Land Suitability Analysis of Over the Horizon Surface Radar for Sea Defense using Geographic Information System

F Kurniawan1*, R O Bura1,2* and A A Lestari1

1Faculty of Defense Technology, Indonesia Defense University, Bogor, Indonesia
2Faculty of Mechanical and Aerospace Engineering, Bandung Institute of Technology, Bandung, Indonesia

*Corresponding author : Romie Oktovianus Bura (romiebura@idu.ac.id), kurnfajar@gmail.com

Abstract. Study of Land suitability using Geographic Information Systems (GIS) is a way to determine the location for many fields, including in the defense field. The Sunda Strait is part of the international shipping route where there are several cases of international smuggling in this region, so that it becomes a concern for Indonesia defense. The concept of marine defense by applying Radar is something must be done at this time. Over The Horizon (OTH) Surface Radar is a type of High-Frequency (HF) radar with a detection distance that goes beyond the earth horizon. Research on OTH Surface Radar Placement is something that can be done at this time, considering Indonesia has not applied it at this time. The method used in this study is to determine the best placement by comparing the parameters of two types of OTH Surface Radar that have been used in other countries to determine the criteria of placement parameters. The analysis process will use the Analysis Hierarchy Process (AHP) by determining the importance of the parameters for OTH Surface Radar Land Suitability. The GIS process is carried out using the Overlay method which is used to determine the suitability based on a matrix of geographic parameters obtained between weight and class. The result is one suitable location to be the main area in the placement of OTH Surface radars for defense in the Sunda Strait located in the district of Pulo Merak, Serang Regency.

1. Introduction

Geographic Information System (GIS) is a manual or computer system used to collect, store, manage, and produce information that has spatial or geographic references[1]. The use of GIS has been widely applied at this time. Land suitability using GIS will facilitate the processing of spatial data in the form of earth shape data. The IASL (International Archipelago Sea Lines) concept aims to fulfill Indonesia's interests in the security and sovereignty of its territorial waters, as well as provide opportunities for foreign vessels to exercise the rights of archipelagic sea lanes [2]. So, if the cruise on the Sunda Strait is hampered by threats, it will certainly have an impact on the economy of Indonesia and other countries. Fish theft, drug smuggling, human trafficking, and others are real threats that exist in IASL as International Cruise line.

The Sea Surface radar is something that should be a concern for Indonesia, especially to oversee the Sunda Strait which is a National Vital Object because it involves the nation's economy. The use of sea surface radar is one form of efficiency in the form of regional security operations by reducing the cost of field operations and is increasing ability from sea safeguards. Radar for Indonesia currently has an important role in the National Defense and Security Tool. Radar Over the Horizon Surface is a
radar that can be applied in Indonesia at this time, operates with High Frequency (HF) electromagnetic wave frequencies between 1-30 MHz [3]. Research on land suitability for OTH Surface Radar is important to defense study in Indonesia, with the aim of a recommendation to optimize the ability and efficiency when it has been applied in Indonesia.

2. Research methods

2.1. Research methods
The type of method used in research is through a quantitative approach obtained from literature studies and spatial analysis by utilizing Geographic Information Systems (GIS). While the parameters used will be sourced from the study of Radar Placement according to Rudolph in Domenikiotis (2010) which divides Radar placement into two placement criteria, Strategic and Tactical / Local. Strategic criteria are a form of placement based on radar requirements to function optimally, such as the required distance and distance to energy facilities. Whereas Tactical or Local Criteria are chosen based on their ability to know the shape of the object and the geography of the area under study[4].

To overcome the limitations to obtain OTH Surface Radar data that has not been applied in Indonesia, then the comparison of OTH Surface Radar that has been applied in other countries will be the basis for determining the range of placement parameters for OTH Surface Radar. Radar placement data in other countries obtained from literature studies will be projected on Google Earth to determine the shape of the parameters to be searched. The process in making Radar land suitability maps through three stages including data collection, processing, and geospatial analysis through overlapping methods. The overlay technique itself is a GIS technique to obtain the best area by combining regional data parameters with a base score in a predetermined class, the research sample is used is in the western region of sub-district Banten Province which borders with the Sunda Strait.

2.2. Data collection
The following are the data obtained for analysis.

- DEM and Satellite Imagery Processed by BIG (Geospatial Information Agency)
- Coordinates of OTH Surface Radar coordinates in other countries from the literature study
- Images of OTH Surface Radar in other countries Analysis from Google Earth

2.3. Data analysis
The analysis process begins by determining the area with the lowest distance range between Banten Province and Lampung Province, on the basis that the region will definitely be passed by ships on a voyage. This process is used for the efficiency of the research area in Banten Province. The next analysis is to determine parameters based on the application of OTH Radar in other countries. The results obtained will be in the form of a parameter matrix to determine the required Radar capability in the Sunda Strait. The next process is Spatial Analysis in the form of Regional Stage Analysis and Land Suitability Analysis.

![Figure 1. Data Flow Analysis.](attachment://data_flow_analysis.png)
The analysis will use the parameters that have been obtained (Figure 1). Data analysis method used is spatial analysis. Spatial Analysis is the use of maps containing Earth's spatial data processed through GIS Application with the required parameters. These parameters are obtained from the processed Radar area which is applied in other countries as well as from literature studies for existing parameters. The data is then analyzed by overlaying to produce new spatial data. This overlay technique will be used in the determination of local criteria related to surface geography namely spot height, land use, and slope. The results of this process will produce a display area that matches for OTH Surface Radar criteria. The results will be re-evaluated with parameters in the last hierarchy to determine the most suitable area.

3. Results and discussion

3.1. Analysis of the OTH Surface Radar Comparison

Criteria for the type of OTH Surface Radar that became the comparison were obtained through observations of literary studies to obtain 2 types of OTH Surface Radar as a comparison, namely Wellen Radar (WERA) and Coastal Ocean Dynamics Application Radar (CODAR) in 4 different locations. WERA and CODAR radars were chosen because they are commercial OTH Surface radars and are radars included in the United States integrated surveillance system program [5]. To get the geographical parameters of the placement of the radars, the process is carried out using Google Earth to search based on map coordinates and comparison of images obtained from literature studies.

Due to limited image resolution and the possible confidentiality of Radar placement when accessed through Google Earth. Then, to determine the fix location of the Radar, a ring buffer with a diameter of 1 km is carried out with continued analysis to obtain the maximum height and slope range in the area. This buffer is based on the Decree of the Director-General of Civil Aviation Number SKEP / 113 / VI / 2002 relating to the Criteria for Placement of Aviation Electronics and Electrical Facilities in the Chapter of ATC Radar Placement Standard in Point A, which say the area of land needed to build a radar equipment, tower / radar antenna and other supporting facilities of at least 100 m x 100 m [6].Criteria from 4 Radar locations for comparison have been analyzed through Google Earth and obtained the results of geographic parameters that are combined with the results of parameters in the literature study. So, this is the result of a comparison Radar Over the Horizon Surface.

| Radar Type | Location | Antenna | Coverage | Max Height | Average Slope |
|------------|----------|---------|----------|------------|---------------|
| WERA       | Spanyol (Cabo-Torres & Cabo Penas) | 2 x 16 Channels (Tx – Rx) | 50 Km | 105 m & 104 m | 7.2% - 7.3% & 8.7% - 9% |
| WERA       | Ingris (Cornwall Coast) | 2 x 16 Channel (Tx – Rx) | 110 Km | 73 m | 4.3% - 5.5% |
| CODAR      | Amerika Serikat (Cape Hatteras) | 1 x 12 Channels | 12 Km | 6 m | 1 – 0.8% |
| CODAR      | Amerika Serikat (Leffis Key & Blind Pass) | Tx – Rx | 73 Km | 6 m & 3 m | 8.7% - 9% & 0.6% - 0.8% |

3.2. Analysis of the distance required by the study area

Operational Coverage will be the determining factor for determining the best OTH Surface Radar type with regional conditions in Banten based on the Radar criteria obtained from the comparison table (Table 1). Reach distances are analyzed through the Geographic Information System by providing a point at the farthest region in the Sunda Strait, then drawn lines connecting with each other so as to produce new polygons.
To determine the best range of distance from the OTH Surface Radar with the criteria for the area closest to Java and Sumatra. So the way to do this is to project polygons from the farthest regions of the Sunda Strait[7]. Polygon projection is done by ignoring the point of Tanjung Guha Kolak which is done to produce an area of a polygon that covers the entire land area on the outskirts of Banten. The projected polygons are separated through lines facing 135° with a separation distance of about 29-30 km to produce 5 lines, from the results of these projections, it is found that lines 1 and 2 are the areas with the narrowest distance between the islands of Sumatra and Java with a distance of 25 - 50 km.

Based on the distance range needed, it can be concluded that from the 4 types of radar that became a comparison, only one area that did not meet the qualifications was the WERA Radar placed on the Cornwall Coast because the range was only 12 km. The research area will also be narrowed based on the results of the analysis so that the focus of the research is in 2 cities, Cilegon and Serang Regency, with 6 districts.

3.3. Analytical hierarchy process
Analytical Hierarchy Processing this research was carried out to get priority weights from Radar parameters. The results of the analysis are obtained from the assessment of experts or individuals who understand and are involved in determining the location of the OTH Surface Radar. AHP functions in this research especially in overlay techniques that require the value of the results from the class and parameter weights. This analysis uses expert choice 11 software to simplify the process of determining parameter weights. Assessment through individuals certainly has limitations in stating perceptions consistently, especially if compared to many elements. Consistency in AHP is needed because it is in line with the concept of transitivity in the analysis of preferences (utilities). to overcome the consistency value that is too high, the calculation in AHP will be based on the formula of Consistency Ratio

![Figure 2. Line of Distance required.](image)

Figure 2 above is the processing result of AHP which is used to determine the weight of Parameter in Radar OTHS where the sea distance is the parameter with the highest weight.
3.4. Regional stage analysis
Regional stage analysis is a physical analysis of geographic carried out to determine the geographic characteristics in the study area [8]. Based on the analysis obtained from the comparison of the radars that have been applied, the Spotheight, Accessibility and Sea Distance for the Parameter Matrix is obtained which is a combination of literature studies and analysis results. The parameters of land cover are obtained from the Frame Work of Land Evaluation (1976) theory [9]. While the slope based on the study of slope class interpretation is classified based on the theory of Van Zuidam (1985) [10]. In below is the parameter matrix of the regional analysis shown.

**Table 2. Parameter Matrix of Regional Analysis.**

| Parameter       | S1 (Very Suitable)                                      | S2 (Suitable)                              | S3 (Enough)                              | N (Not Suitable)                             |
|-----------------|---------------------------------------------------------|--------------------------------------------|------------------------------------------|---------------------------------------------|
| Land Use        | Dry land, bush, savanna, vacant land                    | Plantation, dry land agriculture, mixed bush farming, rice fields | Settlement                               | Pond and Grow Water, Forest                 |
| Height          | 51 - >100 m                                            | 26 – 50 m                                  | 6 – 25 m                                 | 0 – 5 m                                    |
| Slope           | 0 – 2% Flat & Almost Flat                              | 2 – 7% Almost tilted                       | 7 – 15% Tilted                           | 15 - 30% Steep                             |
| Sea Distance    | 0 – 500 m                                              | 500 m – 1 Km                              | 1 Km – 3 Km                              | >3 Km                                      |
| Road Accessibility | 0 – 500 m                                              | 500 m – 1 Km                              | 1 Km – 1.5 Km                           | >1.5 Km                                   |

The Spot height map is made from Dem data that is processed using a grid with a distance between 0.8 km from the vertical point and Horizontal point 0.5 km. land use is generated from the RBI Data and slop is generated from DEM data. Figure 3 below is the Class Analysis Result of the three parameters overlay using Intersect to produce a new spatial value from the parameter.

![Figure 4. Results of Regional Analysis Overlay.](image-url)
3.5. Land suitability analysis of radar over the horizon surface

Land suitability analysis for the location from Radar Over the Horizon Surface is a combination of topography, sea distance, accessibility and spotheight parameters. The result in Figure 4 is the region with the highest suitability value based on the results of the overlay analysis of the study area.

Figure 5. Map of Selected Locations.

From figure 4 it can know that the selected region has a characteristic with green color, while the box with the blue outline indicates that the area is the main location and the box with the yellow outline is an alternative region. In addition to the main area, there are two alternative areas with a lower altitude than the main area that can be used as part of the OTH Surface Radar characteristics that require separate Antenna Transmitter and Receiver with a minimum distance of 10 km. the selected location have conformity values as follows.

Table 3. Selected Location.

| Sub-District  | Condition                                    | Height | Location | Criteria  |
|--------------|----------------------------------------------|--------|----------|-----------|
| Pulo Merak   | Land Cover is vacant land, Slope is Flat     | 86 m   | 106° 1' 5° 54'  | Very Suitable |
|              | to Slightly Tilted, 500m to Accessibility     |        | 19,222" E 12,491" S | |
|              | Road, 450m Sea Distance                       |        |          |           |

4. Research result

Based on the detection distance with the lowest Sea distance between Java Island and Sumatera Island in the Sunda Strait, the research area focuses on the District of Serang and Cilegon City bordering the Sunda Strait. The results of the research that have been carried out produce that there is an area that is suitable to be placed OTH Surface Radar in the study location. The suitability of the region is obtained from the parameters based on the placement of the OTH Surface Radar Benchmark which is applied in other countries as a comparison plus a literature study.

There is still land that has not been used in the study area, flat terrain plus height that is considered sufficient and optimal for the Radar OTH Surface is one of the parameters in determining the feasibility of the Location. From the parameters that have been processed using a Geographic Information System, it is found that one location is the top priority for the placement of OTH Surface Radar in Banten Province bordering the Sunda Strait in Pulo Merak District with area is prioritized
based on land cover is vacant/bare land, slope which starts from flat to steep, and the access of main roads and nearby communication facilities make this location a priority for Radar OTH Surface placement.

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