KnE Life Sciences
ICMScE
International Conference On Mathematics And Science Education
Volume 2024

Research Article

Potential of Solar Energy Mapping in East Priangan Using Satellite Imagery and Environmental Based on GIS

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Published: 27 March 2024

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Selection and Peer-review under the responsibility of the ICMScE Conference Committee.

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Abstract.
Renewable energy is an energy that can be used to turn on all the energy that is still widely used in the world, including in Indonesia. Solar energy is a renewable energy that uses solar energy as the main ingredient in the formation of electrical energy. Solar energy is one of the most likely energies in a country that is on the equator like Indonesia. One of the interesting problems is how to determine the most effective area for the installation of solar power plants to make the power received by the power plant more effective. This study aims to analyze the effective area for installing solar panels using a Geographic Information System (GIS) as well as mapping of Centralized Solar Power (CSP) and centralized solar photovoltaic (SPV) in the East Priangan area, West Java. The method used in this study is based on the use of remote sensing of the average annual horizontal irradiation (GHI) and Normal Direct Irradiation (DNI). Solar irradiation data (GHI and DNI) were obtained from data from the surface meteorological program and solar energy by NASA, while Land Use/Land Cover, and Digital Elevation Models were used with the use of GIS. The results show that high areas in East Priangan get more effective CSP and SPV results than low areas, but low areas show an average effectiveness value in denuded areas.

Keywords: solar energy, east Priangan, satellite imagery, environmental, GIS

1. INTRODUCTION

Energy is an important component in life, especially in the 21st century. Various renewable energy innovations have been present from various elements, such as water, wind, solar, to nuclear [1]. According to Ahmadi [2] in his research revealed that wind and solar energy is energy that can be made power plants on a very large scale. Even based on a study conducted by Guerra [3] stated that of all power plants, the number of solar power plants currently holds the highest power generation. In addition, solar power plants are very promising in terms of electricity revenue as stated by Al-Kayiem [4] in his research which states that in Iraq the number of construction of solar power plants will help electricity income to be distributed to its citizens, especially if the solar power plant is built. in areas with high Global Horizontal Irradiancce (GHI) and Direct Normal Irradiance (DNI) values.

According to Zang [5], GHI is the absorption of solar radiation from a normal angle, GHI can usually be represented by using the horizontal angle added together with the DNI. Meanwhile, DNI is the absorption of solar radiation obtained from the reflection of direct radiation from the sun to the ground and reflected by the solar panel [6]. Centralized Solar Photovoltaic (SPV) is a panel that is used to absorb GHI efficiently, in which the electricity conversion is carried out directly using a solar inverter so that the installation of the panel is not too complicated to do even in narrow places [7, 8]. Meanwhile, Centralized Solar Power (CSP) is a centralized panel, and the reference can be on a large scale, whereas CSP can only be used in large areas, and is less feasible in urban areas because the components used are very large and require a lot of space [9, 10].

Potential estimation based on energy resources will certainly help in identifying an appropriate technology and also reduce implementation and operational costs. In Indonesia itself, it is a country with a GHI value of around 3.6 to 6.0 kWh/m^2 per day and 1316 to 2194 kWh/m^2 per year [11–13]. Of course, there is an advantage in the effectiveness of the construction of solar power plants, because the sunlight that comes and is absorbed by the panels will be absorbed effectively if the GHI value is in the range of 3.5 to 5.0 per day [14]. However, various difficulties come from various perspectives on the construction of power plants, especially solar power, namely from the search for potential places for construction, as stated by Aly who stated that the main difficulty in the construction of a solar power plant is in determining the potential area and usually it takes days to find it, because the surveyor must look for GHI and DNI data which then calculate the electrical output [15]. In addition, Shorabeh [16] adding another difficulty in the construction of a solar power plant is that the place to be visited is sometimes not known about the slope of the place and the climate there, so sometimes the surveyor will always have difficulty.

The construction of power plants focuses on the difficulty of finding GHI and DNI data, as well as other information such as the slope of the place to the climate. Technological developments make it possible to facilitate the discovery of such things as in the use of Geographic Information Systems (GIS). The use of GIS is believed to be able to simplify a lot of work and search for data to look for potential various energy alternatives while adding aspects such as geographical location, slope, rainfall, land surface temperature, etc. Like Colak did [17] in his research which aims to map the potential of effective solar energy areas assisted by GIS. The linear research linear with Colak, and conducted by Martin [18] get results with the use of GIS can detect the roof of the house that is suitable for installing solar panels to save energy. Based on various information obtained, this study aims to find the potential for solar energy in the eastern Priangan area which is then mapped with the help of GIS.

2. RESEARCH METHOD

The study was conducted in West Java by testing cities and districts based on Permendagri No. 137 Year 2017 which can be seen in Figure 1.

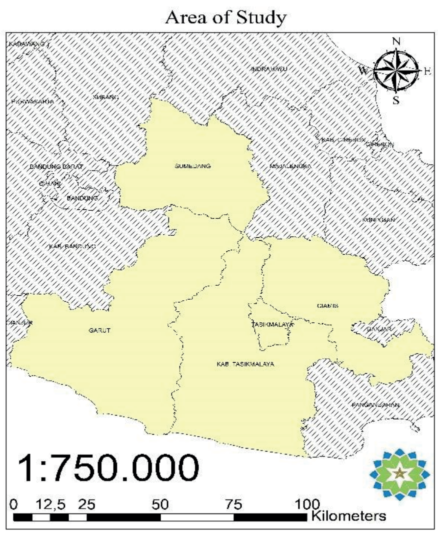

Figure 1: Area of study.

The data used is using data from DEMNAS with a resolution of 30 m in order to obtain satellite images that can be processed based on their needs such as; (1) Altitude; (2) the slope of the land; (3) Analysis of spatial information. In addition, the use of Sentinel-2A satellite imagery is carried out to analyze Land Use Coverage. Due to the limited availability of data, this study uses data for 2020 only, and without comparison. The conversion of sunlight into electricity without interference from the heat engine is the main application of solar photovoltaic systems which are an alternative to conventional energy sources from large-scale power plants [19, 20]. Mathematically, the search for potential SPV areas can be analyzed or calculated using the equation used by Hoogwijk which can be seen in equation 1[21].

$$E_i = G_i \times \eta_m \times p_r (1)$$

$$G_i = A_i \times h^{-1} \times I (2)$$

The information in equation 1 shows that Gi is a geographic potential with the equation that can be seen in equation 2, η_m is the conversion efficiency for the PV module which depends on the PV cell type and module temperature 1000 W/m^2, standard module temperature 25^{o}C and air mass 1.5, generally p_r used in Asean is 0.66 due to the use of forest land and not barren [22]. While the information in equation 2 shows that A_i is the area suitable for PV installation, h is the number of hours of sunshine in a day based on global radiation, and I is the insolation in kWh/m^2/day units.

The use of CSP technology in efficiency can be further classified based on how the device can focus the sun's rays. The percentage to the efficiency of land use from the collector and power cycle technology can be seen in the Table 1 [23].

TABLE 1: Efficiency percentage and land use factor based on collector and power cycle technology in percent (%).

Collector & Power Cycle Technology	**Solar-Electric Aperture Related Efficiency**	**Land Use Factor**	**Land Use Efficiency**
Parabolic Through Steam Cycle	11 – 16	25 – 40	3.5 – 5.6
Central Reciever Steam Cycle	12 – 16	20 – 25	2.5 – 4.0
Linear Fresenel Steam Cycle	8 – 12	60 – 80	4.8 – 9.6

Mathematically, the potential of the CSP area can be calculated using a mathematical equation that has been formulated by Trieb which can be seen in equation 3 [23].

$$E_i = G_i \times Land\ Use\ Efficiency (3)$$

Gi is the geographic potential with the equation that can be seen in equation 2, but using direct normal radiation on the number of hours of sunshine in a day.

3. RESULTS AND DISCUSSION

The distribution of annual average global horizontal irradiation (GHI) and annual average direct normal irradiation (DNI) over Indonesia, especially in the eastern Priangan area, can be seen in Figure 2.

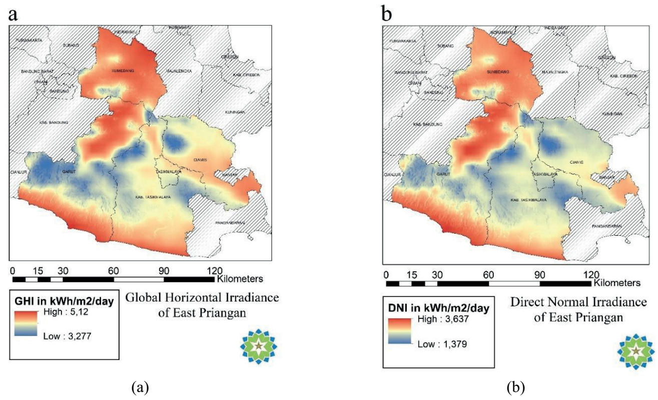

Figure 2: (a) Global horizontal irradiance of east priangan; (b) Direct normal irradiance of east priangan.

GHI and DNI mapping were taken based on data from NASA SSE Release 6.0. The average GHI in East Priangan got the highest score on 5.12 kWh/m^2/day, and lowest at 3.277 kWh/m^2/day. In addition to GHI, the average DNI in East Priangan got the highest results in 3.637 kWh/m^2/day, and lowest at 1.379 kWh/m^2/day. The areas with the highest GHI and DNI are in Sumedang and North Garut, while the areas with the lowest GHI and DNI are in South Garut, Tasik Regency and Tasik City. Ciamis gets the standard GHI and DNI categories, which means it's not in the high or low range.

Distribution of potential SPV and CSP in the cities of East Priangan such as; (1) Sumedang; (2) Garut; (3) Lake City; (4) Tasik Regency; and (5) Ciamis can be seen in Table 2.

TABLE 2: Solar potential for SPV and CSP in east priangan (in GW).

No	City	SPV Potential	CSP Potential
1	Sumedang	1267.968	1029.624
2	Garut	1132.203	103.615
3	Kota Tasik	293.328	-
4	Kabupaten Tasik	805.738	82.776
5	Ciamis	563.285	67.333

Overall, the East Priangan area can produce approximately 4062,522 GW of Solar PV (SPV) and 1283,348 GW for CSP. Sumedang got a very high potential value of SPV and CSP, which was then followed by Garut. However, Tasik City, Tasik Regency, and Ciamis are areas that are not suitable because Tasik City is very densely populated, Tasik Regency has many steep cliffs, and Ciamis is an area that gets standard GHI and DNI. Tasik City did not get CSP Potential, this is because Tasik City is an urban area filled with buildings, so it is not feasible to install CSP, because according to Yu stated that urban areas are not suitable for building solar power plants using CSP technology, because urban areas do not have much land [24]. In line with the opinion expressed by Mohammadi, which states that urban areas are very risky with the risk of damage if CSP is built in urban areas because CSP requires many components so for sustainability, it must be far from residential areas. The overall potential of SPV and CSP can be seen in Figure 3.

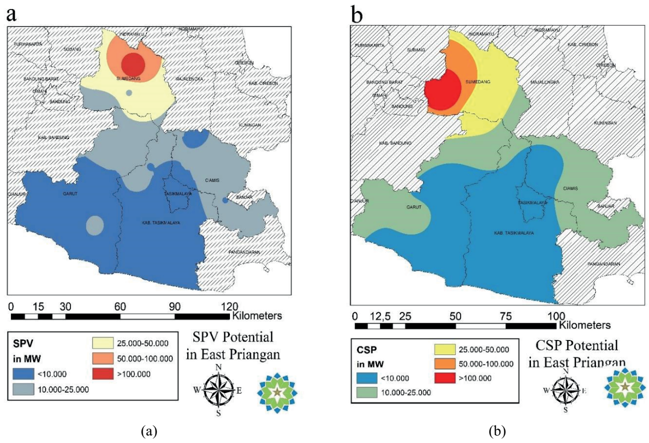

Figure 3: Solar potential area for (a) SPV, and (b) CSP in East Priangan.

In terms of area, the area of East Priangan, West Java, which can effectively build a solar power plant is an area of 4844.680 km^2, specifically per region, namely; (1) Sumedang 116.218 km^2; (2) Garut 105.875 km^2; (3) Kota Tasik 12.102 km^2; (4) Kabupaten Tasik 82.409 km^2; (5) Ciamis 94.574 km^2.

4. CONCLUSION

The findings show that as a whole the Priangan Timun area of West Java can be built with a solar power plant with an area of 4844,680 km^2. The Sumedang and Garut areas get areas that can be categorized as effective and feasible because the GHI and DNI are very high in the entire Sumedang and North Garut areas, but the Tasik area is said to be less feasible because there are many steep cliffs and areas that are less strategic even though the GHI and DNI scores get decent category, and Ciamis gets the average category and is not too high or low.

Acknowledgments

The author thanks LP2M UIN Sunan Gunung Djati Bandung as the donor, and all staff of UIN Sunan Gunung Djati Bandung who have helped in expediting the research process.

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