during the oil spill disaster even though I didn't understand why						
13	The benefits of preparing for an oil spill disaster outweigh the costs						
14	I feel that scientists agree on how to reduce the catastrophic impact of the oil spill						

SWOT QUESTIONNAIRE

1. State the internal strength factors faced in the management of the coastal area of Muara Gembong:

a.……………………………………………………………………………

b.……………………………………………………………………………

c.……………………………………………………………………………

d.……………………………………………………………………………

e.……………………………………………………………………………

2. State the internal weakness factors faced in the management of the Muara Gembong coastal area:

a.……………………………………………………………………………

b.……………………………………………………………………………

c.……………………………………………………………………………

d.……………………………………………………………………………

e.……………………………………………………………………………

3. State the external opportunity factors faced in the management of the Muara Gembong coastal area:

a.……………………………………………………………………………

b.……………………………………………………………………………

c.……………………………………………………………………………

d.……………………………………………………………………………

e.……………………………………………………………………………

4. State the external threat factors faced in the management of the coastal area of Muara Gembong:

a.……………………………………………………………………………

b.……………………………………………………………………………

c.……………………………………………………………………………

d.……………………………………………………………………………

e.……………………………………………………………………………

AHP Questionnaire

1. In the context of Coastal Zone Management to protect the coastal area of Muara Gembong from oil pollution, according to you, which actor is more important?

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column								Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	
Local Government																		NGO
Local Government																		Akademisi
Local Government																		Masyarakat
Local Government																		Pengelola Pariwisata
NGO																		Academics
NGO																		Coastal residents
NGO																		Tourism Manager
Academics																		Coastal residents
Academics																		Tourism Manager
Coastal residents																		Tourism Manager

2. In the context of Coastal Zone Management to protect the Muara Gembong coastal area from oil pollution, according to you, which aspect of management is more important related to the Local Government?

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column								Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	
Fishery Business																		Transportation
Fishery Business																		Conservation
Fishery Business																		Tourism
Transportation																		Conservation
Transportation																		Tourism
Conservation																		Tourism

3. In the context of Coastal Zone Management to protect the coastal area of Muara Gembong from oil pollution, according to you, which aspects of management are more important related to NGOs

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column								Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	
Fishery Business																		Transportation
Fishery Business																		Conservation
Fishery Business																		Tourism

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column								Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	
Transportation																		Conservation
Transportation																		Tourism
Conservation																		Tourism

4. In the context of Coastal Zone Management to protect the coastal area of Muara Gembong from oil pollution, according to you, which aspects of management are more important related to academics?

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column								Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	
Fishery Business																		Transportation
Fishery Business																		Conservation
Fishery Business																		Tourism
Transportation																		Conservation
Transportation																		Tourism
Conservation																		Tourism

5. In the context of Coastal Zone Management to protect the coastal area of Muara Gembong from oil pollution, according to you, which management aspect is more important related to Coastal Residents?

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column								Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	
Fishery Business																		Transportation
Fishery Business																		Conservation
Fishery Business																		Tourism
Transportation																		Conservation
Transportation																		Tourism
Conservation																		Tourism

6. In the context of Coastal Zone Management to protect the coastal area of Muara Gembong from oil pollution, according to you, which aspect of management is more important related to tourism management?

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column								Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	
Fishery Business																		Transportation
Fishery Business																		Conservation

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column								Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	
Fishery Business																		Tourism
Transportation																		Conservation
Transportation																		Tourism
Conservation																		Tourism

7. In the context of Coastal Zone Management to protect the coastal area of Muara Gembong from oil pollution, according to you, which management aspect is more important related to fisheries business?

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column								Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	
Increased Synergy and Coordination between related parties																		Optimization of related technology devices
Increased Synergy and Coordination between related parties																		Improvement of guidance, supervision and control mechanisms

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column								Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	
Optimization of related technology devices																		Improvement of guidance, supervision and control mechanisms

8. In the context of Coastal Zone Management to protect the Muara Gembong coastal area from oil pollution, according to you, which management aspect is more important related to transportation?

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column								Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9	
Increased Synergy and Coordination between related parties																		Optimization of related technology devices
Increased Synergy and Coordination between related parties																		Improvement of guidance, supervision and control mechanisms

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column									Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9		2	3	4	5	6	7	8	9	
Optimization of related technology devices																			Improvement of guidance, supervision and control mechanisms

9. In the context of Coastal Zone Management to protect the Muara Gembong coastal area from oil pollution, according to you, which management aspect is more important related to conservation?

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column									Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9		2	3	4	5	6	7	8	9	
Increased Synergy and Coordination between related parties																			Optimization of related technology devices
Increased Synergy and Coordination between related parties																			Improvement of guidance, supervision and control mechanisms

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column									Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9		2	3	4	5	6	7	8	9	
Optimization of related technology devices																			Improvement of guidance, supervision and control mechanisms

10. In the context of Coastal Zone Management to protect the coastal area of Muara Gembong from oil pollution, according to you, which management aspect is more important related to tourism?

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column									Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9		2	3	4	5	6	7	8	9	
Increased Synergy and Coordination between related parties																			Optimization of related technology devices
Increased Synergy and Coordination between related parties																			Improvement of guidance, supervision and control mechanisms

Left column	Left and Right Coloumn Equally important	Fill in if the ACTOR in the Left Column is more important than the ACTOR in the Right Column									Fill in if the ACTOR in the Right Column is more important than the ACTOR in the Left Column								Right Coloumn
	1	2	3	4	5	6	7	8	9		2	3	4	5	6	7	8	9	
Optimization of related technology devices																			Improvement of guidance, supervision and control mechanisms

JK	J	LT	Pen	KB1	KB2	KB	KB	K	KI	K	KI	K	KI	K	K	KI	KI	K	K	K	KI	KB	KI	K	KI	KI	K	K	K	KE	KE	KI	K	K	K	KI	KE	KB	K	KE	K	KI	KE	KB	KE	PR	PR	PF	PI	P	PF	P	PI	PI	PI	PR	PF	PI	PI
1	1	1	4	4	4	4	4	4	2	4	4	3	2	2	4	4	3	2	3	4	3	3	4	3	4	3	2	2	3	4	1	4	2	2	3	2	4	4	1	2	4	4	3	3	2	3	2	4	6	4	2	2	4	3	5	4	6	4	2
1	1	1	4	5	5	3	2	4	3	2	3	4	4	3	3	5	3	3	3	4	3	4	4	3	4	4	3	2	4	4	2	3	3	2	4	3	5	3	2	3	2	4	3	4	3	5	3	4	5	4	6	4	6	3	4	4	4	4	4
1	4	2	5	3	5	4	3	4	3	4	4	4	3	2	3	5	3	3	3	4	2	4	3	4	5	4	3	3	4	4	1	3	3	1	3	4	5	2	2	2	3	4	2	2	3	2	3	4	5	4	2	4	6	3	4	3	4	4	4
1	4	1	5	3	3	4	4	4	4	2	2	4	4	3	4	4	3	3	3	5	4	4	4	2	5	5	3	1	5	4	1	3	2	4	2	2	4	2	3	2	4	4	3	3	2	3	2	4	4	4	3	4	4	4	4	4	5	4	4
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2	2	1	5	4	4	3	3	3	2	4	3	4	3	3	4	4	3	3	3	4	3	3	4	2	4	2	3	2	4	4	1	4	3	2	3	2	4	4	1	3	3	4	3	3	2	4	2	4	4	4	2	3	6	3	5	4	4	3	3
2	2	1	5	5	3	4	3	3	2	3	4	4	2	4	3	4	3	2	3	3	2	3	4	3	3	2	2	2	4	5	3	4	2	3	3	2	4	3	3	2	3	3	3	3	2	4	2	4	4	4	2	4	4	2	5	4	6	4	2
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2	3	2	5	4	5	5	4	4	3	3	3	3	3	3	2	4	4	3	2	5	3	4	3	2	4	4	3	3	4	5	1	3	3	2	3	3	4	4	2	1	4	4	4	2	2	3	2	5	4	5	6	4	5	3	4	3	5	4	4
1	3	1	4	3	4	4	2	4	2	2	5	4	4	4	4	5	3	3	3	4	1	2	2	2	4	2	2	3	3	4	1	5	2	2	3	2	5	2	1	2	3	4	3	3	3	4	3	4	5	4	6	3	6	1	6	5	4	3	5
1	2	1	5	5	3	4	4	3	2	3	4	4	2	3	3	4	2	3	3	4	3	3	3	4	4	3	3	2	4	4	2	4	2	2	3	2	4	3	3	2	4	3	3	3	2	2	2	4	6	4	4	3	4	4	5	3	4	4	4
2	3	1	5	3	3	3	3	3	2	4	4	3	3	3	4	4	3	3	3	4	4	3	3	3	4	3	3	2	5	4	3	4	3	2	4	2	4	2	3	3	3	4	3	3	2	4	2	4	4	4	3	3	4	2	5	3	6	4	4
1	3	1	4	5	3	4	4	4	2	3	4	4	4	4	3	4	3	3	3	4	4	4	4	3	4	3	2	1	5	5	1	3	2	2	4	2	4	3	3	2	4	4	3	3	2	3	2	6	4	3	3	2	4	2	4	4	4	4	5
1	2	2	5	5	4	4	2	4	2	4	4	4	4	3	3	4	2	3	3	4	3	4	5	4	6	4	3	2	5	5	1	3	3	3	3	2	4	3	1	2	4	4	3	3	2	2	2	4	4	4	2	4	4	2	4	5	4	4	4
1	1	1	4	4	4	4	3	5	3	4	3	5	3	2	3	5	4	3	3	4	3	3	3	3	4	2	2	2	4	4	1	4	3	2	3	3	5	4	1	2	3	4	2	3	3	5	3	4	5	4	5	4	6	3	5	3	6	3	2
1	2	2	5	5	4	4	2	4	4	3	4	3	2	4	4	4	3	3	3	5	2	3	3	2	5	3	2	1	5	4	3	4	2	1	2	2	4	3	1	2	4	4	3	3	2	3	2	4	4	4	2	4	4	5	5	5	5	5	5
1	1	1	5	5	4	3	3	4	2	2	2	5	2	3	3	4	4	3	3	5	3	4	4	2	4	2	2	3	4	4	3	3	2	2	2	2	4	3	1	3	4	4	3	3	2	5	2	4	6	4	2	4	4	3	4	4	5	5	4
1	4	2	3	5	4	4	2	3	3	3	4	4	2	3	2	4	2	2	2	4	2	4	3	3	4	4	3	1	4	5	1	3	2	2	3	4	4	3	1	2	4	5	2	2	2	4	2	5	4	5	3	5	5	2	4	3	4	4	4
1	4	2	5	3	4	2	3	4	4	4	4	4	4	4	3	4	3	3	3	4	4	2	3	2	4	3	3	2	4	4	3	5	2	2	3	2	4	2	1	2	4	4	3	3	2	3	2	4	4	4	4	3	4	4	4	3	4	3	3
1	1	1	4	5	5	4	3	4	3	2	4	4	2	3	2	5	3	3	2	4	2	4	3	4	5	2	2	2	4	6	2	3	2	1	3	2	5	3	2	2	4	4	3	3	3	2	3	5	5	5	4	3	4	2	5	5	5	3	3
2	3	2	3	3	4	4	3	3	2	3	4	5	5	2	4	4	3	3	3	3	3	4	3	3	4	2	3	2	5	5	3	3	5	4	3	2	4	2	4	2	4	3	3	3	2	5	2	4	6	4	2	3	4	3	6	4	6	3	3

Respondent 1

Compare the relative importance with respect to: Goal: The Management Strategies to Protect Coastal Area in Muara Gembong from Oil-Polluted Seawater

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Local Government	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Non-Governmental O
2	Local Government	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Academics
3	Local Government	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Coastal Residents
4	Local Government	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tourist Area Manage
5	Non-Governmental O	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Academics
6	Non-Governmental O	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Coastal Residents
7	Non-Governmental O	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Tourist Area Manage
8	Academics	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Coastal Residents
9	Academics	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Tourist Area Manage
10	Coastal Residents	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourist Area Manage

Compare the relative preference with respect to: Local Government (L: .584)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Non-Governmental Organization (NGO) (L: .090)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Academics (L: .205)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	**9**	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	**9**	Conservation
5	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
6	Conservation	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Coastal Residents (L: .064)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Tourist Area Manager (L: .057)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Fishery Business (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Optimization of relate
2	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis
3	Optimization of relate	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis

Compare the relative preference with respect to: Sea Transportation (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Optimization of relate
2	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis
3	Optimization of relate	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis

Compare the relative preference with respect to: Conservation (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Optimization of relate
2	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis
3	Optimization of relate	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	**9**	The control mechanis

Compare the relative preference with respect to: Tourism (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Optimization of relate
2	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis
3	Optimization of relate	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis

Respondent 2

Compare the relative importance with respect to: Goal: The Management Strategies to Protect Coastal Area in Muara Gembong from Oil-Polluted Seawater

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Local Government	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Non-Governmental O
2	Local Government	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Academics
3	Local Government	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Coastal Residents
4	Local Government	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tourist Area Manage
5	Non-Governmental O	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Academics
6	Non-Governmental O	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Coastal Residents
7	Non-Governmental O	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourist Area Manage
8	Academics	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Coastal Residents
9	Academics	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Tourist Area Manage
10	Coastal Residents	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourist Area Manage

Compare the relative preference with respect to: Local Government (L: .468)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	**6**	7	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	**8**	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	**8**	9	Tourism
4	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Non-Governmental Organization (NGO) (L: .136)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Conservation
5	Sea Transportation	9	8	7	6	5	4	3	2	1	2	3	4	5	**6**	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism

Respondent 3

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Local Government	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Non-Governmental O
2	Local Government	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Academics
3	Local Government	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Coastal Residents
4	Local Government	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tourist Area Manage
5	Non-Governmental O	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Academics
6	Non-Governmental O	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Coastal Residents
7	Non-Governmental O	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Tourist Area Manage
8	Academics	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Coastal Residents
9	Academics	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Tourist Area Manage
10	Coastal Residents	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Tourist Area Manage

Compare the relative preference with respect to: Local Government (L: .567)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Tourism
4	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Non-Governmental Organization (NGO) (L: .169)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	7	**6**	5	4	3	2	1	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Academics (L: .151)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Coastal Residents (L: .033)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Tourist Area Manager (L: .081)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Academics (L: .277)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Coastal Residents (L: .051)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	**6**	7	8	9	Tourism
4	Sea Transportation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Tourist Area Manager (L: .068)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Sea Transportation
2	Fishery Business	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Conservation
3	Fishery Business	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Tourism
4	Sea Transportation	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Conservation
5	Sea Transportation	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tourism
6	Conservation	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Tourism

Compare the relative preference with respect to: Sea Transportation (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Optimization of relate
2	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis
3	Optimization of relate	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	**9**	The control mechanis

Compare the relative preference with respect to: Fishery Business (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Optimization of relate
2	Synergy & coordinatio	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	The control mechanis
3	Optimization of relate	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis

Compare the relative preference with respect to: Conservation (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Optimization of relate
2	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis
3	Optimization of relate	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis

Compare the relative preference with respect to: Tourism (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	**9**	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Optimization of relate
2	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanis
3	Optimization of relate	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	**9**	The control mechanis

Compare the relative preference with respect to: Fishery Business (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Optimization of relatec
2	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanisı
3	Optimization of relatec	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	The control mechanisı

Compare the relative preference with respect to: Sea Transportation (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Optimization of relatec
2	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanisı
3	Optimization of relatec	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	The control mechanisı

Compare the relative preference with respect to: Conservation (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Optimization of relatec
2	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanisı
3	Optimization of relatec	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	The control mechanisı

Compare the relative preference with respect to: Tourism (L: .250)

Circle one number per row below using the scale:
1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

1	Synergy & coordinatio	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Optimization of relatec
2	Synergy & coordinatio	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	The control mechanisı
3	Optimization of relatec	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	The control mechanisı

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