Identification of Suitable Sites for Solar Panel Plants using Geospatial Technology

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Abstract

The Indian government is promoting the use of renewable energy sources to meet the nation's existing energy needs. Solar energy is one of the cleanest, most abundant, and free forms of energy used to supply the growing need in many countries. Sanchi in Madhya Pradesh is the first city in the country to fulfill its complete electrical needs through solar energy. Thus, finding suitable sites for solar plants in other parts of the states is the need of the hour. The present study is an attempt to identify suitable sites for solar panels using Analytical Hierarchy Processes (AHP) in Sehore District of Madhya Pradesh. Seven factors, i.e., land use & land cover (generated under the Space-based Information System for Decentralized Planning - SISDP project), soil, land capability classes, slope, aspect, geomorphology, groundwater potential, land degradation, which are affecting the process, have been selected to find suitable areas for solar panels. AHP has been used to assign relative weightage among all seven selected criteria and to delineate areas suitable for solar panel plants. The site suitability map is classified into four classes: highly suitable, moderately suitable, less suitable, and not suitable, with an area of 3.7%, 42.3%, 52.5% and 1.5% of the total area under each category, respectively. This study demonstrates the potential of the dataset created under the SISDP-U project for grassroots-level planning.

Keywords Solar Panel, AHP, SISDP-U, Energy.

Introduction

Electricity is necessary for many different purposes, including household, business, and industrial ones. The utilization of electrical power appropriate for each of these applications is required. Hydropower, thermal power and nuclear power are all traditional techniques for generating electricity. With growing awareness of the dangers of climate change, several countries have begun to develop strategies for transitioning to low-carbon economies. This has resulted in a focus on the usage of renewable energy sources; Indian Government is focusing on renewable sources for generating electrical energy, such as, geothermal resources, sunlight and wind. Solar energy is the cleanest and most prolific renewable energy source accessible. Solar technology can use this energy to generate electricity, provide light or a warm interior atmosphere and heat water for domestic, commercial or industrial use. Solar power is a rapidly growing business in India. In 2021, India was ranked fourth in the world in terms of solar power generation. According to the International Energy Agency's (IEA) World Energy Outlook 2021 study, India's current share of global primary energy consumption was 6.1% in 2021 and is expected to rise to 9.8% under conservative policy scenarios by 2050 (IEA, 2021).

The increased demand for power is expected to increase India's reliance on coal, oil, and natural gas as a source of energy. Domestic coal output and oil imports, however, will not only fall short of satisfying demand, but will also have a negative impact on the environment and the economy. One method India may improve its energy security in the face of increased demand is to increase the number of solar power units and its reliance on renewable energy sources. Several National Solar Mission have been launched by the Central Government to promote environmentally sustainable growth and address challenges of energy security and energy poverty (Garni and Awasthi, 2017). The fundamental purpose of this mission is to establish India as a global leader in solar energy. Sanchi in Madhya Pradesh is the first city in the country to fulfill its complete electrical needs through solar energy. Thus, finding suitable sites for solar plants in other parts of the states is the need of the hour. The present study has attempted to identify suitable sites for solar panels using AHP) in Sehore District of Madhya Pradesh. Seven factors, i.e., land use & land cover (generated under the Space-based Information System for Decentralized Planning - SISDP project), soil, LCC, slope, aspect, geomorphology, Groundwater potential, land degradation, which are affecting the process, have been selected to find suitable areas for solar panels (Mahmoud et.al, 2021).

Materials and Methods

Study Area and Dataset: Sehore, Madhya Pradesh, India is situated at geographic coordinates 23° 11' 54.3732'' N and 77° 5' 42.6624'' E. It is located in the Malwa area at the foothills of the Vindhyachal Range. The temperature here is 25.5 °C on average. The annual rainfall here is approximately 1063 mm. The climate of Sehore is temperate, and the summer season presents some difficulties in terms of very high temperatures. The Tropic of Cancer passes through Sehore district thus, the Sun directly overhead the region.

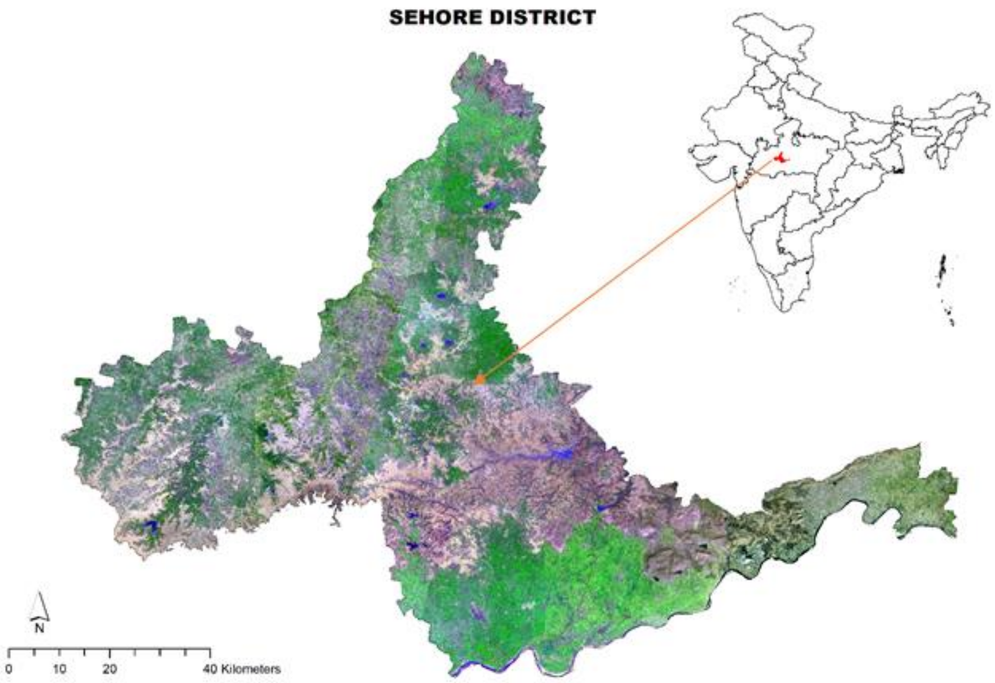

Fig. 1 Sehore district of Madhya Pradesh showing the locations of the study area, Satellite True color composite image from the LISS IV and Cartosat.

Methodology: Combinations of factors are necessary in this study to characterize and select the places with the highest appropriateness for solar panel installation. Several factors have been used in earlier research to choose optimal locations for Solar Panel installation (Alhammad et .al, 2022). Seven factors, i.e. land use & land cover (generated under the Space-based Information System for Decentralized Planning -SISDP), soil, Land capability class, slope, geomorphology, groundwater potential, land degradation (legacy data from Bhuvan) have been used to select the suitable site for solar panel installation.

Land use & land cover: It provides current information about features present on the ground like agriculture, forest, urban area, wasteland and waterbody. It has generated from merge data of LISS IV and Cartosat Dem at a scale of 1:10,000. Data have digitized on four level, in level I is having five classes followed by 28 classes, 46 classes and 84 classes in level II, III and IV, respectively. In this study, level IV classes have been used and aspect dense scrub land, sparse scrub land classes have been considered suitable for the solar power plant. The total land of Sehore district is 650018 ha, out of which, the agriculture area is about 68%. The major crops grown in the Kharif season are Soybean, Rice, Maize, Jowar, Pigeon pea and Wheat, Chickpea and sugarcane are the popular crops in Rabi season. The Forest area is about 15%.

Slope: The Earth's slope was a significant consideration in locating optimal places for solar installations. The gradient of the Earth impacts the reception of solar radiation. As a result, less than 4 percentage slope locations receive the most radiation and generate the most energy from solar panel installation. The risk of solar panel shadowing increases as the percentage of land slope increases. Because direct sunlight is obstructed during shade circumstances, the solar panel output power generation is limited. Furthermore, locating solar farms on steep slopes raises construction costs.

Soil texture: The soil texture criterion is crucial because it enables the selection of the soil structures with the best ground mounting systems for PV panels, electrical earthing systems, and utility substations. Sandy loam soil is unfavorable for mounting solar arrays because it is abrasive. According to soil texture area under Sehore is divided into the five types of soil texture namely- clay, sandy loam, sandy clay loam, loam and clay loam.

Groundwater potential: Groundwater potential map gives the information regarding ground water level present on the surface. According to ground water potential, the area under Sehore is divided into the seven types of ground including excellent, good, good to moderate, moderate, moderate to poor and poor. In north earthen part of shore has poor ground water potential but in southern portion of Sehore has excellent ground water potential.

Land capability class: The United States Department of Agriculture's Soil Conservation Service classified properties into eight capacity classes based primarily on topographic circumstances. There are eight capability classes, whereas the area under Sehore is five classes, which are class II, Class III, class IV, class VI and class VII. The major Class II class are present in the Sehore district.

Land Degradation: In Sehore district high Soil erosion due to undulation & non bunding of farms deterioration in Soil health due to adoption of Soybean – Wheat, Paddy – Wheat, Soybean- Chickpea cropping system deterioration in soil health due to imbalance use of plant nutrient. Lack of knowledge about bio fertilizer & its application. The total land of Sehore district is 650018 ha, out of which, the degraded land area is about 18%. It includes Barren and rocky area, Gullies And water erosion Sheet-Slight, Moderate and Sever. In southern portion of Sehore major gullies erosion occur due to undulation of land in forest area (Sunil Mittal 2016).

Results

Analytical Hierarchy Processes: Relative weights of input layer were assigned using AHP). The pairwise comparison method was developed by (Saaty, 1980) in the context of the AHP. This method involves pairwise comparisons to create a ratio matrix and produces the relative weights as output. Specifically, the weights are determined by normalizing the eigenvector associated with the maximum eigenvalue of the (reciprocal) ratio matrix. As a result, a reciprocal matrix was created, with each element representing the dominance of one aspect over another in terms of their suitability for the installation of solar PV systems (González-Prida, 2012). Following that, divide each ingredient in half. The created reciprocal matrix by the sum of its column. Finally, the weight of each element was calculated by averaging across the columns. Thereafter, the consistency of the calculated weights was evaluated using the Consistency Index (CI) (Dongrong Li 2013).

Table 1. SISDP-U Criterial weight.

SI.no.	GWP	SISDP-U Weight	Remark
1	Excellent	5	Highly suitable
2	Good	4	Moderately suitable
3	Good to moderate	3	Suitable
4	Moderate	3	Suitable
5	Moderate to poor	2	Less Suitable
6	Poor	1	Not Suitable
7	Poor	1	Not Suitable
8	Waterbodies	0	Water body
9	Loamy	4	Moderately suitable
10	Clayey	3	Less suitable
11	Clay loam	4	Moderately suitable
12	Sandy clay loam	4	Moderately suitable
13	Sandy loam	6	Highly suitable
14	0-1 % Slope	10	Highly suitable
15	3-7 % Slope	10	Highly suitable
16	8-11% Slope	10	Highly suitable
17	15-11% Slope	6	Suitable
18	15-30 % Slope	4	Less Suitable
19	30-45 % Slope	4	Less Suitable

20	>45 % Slope	8	Moderately suitable
21	I	2	Not suitable
22	II	3	Less suitable
23	III	3	Less suitable
24	IV	4	Suitable
25	V	6	Moderately suitable
26	VI	7	Moderately suitable
27	VII	8	Highly suitable
28	VIII	9	Highly suitable
29	Water erosion-A1 Sheet - Slight	7	Degraded
30	Water erosion-A2 Sheet - Moderate	7	Degraded
31	Water erosion-A3 Sheet - Severe	7	Degraded
32	Water erosion-A5 Gullies	1	Degraded
33	Others-H2 Barren rocky/ Stony waste	7	Degraded
34	Dense scrub land (DS)	6	
35	Sparse scrub land (SS)	6	

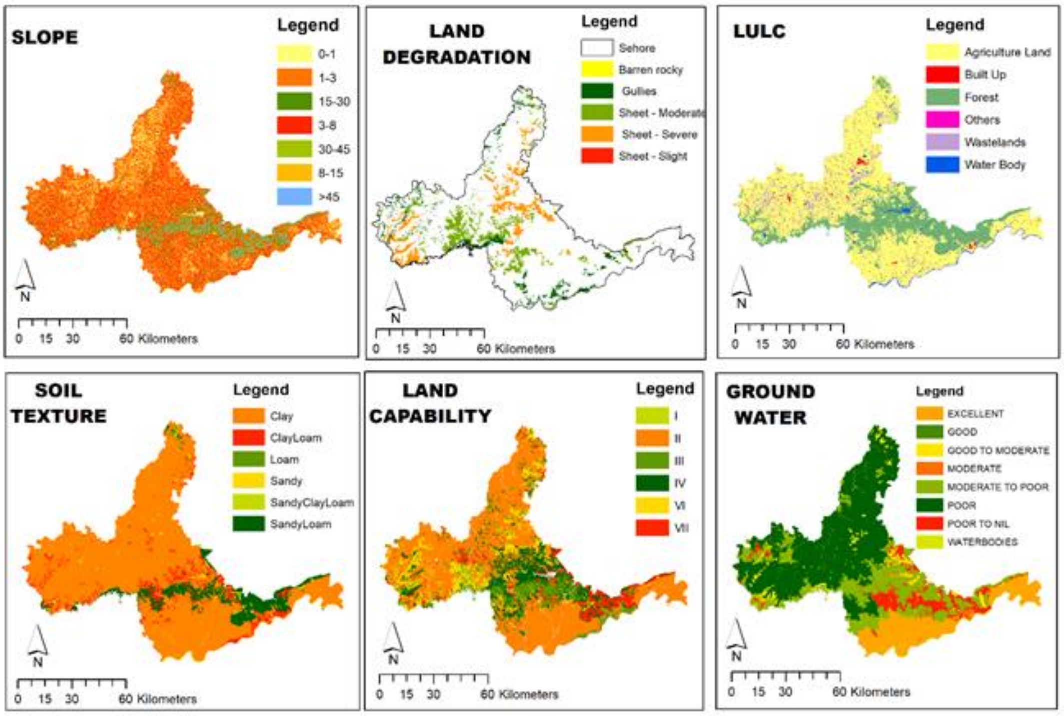

Fig. 2 This is a figure show the factor which used in sites suitability for solar panel (**a**) Slope (**b**) Land degradation (c) Land use Land cover (d) Soil texture (e) Land Capability class (f) Ground water potential.

Suitable sites for Solar panel: Figure 3 depicts the suitability map, which includes locations assessed as having Highly suitable, Moderately Suitable, Less Suitable, and Not Suitable for establishing PV power plants in Sehore district of M.P. The site suitability map is classified into four classes, namely, highly suitable, moderately suitable, less suitable, and not suitable, with an area 3.7%, 42.3%, 52.5% and 1.5% of total area under each category, respectively. When planning the construction of a Solar panel plant in Sehore, areas categorized as Highly suitable should be prioritized

Table 2. This table shows the SISDP-UP relative weightage.

Sl. no.	Classes	Relative weightage
1	Soil texture, erosion and depth	0.06
2	Slope	0.09
3	Ground Water Potential	0.10
4	Land Capability Classification	0.19
5	Land use/cover	0.56

Table 3. This is a table show the Suitability area for solar panel.

Class	**Area**	**Percentage**
Highly Suitable	23048	3.54
Moderately Suitable	273401	42.06
Less Suitable	345719	53.18
Not Suitable	7850	1.207

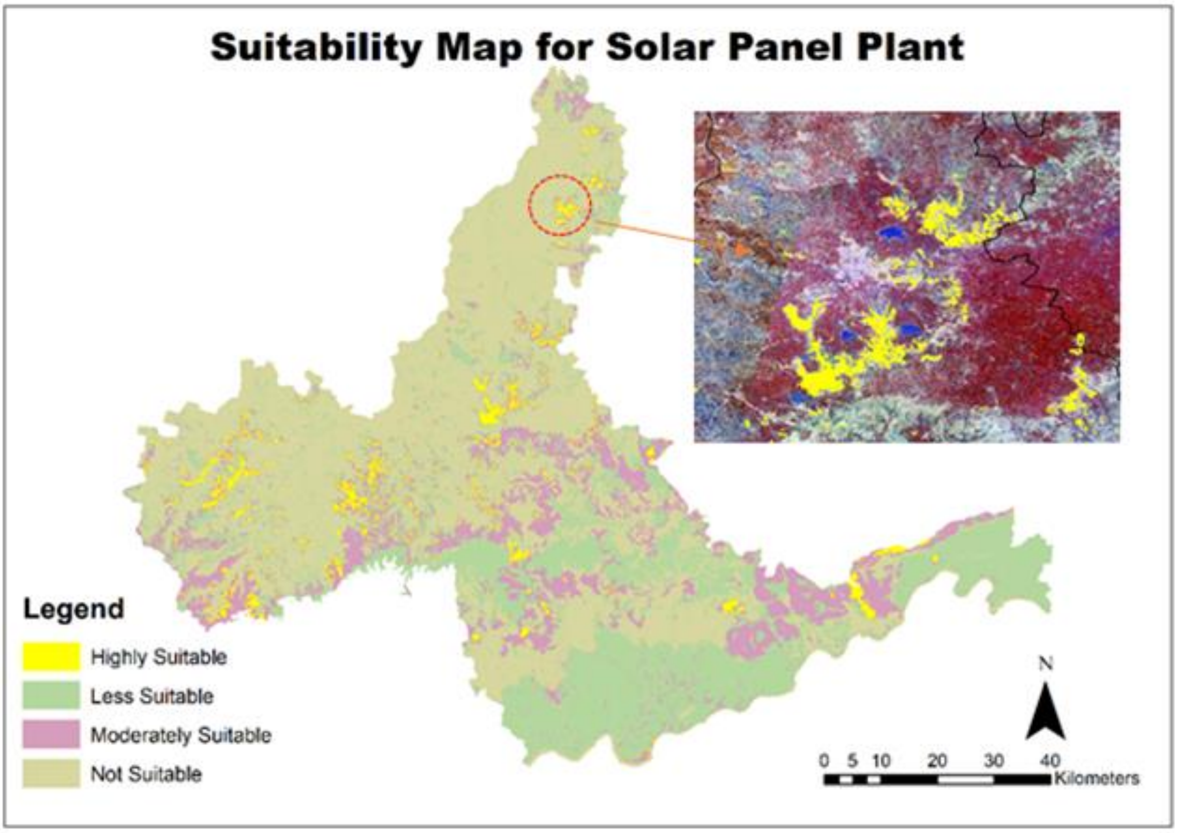

Fig. 3 This is a figure Shows the suitability map for solar panel installation in Sehore district of Madhya Pradesh with 4 different classes.

Conclusions

The present study has attempted to identify suitable sites for solar panels using AHP) in Sehore District of Madhya Pradesh. AHP has been used to assign relative weightage among all seven selected criteria and delineated areas suitable for solar panel plants. The site suitability map is classified into four classes, namely, highly suitable, moderately suitable, less suitable, and not suitable, with an area 3.7%, 42.3%, 52.5% and 1.5% of total area under each category, respectively. This study highlights the potential of dataset prepared under SISDP to address the problem of optimization of land use at grass root level. The weightage assigned under the SISDP includes 16 different criteria to resolve the land allocation issues related to the industry, Argo-forestry etc.

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Citation

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