Land Evaluation Mapping of Sidrap Wind Power Plant Location using Remote Sensing and GIS

Yunus Isnaeni, Agnes Putri Devinta, Anwar Wahyudin, Atika Ratnaningsih, Rakhmat Dwi Putra, Wedha Ratu Della, Wirastuti Widyatmanti*, Sudaryatno, Retnadi Heru Jatmiko

Department of Geographic Information Science, Faculty of Geography,
Universitas Gadjah Mada, Yogyakarta, Indonesia
*Corresponding author: widyatmanti@gmail.com

KEY WORDS : evaluation, suitability, wind power plant, remote sensing, geographic information system

ABSTRACT: In the past few decades, environmental awareness and enthusiasm for preserving the earth have begun to increase. The world community start to switch from fossil-source energy to renewable energy sources such as hydropower, wind power, biogas and solar energy with photovoltaic (PV) systems. The construction of the Sidrap PLTB in Watang Pulu, Sidenreng Rappang Regency is of particular concern because it is one of the large-scale PLTBs with large power targets. The purpose of this study is to determine the suitability of the existence of Sidrap PLTB on the potential of global and regional wind as the main requirement for the establishment of PLTB, and to determine the suitability of the location of the Sidrap PLTB based on land suitability parameters using remote sensing and geographic information system (GIS).

Evaluation of the construction of the power plant is based on global wind potential and land suitability of the location of the Sidrap PLTB which is seen from the average wind speed, surface roughness, slope and distance from the location of the settlement. Landsat 8 and SRTM were utilized to derive landuse and topographic parameter from digital elevation model (DEM). The result showed that location of the construction of the Sidrap PLTB lies on the region with potential wind conditions both globally and regionally. Sidrap Regency is the most suitable area for PLTB development compared to other regions in South Sulawesi Province. The suitability of the Sidrap PLTB is reviewed from the parameters of wind speed, surface roughness, slope, and distance to settlements. Based on these parameters, there are 5 turbines that are in the S1 class, 14 turbines are in the S2 class, 8 turbines are in the S3 class, and 3 turbines are located in class N. This happens because of the various limiting factors. The existence of a turbine located in class N due to its location in the valley between the hills so it has a low value compared to the location at the top of the hill.

1. INTRODUCTION

The development of electricity infrastructure in Indonesia is still very limited. Some parts of Indonesia still feel a lack of access to electricity, namely the provinces of Riau Islands, East Nusa Tenggara and West Nusa Tenggara, which are mostly small islands (Budiyanti, 2014). The total generating capacity owned is only 35.33 GW (gigawat) for the entire population of Indonesia, which amounts to more than 250 million people (BPS, 2010 in Angg, 2017). Electricity in Indonesia still relies on oil and coal sources. Estimates to experts, the potential of petroleum energy will be exhausted within the next 40-68 years. Coal fossil energy sources can be said to be cheaper, but coal reserves alone will be exhausted within the next 177,400 years (Angg, 2017).

The last few decades, environmental awareness and the spirit of preserving the earth began to increase. The world community has begun to switch to renewable energy sources such as water sources, wind power, biogas and solar energy with a photovoltaic (PV) system. One of the efforts in saving energy in the State of Indonesia is the establishment of a wind power plant which is developed on a small scale and can only provide energy for 50-100 families. Referring to the national economic policy, the government has argued that by 2025, existing PLTBs throughout Indonesia could produce 250MW (Abas, 2011).

Indonesia has a weak wind type. The amount of energy capacity generated by existing PLTBs is still very small. Development of a comprehensive map of the potential energy of wind / wind requires up to billions of rupiah. According to Soeripno Martosaputro from Lapan, mapping of wind potential requires a maximum of one year measurement time continuously and accurately in selected locations to be right on target (Angg, 2017). In the paper Wind Energy Policy Development in Indonesia, the National Institute of Aviation and Space Research (LAPAN), states that the type of wind gusts in Indonesia is a medium type with speeds of 4m / s to 5m / s. Potential winds for the development of PLTB are gusts with speeds above 5m / s and have consistent gusts throughout the year, and these types of gusts are only found in a few regions of Indonesia such as the Nusa Tenggara islands, Maluku, the southern coast of Sulawesi Island and parts of the South Coast of Yogyakarta.

The electrification ratio of Sulawesi Island is one of the lowest compared to other regions. This has become an opportunity for the private sector in providing electricity to meet the demands of the community. One of the developers of the Sidrap PLTB is PT UPC Renewables Indonesia, which has built a PLTB in an area of 100 hectares precisely in Lainungan and Mattirotasi Villages, Watang Pulu District, Sidenreng Rappang Regency. Mapping the suitability of land for a suitable location in the development of a Wind Power Plant requires an in-depth study both in terms of physical, social and disaster potential and the most important is the study of the wind potential.

The existence of the construction of the Sidrap PLTB in Watang Pulu, Sidenreng Rappang Regency is of particular concern because it is one of the PLTBs that has a large enough scale with a large power target. The construction of a PLTB is not easy to start and is not easy to stop because it is a very large project, especially investment and costs as well as a study of determining the location of the old with a good feasibility study so that the PLTB can run and be sustainable. An evaluation of the construction of the PLTB is required based on global wind potential and land suitability for the location of the Sidrap PLTB, which can be seen from the average wind speed, surface roughness, slope and distance from the settlement location. Remote sensing and GIS help in extracting and processing the data needed in evaluating the existence of the Sidrap PLTB site.

2. STUDY AREA

Seventy five (75) MW Sidrap PLTB is a ”Bayu” (Wind) Power Plant located in Mattirotasi and Lainungan Villages, Watangpulu District, Sidenreng Rappang Regency (Sidrap), South Sulawesi Province. The increasing usage of electricity requires alternative renewable energy to support electricity needs. The selection of Sidrap hill area as a PLTB location is because it has good wind potential, with an estimated wind speed of around 7 m / s which is suitable for the needs of the propeller driven propeller. The wind conditions at the Sidrap PLTB’s location are intermittent but have a fairly stable wind speed.

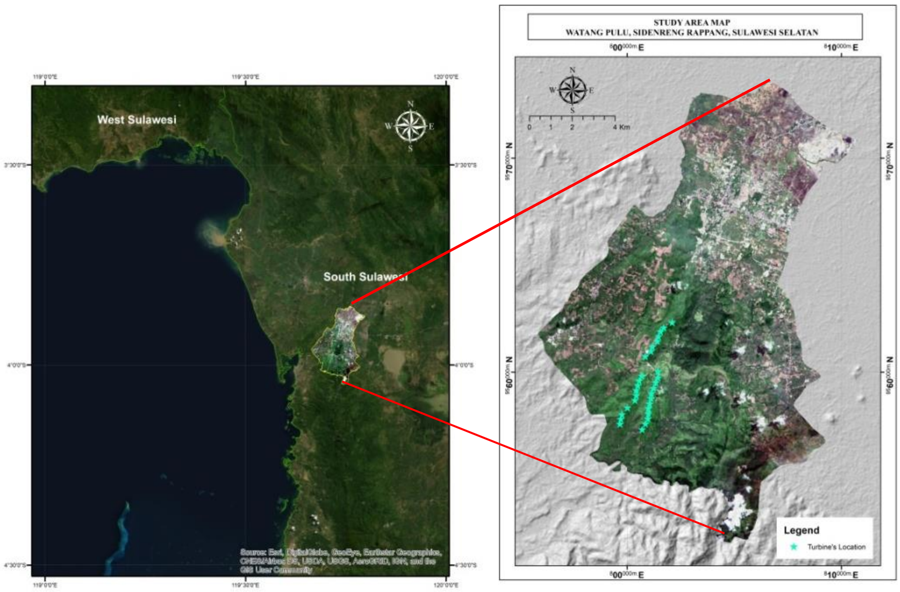


Figure 1. Study Area Location (Source : Sentinel-2B Image)

2

3. METHODOLOGY

Data processing begins with extracting data from the images obtained. Data analyzed globally can be directly analyzed, to determine the topography of South Sulawesi in observing wind patterns formed using hillshade data from ASTER GDEM data derivatives. Evaluation of the existence of Sidrap PLTB is determined by checking parameters from the overlay results of all parameters to produce a map of land units. Land suitability for Sidrap PLTB is determined through matching classification by the decision tree method. The parameters used are wind speed, surface roughness, slope, and distance of settlement location.

Table 1. Classification of Land Suitability Class (with Author Modification)

Parameter	S1 (Highly Suitable)	S2 (Moderately Suitable)	S3 (Marginal Suitable)	N (Not Suitable)	Reference
Average Wind Speed (m/s)	5,5-10,7 m/s	10,8-13,8 m/s	3,4-5,4 m/s and 13,9-25 m/s	0-3,3 m/s and >25 m/s	-Gipe (2004) in Angg (2017) - Gamesa Turbine Specifications
Surface Rougness	Ridge	Top Slope of the Hill	Plain and Bottom Slope of the Hill	Valley	-TPI (Topography Position Index)
Slope (%)	0 – 8 %	8 – 15 %	15 – 25 %	> 25 %	-Pedoman Penyusunan Pola Rehabilitasi Lahan dan Konservasi Tanah (1986)
Buffer Map of Settlements	>450 Meters	300 – 450 Meters	150 - 300 Meters	<150 Meters	https://sciencing.com/much-land-needed-wind-turbines-12304634.html

Each parameter that was successfully classified in the wind speed classification class, surface roughness classification class, slope slope classification class and settlement distance zoning class were overlaid to obtain a land unit map. Through the land unit map, sampling is carried out through the Stratified Random Sampling method to validate the parameter map used. The parameters that have been sampled from the land unit map need to be validated by checking each parameter of the class of parameters used.

The parameters that have been carried out field checks help in the analysis of land suitability evaluation. The parameters that have been explained in accordance with the class made are overlaid and a matching classification is performed using a decision tree system to produce a Map of Land Suitability of the Sidrap PLTB. The land suitability information is used in evaluating the existence of the Sidrap PLTB location. An additional evaluation was carried out to observe the condition of the rock where the Sidrap PLTB was located.

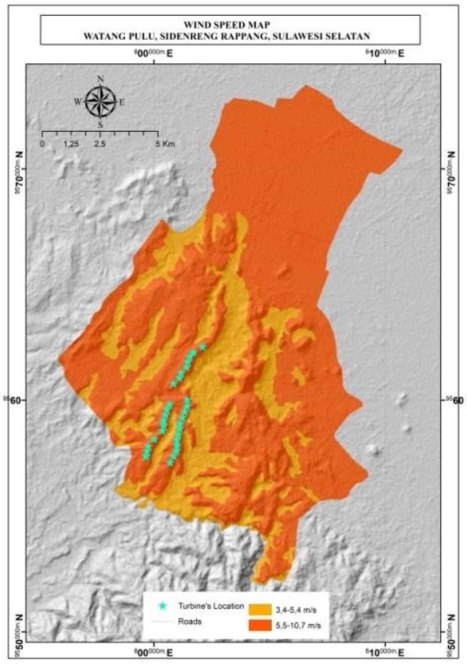


Figure 2. Average Wind Speed Map

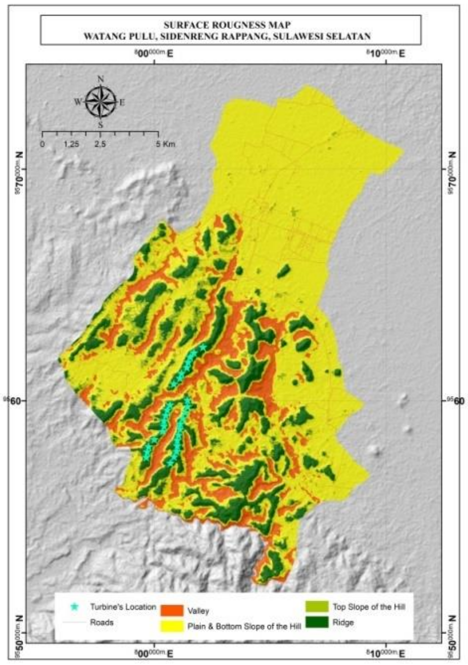
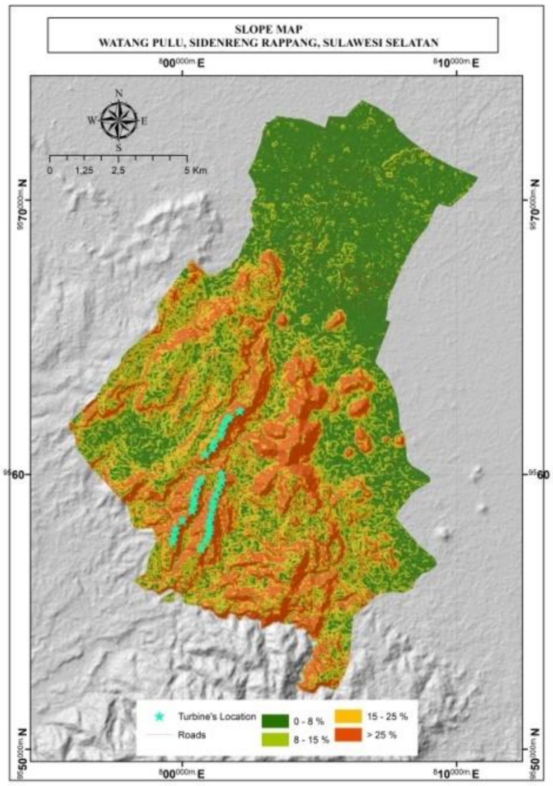


Figure 3. Surface Roughness Map



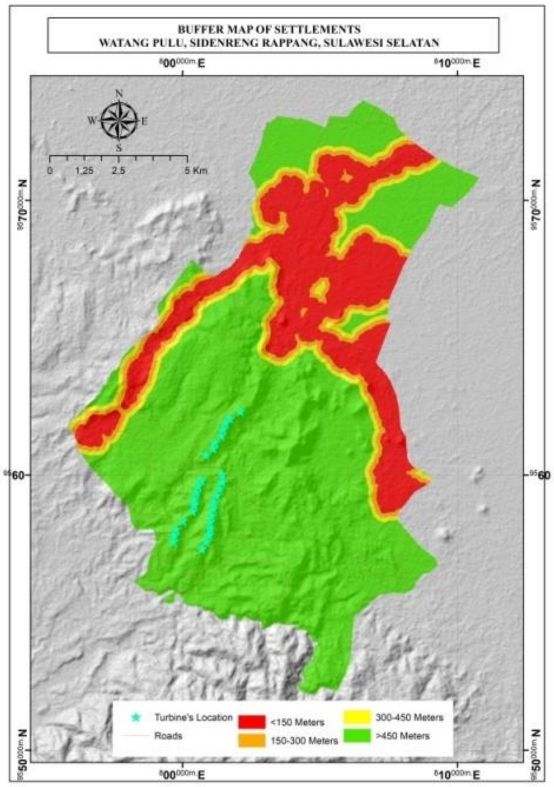


Figure 4. Slope Map Figure 5. Buffer Map of Settlements

Land suitability class is visualized to show land suitability information in Sidrap PLTB's turbines with the following classification:

Class S1 - Highly Suitable: Land has no significant or significant limiting factors for sustainable use, or limiting factors are minor and will not affect the power plant tubine

Class S2 - Moderately Suitable: Land has a limiting factor, and this limiting factor will affect the location of the turbine power plant. This limitation can be overcome by power plant.

Class S3 - Marginal Suitable: Land has a heavy limiting factor, and this limiting factor will greatly affect the location of the turbine power plant. To overcome factors

restrictions on S3 require high capital and interference from the UPC Sidrap Bayu Energy.

Class N - Not Suitable: Land because it has a very heavy limiting factor and / or is difficult to overcome.

4. RESULT AND DISCUSSION

Indonesia's wind potential tends to be intermittent where there are no windy days and Indonesia's average wind speed tends to be small so that the construction of nuclear power plants is difficult to carry out. The small wind speed does not provide power output to supply the electricity needs of the community. But in some regions in Indonesia there are sizable wind power points in driving turbines. Potential wind gusts for the development of PLTB are gusts with speeds above 5m / s and have consistent gusts throughout the year, and these types of gusts are only found in a few regions of Indonesia such as the Nusa Tenggara islands, Maluku, the southern coast of Sulawesi Island and parts of the South Coast of Yogyakarta and hills in South Sulawesi. So that the establishment of PLTB in the hills is very suitable to provide electricity to the community.

4

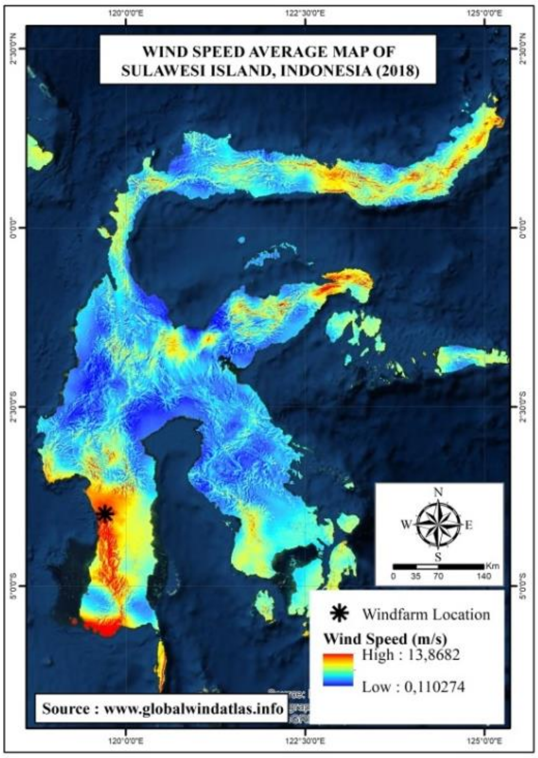


Figure 6. Wind Speed Average Map of Sulawesi Selatan Island

Based on the geological map of South Sulawesi, there are two major faults that extend from north to south and cause two areas that have a higher side. This causes the formation of a wind tunnel where the wind accumulates and causes high wind speeds in the region. The process is called the funnel effect where when a lot of wind (high pressure) and enter a narrower region (low pressure), the wind speed will be even greater. The wind trend in South Sulawesi originates from the east and southeast directions and also accumulates a lot in the hills in South Sulawesi. This causes regions in parts of South Sulawesi to have good wind potential for the construction of power plant, especially in the hills in parts of Sidenreng Rappang Regency, Regency and City of Pare-Pare, Soppeng Regency, and Barru Regency.

Areas in parts of South Sulawesi have good wind potential for wind power plant development especially in the hills in parts of Sidenreng Rappang Regency, Regency and City of Pare-Pare, Soppeng Regency, and Barru Regency and in coastal areas in Jenoponto also have good wind potential without obstacles so potential in the construction of nuclear power plants. The average wind speed in the region reaches 7.2 m / s and is quite suitable for setting up wind power plant with the right turbine selection.

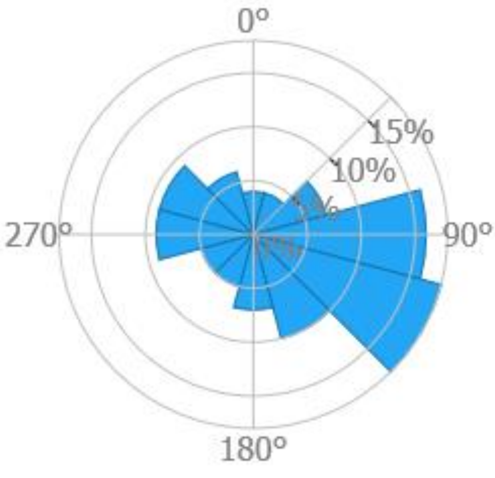


Figure 7. Wind Rose of South Sulawesi

Through observation of the wind direction in South Sulawesi using digital remote sensing data ventusky.net for 3 consecutive years in the dry and rainy season an analysis was found that the wind trend in the dry season is from the southeast while in the rainy season comes from the west and southwest. The magnitude of the existing wind speed tends to be greater during the dry season. This is evidenced by South Sulawesi wind rose data on the globalwindatlas.info website that the tendency of wind direction in the region is from the southeast and east.

Areas in parts of South Sulawesi that have good wind potential for wind power plant development are hills in parts of Sidenreng Rappang Regency, Regency and City of Pare-Pare, Soppeng Regency, and Barru Regency. The region also has a demand for electricity supply, which is why wind power plant was established to meet the needs of the local community. Before carrying out the construction, it is necessary to determine a suitable location with many considerations, one of which is the accessibility factor in transporting turbine construction materials. Easy and close and safe access to turbine materials. There is also a need for a close transmission line (PLN) from the establishment of Sidrap PLTB in order to shorten the electricity line in distribution to PLN (State Electricity Company in Indonesia) to reduce the effects of the danger of installing high-voltage electricity and reduce costs. The existence of a backup capacity from PLN considering the nature of wind in Indonesia is intermittent so it needs electricity backup capacity if the Sidrap PLTB is unable to provide electricity on a certain day.

Sampling was carried out using the Stratified Random Sampling method to validate the parameter map used. The parameters that have been sampled from the land unit map are validated by checking each parameter of the class of parameters used. The parameters that have been carried out field checks help in the analysis of land suitability evaluation. Through the field data, it can be proven that although the winds in Watang Pulu Subdistrict have a fairly large average speed and tendency of wind direction from southeast to northwest, there is turbulence / disturbance which causes the wind speed to become small and to experience wind deflection. Although the measurement activity is only done at about 2 meters high, but it is enough to prove the existence of disturbance caused by variables such as buildings, trees, roads, and hill cover. The change in wind direction caused by the object can be seen in the image below.

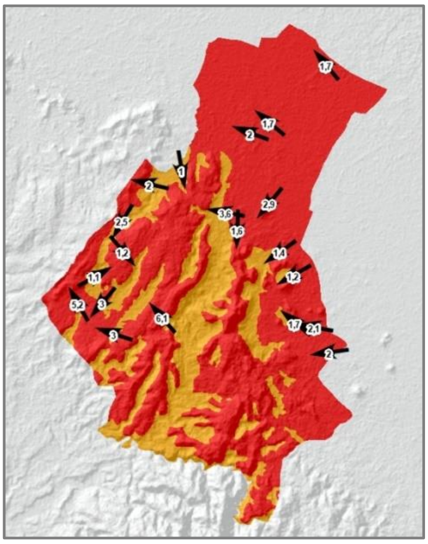


Figure 8. Illustration of turbulence

Evaluation of the existence of Sidrap PLTB is determined by checking parameters from the overlay results of all parameters to produce a map of land units. Land suitability for Sidrap PLTB is determined through matching classification with a decision tree method to produce a Map of Land Suitability for Sidrap PLTB. The land suitability classification process can be seen in Appendix 1. The resulting map has 4 suitability classes, namely S1, S2, S3, and N classes.

6

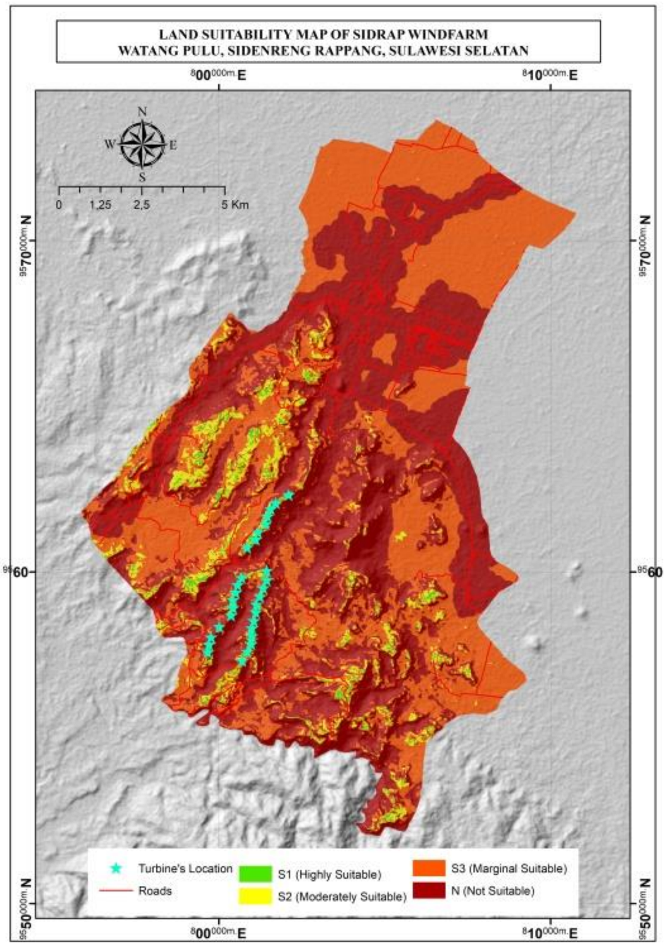


Figure 9. Land Suitability Map

Based on the map generated from processing using the classification matching decision tree, the Sidrap PLTB turbine is in a location with the suitability of S1 to N. To find out the land suitability of each turbine can be seen in Table 2. Turbines in the Class S1 - Highly Suitable is a land that does not have a significant or significant limiting factor to sustainable use, or a limiting factor is minor and will not affect the power plant tubin. Turbines in Class S2 - Moderately Suitable have a land with a limiting factor, and this limiting factor will affect the location of the PLTB turbine. This limitation can be overcome by PLTB. Whereas Class S3 - Marginal Suitable, land has a severe limiting factor, and this limiting factor will greatly affect the location of the PLTB turbine. To overcome the limiting factor in S3 requires high capital and interference from the UPC. There are turbines that are in Class N - Not suitable, ie land has a very heavy limiting factor and / or is difficult to overcome.

Table 2. Evaluate the results of the land suitability map

Turbine	Suitability	Turbine	Suitability
1	N	16	S3
2	S3	17	S3
3	S2	18	S1
4	S2	19	S2
5	S3	20	N
6	S2	21	S2
7	S3	22	S2
8	S2	23	S3
9	S3	24	S2
10	S1	25	S3
11	S1	26	S2
12	S2	27	S2
13	N	28	S1
14	S1	29	S2
15	S2	30	S2

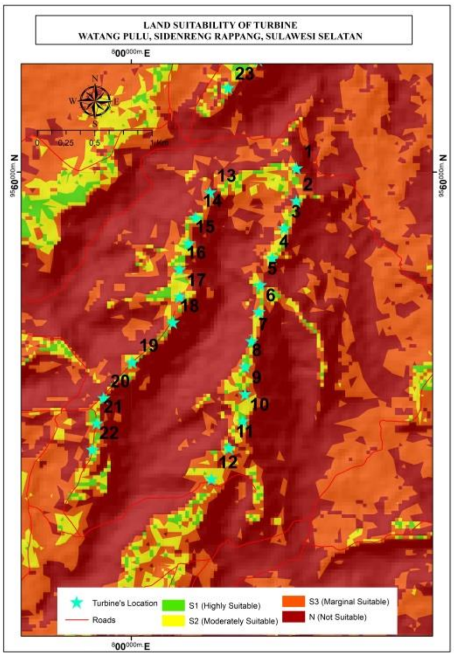


Figure 10. Land Suitability Map of Turbine Sidrap PLTB's

Based on these parameters, there are 5 turbines that are in the S1 class, 14 turbines are in the S2 class, 8 turbines are in the S3 class, and 3 turbines are located in the N. class. This happens because of the various limiting factors. The existence of a turbine is located in class N due to its location in the valley between the hills so it has a low value compared to the location at the top of the hill. The slope factor actually has no effect on the winds in the region. The slope weights are considered based on the accessibility and potential for landslides. The Sidrap PLTB was built in an old volcanic geological area which due to compact rock conditions with a thin layer of soil allows the wind power plant to stand firm even in an area that is quite steep with a shallow turbine foundation. Figure 11 below explains in general the condition of compact rock with a very thin layer of soil at the location of the turbines of wind power plant standing.

Figure 11. Geology of Sidrap PLTB's Location

5. CONCLUSION

Based on the research that has been done, it can be concluded that 30 turbines on Sidrap PLTB's, there are 5 turbines that are in the S1 class, 14 turbines are in the S2 class, 8 turbines are in the S3 class, and 3 turbines are located in class N. This happens because of the various limiting factors. The existence of a turbine located in class N due to its location in the valley between the hills so it has a low value compared to the location at the top of the hill.

REFERENCE

Angg, M G., 2017. Analisis Kelayakan Pembangunan Pembangkit Listrik Tenaga Bayu Pantai Biringkassi, Jeneponto, Sulawesi Selatan Studi Pada PT. UPC Renewables Indonesia. Universitas Gadjah Mada, Yogyakarta.

Budiyanti, E., 2014. Mengatasi Krisis Listrik di Jawa dan Sumatera. Info Singkat Ekonomi dan Kebijakan Publik. Vol.VI (05).

Abas, K., 2011. Pengembangan Energi Angin Memungkinkan. Retrieved May, 2019, from http://www.energi.lipi.go.id/utama.cgi?cetakartikel&1177294977

ESDM., 2013. Wind Energy Development Policy in Indonesia. Directorat of Various New Energy and Renewable Energy. Ministry of Energy and Mineral Resources of The Republic of Indonesia, Jakarta.

Anonymous., 1986. Pedoman Penyusunan Pola Rehabilitasi Lahan dan Konservasi Tanah. Directorate General of Reforestation and Land Rehabilitation. Ministry of Forestry, Jakarta.

9