International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.141
Peer Reviewed Bi-Monthly
Vol. 7 No. 2 January – February - 2026

# GIS – Based Site Suitability Analysis for Wind Turbine Installation in India

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**DOI - 10.5281/zenodo.18709369**

***Abstract:***

*Wind energy plays a critical role in achieving sustainable energy transitions, particularly in developing economies with rapidly increasing energy demands. However, the efficiency and feasibility of wind energy projects are highly dependent on optimal site selection, which requires the integration of multiple technical, environmental, and infrastructural factors. This study employs a Geographic Information System (GIS)–based multi-criteria decision analysis to identify suitable locations for wind turbine installation across India at an 80 m hub height. Wind speed data were extrapolated to hub height, and seven key parameters—wind speed, slope, elevation, land use/land cover, proximity to roads, railways, and power lines—were incorporated using a weighted overlay approach. Each parameter was ranked and assigned weights based on technical relevance and operational constraints. The results indicate that Western and Southern India exhibit high suitability for wind energy development, while Northern and Northeastern regions are comparatively less suitable due to complex terrain and unfavourable wind conditions. The findings provide a spatial decision-support framework for planners and policymakers to guide sustainable wind energy deployment in India.*

***Keywords: Wind Energy, GIS, Site Suitability Analysis, Weighted Overlay, Renewable Energy, India***

**Introduction:**

The growing demand for electricity, combined with concerns over climate change and fossil-fuel dependency, has intensified the global shift toward renewable energy sources. Among these, wind energy has emerged as a mature and cost-effective technology capable of contributing significantly to national energy portfolios. India, with its vast geographical extent and diverse climatic conditions, possesses substantial wind energy potential; however, the successful implementation of wind energy projects depends heavily on identifying locations that maximize energy output while minimizing environmental and socio-economic conflicts.

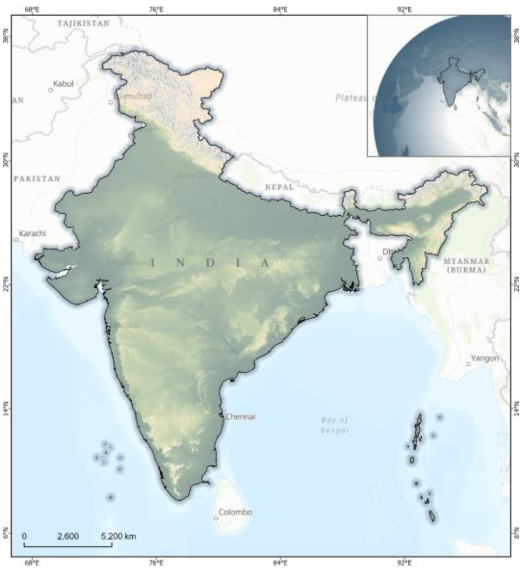
Site selection for wind turbines is a complex decision-making process that involves multiple interrelated factors, including wind characteristics, topography, land use, accessibility, and proximity to infrastructure. Traditional site selection methods are often time-consuming and limited in their ability to integrate spatially heterogeneous data. In contrast, Geographic Information Systems (GIS) provide a robust platform for managing, analysing, and integrating spatial datasets, enabling comprehensive suitability assessments over large areas.

Recent studies have demonstrated the effectiveness of GIS-based multi-criteria evaluation techniques for wind energy planning in various geographical contexts. Building on this approach, the present study aims to assess wind turbine site suitability across India using a weighted overlay analysis at an 80 m hub height, providing a national-scale perspective on wind energy potential.

**Materials And Methods:**

**Study Area:**

The study area covers the entire geographical extent of India, located in South Asia between latitudes 8°4′ N and 37°6′ N and longitudes 68°7′ E and 97°25′ E. India's terrain ranges from the Himalayan mountain system in the north to extensive coastal plains and plateaus in the south and west. This diversity results in significant spatial variation in wind regimes, making India an appropriate case for large-scale wind suitability analysis.

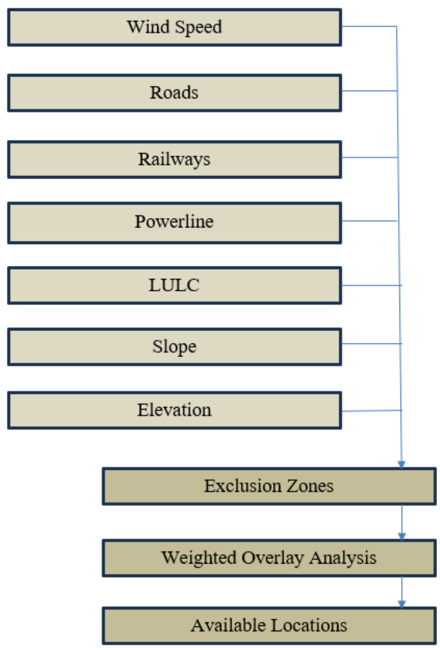



**Data Collection and Preparation:**

Spatial datasets relevant to wind turbine site selection were collected from national and global sources and processed within a GIS environment. All datasets were projected to a common coordinate system and converted to raster format with consistent spatial resolution.

| Data | Source |
|---|---|
| Wind Speed | Global Wind Atlas |
| LULC | MODIS |
| Road and Railway | Diva GIS |
| Slope | SRTM DEM |
| Elevation | SRTM DEM |
| Powerline | Digitized manually for whole India |

The methodology chart:




**Constraints used for the study:**

| Features | 80m |
|---|---|
| Road | 0-118m excluded |
| Railway | 0-118m excluded |
| Urban and Built-up lands | excluded |
| Power grid | 0-118m excluded |
| Waterbody | excluded |
| Slope | >20° unsuitable |
| Forest | excluded |
| Elevation | >1500 unsuitable |

**Wind Speed Extrapolation:**

The wind velocity are corrected on the principle that wind speed differs with length of terrain's roughness, since the wind speed and rotor height are related. The mathematical formula has been adopted for to extrapolate wind speed for different hub heights using available wind speed data.

$$v_{zR} = v_z \frac{ln(z_R/z_0)}{ln(z/z_0)}$$

Where, Vz represents the reference height wind speed while the target hub height for extrapolation is represented by ZR. Z is the measurement height ie, reference height. Zo is the roughness length which is calculated using raster calculator for the whole study area.

**Technical Specifications of Turbine:**

| Hub Height | Model | Rotor Diameter | Rated Power | Cut-in Speed | Cut-off Speed |
|---|---|---|---|---|---|
| 80m | Suzlon S88 – 2.1 MW | 88 m | 2.1 MW | 4 m/s | 25 m/s |

**Weighted Overlay Analysis:**

Weighted Overlay Analysis is a spatial analysis technique widely used in GIS to combine multiple raster datasets to solve complex problems by assigning weights and priorities to each layer based on its importance. Here, the same method is used to find the Wind Turbine Site Suitability. The input data used includes road, railway, slope, elevation, powerline, LULC and wind speed for different hub heights. Suitable locations are looking for different hub heights. So, according to the constraints and other factors, weightage and rankings are given.

Different layers are prepared as mentioned above. The process is done in ArcMap 10.8.2 version. A tool named Weighted Overlay is used for the process. The ranking given for different layers is given in table below:

| | 80m | |
|---|---|---|
| **Parameters** | **Classes** | **Ranking** |
| **Wind Speed** | <3.5 | Restricted |
| | 3.5 - 4 | 2 |
| | 4 -5 | 3 |
| | 5 - 6 | 4 |
| | 6 - 20 | 5 |
| | >20 | 1 |
| **Road (m)** | 0-118 | Restricted |
| | 118 – 5000 | 5 |
| | 5000 – 10000 | 4 |
| | 10000-20000 | 3 |
| | 20000-30000 | 2 |
| | 30000-452673 | 1 |
| **Railway (m)** | 0-118 | Restricted |
| | 118-50000 | 5 |
| | 50000-100000 | 4 |
| | 100000-150000 | 3 |
| | 150000 - 200000 | 2 |
| | 200000 - 1865627.625 | 1 |
| **Slope** | 0 | 5 |
| | 0 - 8 | 4 |
| | 8 - 12 | 3 |
| | 12 - 16 | 2 |
| | 16 - 20 | 1 |
| | 20 - 87.465584 | Restricted |
| **Elevation (m)** | negative 71 to 0 | Restricted |
| | 0 - 600 | 1 |
| | 600 - 900 | 3 |
| | 900 - 1200 | 4 |
| | 1200 - 1500 | 5 |
| | 1500 - 8553 | Restricted |
| **Powerline** | 0 - 118 | Restricted |
| | 118 - 10000 | 5 |
| | 10000 - 50000 | 4 |
| | 50000 - 100000 | 2 |
| | 100000 - 150000 | 1 |
| | 150000 - 1878020.125 | 1 |

| | | |
|---|---|---|
| **LULC** | Barren | 5 |
| | Shrubland | 4 |
| | Crop | 3 |
| | Forest | 2 |
| | Wetland | Restricted |
| | Urban | Restricted |
| | Snow and Ice | Restricted |
| | Waterbodies | Restricted |

Weightage given for different parameters:

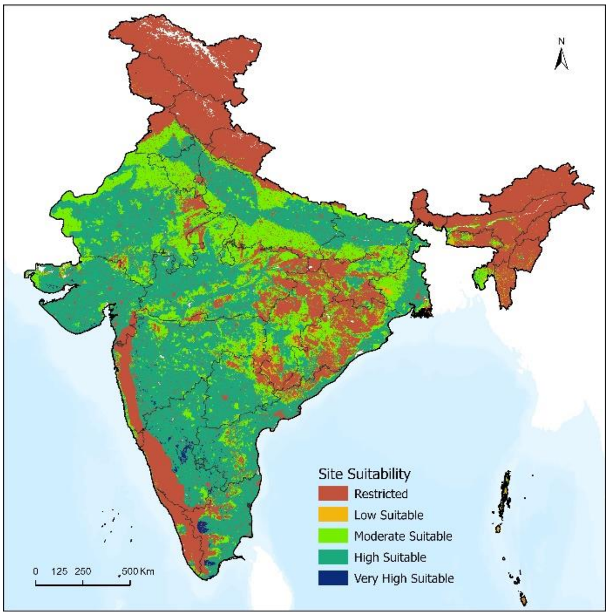
| **Parameter** | **Weight (%)** |
|---|---|
| Wind Speed | 40 |
| Powerline Proximity | 20 |
| Road Accessibility | 10 |
| Railway Accessibility | 5 |
| Slope | 10 |
| Elevation | 5 |
| Land Use/Land Cover (LULC) | 10 |
| Total | 100 |

**Results And Discussion:**

The assessment of suitable sites for the installation of wind turbines included the preparation of different layers and weighted overlay analysis. The study shows the suitable locations where the wind turbines can be installed and the unsuitable locations for the installation.

Western and Southern regions, particularly coastal and plateau areas, exhibit high suitability due to favourable wind speeds, moderate slopes, and better accessibility to infrastructure. These regions align with existing wind energy developments, reinforcing the validity of the GIS-based approach.

In contrast, Northern and Northeastern India show lower suitability scores, largely due to rugged terrain, steep slopes, and complex topography that hinder turbine installation and maintenance. Although certain localized pockets may possess adequate wind speeds, infrastructural and environmental constraints reduce their overall suitability.




**Conclusion:**

This study demonstrates the effectiveness of a GIS-based weighted overlay approach for large-scale wind turbine site suitability analysis in India. By integrating wind speed, topographical, land use, and infrastructural parameters, the analysis identifies Western and Southern India as the most promising regions for wind energy development at an 80 m hub height. The methodology provides a transparent and replicable framework that can support policymakers, planners, and developers in prioritizing suitable locations for wind energy projects. Future studies may enhance the model by incorporating economic, ecological, and social impact indicators to further refine site selection.

**References:**

1. Beata Sliz-Szkliniarz, Joachim Vogt. GIS-based approach for the evaluation of wind energy potential: A case study for the Kujawsko-Pomorskie Voivodeship, 2011
2. Pilar Diaz-Cuevas. GIS-Based Methodology for Evaluating the Wind-Energy Potential of Territories: A Case Study from Andalusia (Spain), 2018

3. https://niwe.res.in/department_wra_100m%20agl.php
4. Selim Serhan Yildiz. Determining Wind Energy Potential Using Geographic Information System Functions: A Case Study in Balikesir, Turkey, 2023
5. https://niwe.res.in/assets/Docu/India's_Wind_Potential_Atlas_at_120m_agl.pdf
6. https://mnre.gov.in/en/wind-schemes-guidelines/
7. https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2024/07/20240704480897552.pdf
8. T.R. Ayodele, A.S.O. Ogunjuyigbe, O. Odigie, J.L. Munda. A multi-criteria GIS based model for wind farm site selection using interval type-2 fuzzy analytic hierarchy process: The case study of Nigeria, 2018
9. Renewable Energy
10. https://en.wind-turbine-models.com/