Spatial Suitability Assessment for Solar Energy Infrastructure Using Multi-Criteria Evaluation (MCE) — Worcester County, MA

Report

1. Introduction

The rapid expansion of renewable energy systems in the United States, particularly solar photovoltaic (PV) installations, requires spatially explicit assessments to determine where infrastructure can be optimally deployed. Identifying suitable locations ensures cost-effective installation, minimizes risks, enhances grid integration, and promotes equitable clean-energy access across communities. Worcester County (Figure 1), Massachusetts, one of the largest counties in the Commonwealth, represents a strategic region where distributed and utility-scale solar systems can significantly support state decarbonization targets.

This study conducts a Spatial Suitability Assessment for Solar Energy Infrastructure using a Multi-Criteria Evaluation (MCE) approach within a Geographic Information System (GIS) environment. The analysis integrates location-based constraints, accessibility factors, and equity considerations to determine the relative suitability of candidate locations for solar deployment across Worcester County.

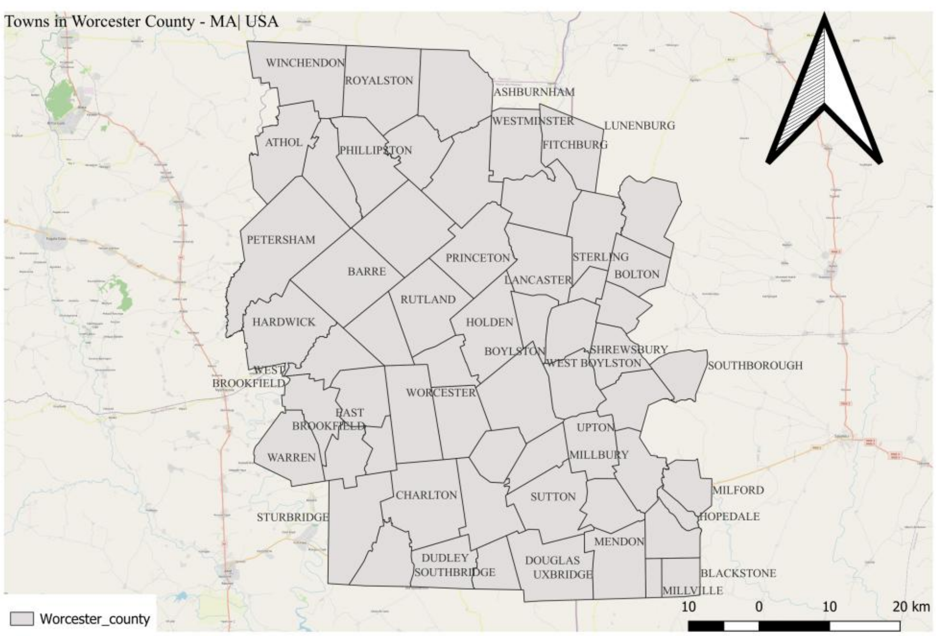

Figure 1. Table 1 Distribution of Towns in Worcester - MA\USA

2. Data and Materials

The analysis relies exclusively on six spatial datasets available for Worcester County:

2.1.Rooftop Solar (Roofprints)

Building footprints were used to assess rooftop solar potential. Each feature represents a potential installation point.

2.2. Parcels

Parcels provide contextual information for ground-mounted solar opportunities and ensure spatial precision for analysis.

2.3. Flood Zones

FEMA-designated flood zones were used to exclude high-risk areas unsuitable for solar development.

2.4. Transmission lines

Electric transmission and distribution infrastructure is critical because proximity reduces interconnection costs and enhances grid integration.

2.5. Road Network

Road proximity facilitates equipment transport, construction access, and long-term maintenance.

2.6. Environmental Justice (EJ) Areas

The Massachusetts EJ layer was used to prioritize communities historically underserved by energy investments, aligning the analysis with equity-centered planning. All layers were projected to **EPSG:26986 (NAD83 / Massachusetts Mainland)**, and spatial indexing was applied to optimize performance.

3. Methods

3.1. Pre-processing and Eligibility Filtering

Rooftop and parcel layers were screened to remove features below a minimum area threshold (<2,000 ft^2 for rooftops and <1 acre for parcels). Features intersecting FEMA flood zones were excluded to reduce exposure to climate-related hazards.

3.2. Proximity Analysis

Two distance-based criteria were incorporated:

- **Distance to transmission lines**: calculated using the *Distance to Nearest Hub* tool.
- **Distance to roads**: representing construction and maintenance accessibility.

Distances were normalized using linear scaling functions:

$$\text{Score} = \text{scale\_linear}(d, d_{\max}, d_{\min}, 0{,}100)$$

Proximity to infrastructure produces higher suitability scores.

3.3. Environmental Justice (EJ) Integration

EJ areas were used to generate a binary score:

- 100 for features inside EJ communities
- 50 for features outside

This embeds equity within the suitability model.

3.4. Multi-Criteria Evaluation (MCE)

The final suitability index combines three criteria:

- Grid proximity (40%)
- Road access (30%)
- Environmental Justice (30%)

$$\text{Suitability} = 0.4(\text{score\_grid}) + 0.3(\text{score\_road}) + 0.3(\text{score\_EJ})$$

The index ranges from **0 to 100**.

3.5. Classification

The final suitability results were categorized into five classes using quantile classification:

1. Very Low Suitability
2. Low Suitability
3. Moderate Suitability
4. High Suitability
5. Very High Suitability

Each class visually represents the spatial distribution of solar suitability across Worcester County.

4. Results

4.1. Spatial Patterns

The resulting map (Figure 2) reveals a spatially heterogeneous distribution of solar suitability across Worcester County.

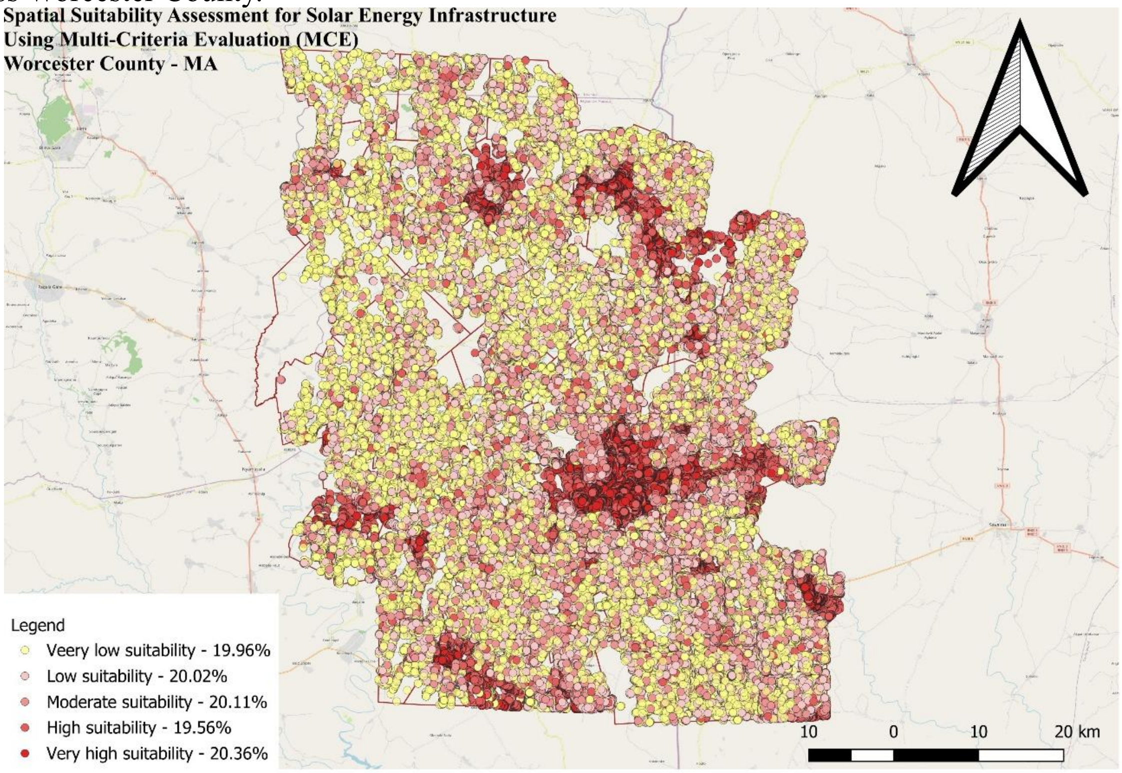

Figure 2. Spatial Suitability for Solar Energy Infrastructure in Worcester – MA | USA

Clusters of high and very high suitability (shown in darker red) appear predominantly in:

- The central corridor of the county
- Areas with dense road networks
- Regions close to transmission infrastructure
- EJ-designated neighborhoods in Worcester City

In contrast, very low suitability areas (yellow-green) dominate sparsely connected or peripheral rural zones with limited infrastructure access.

4.2. Quantitative Distribution of Suitability Classes

Your suitability classes are distributed as follows:

Table 1 Suitability Class Distribution

SUITABILITY CLASS	PERCENTAGE
Very low	19.96%
Low	20.02%
Moderate	20.11%
High	19.56%
Very high	20.36%

These values show an almost even distribution among the five categories. This is expected because quantile classification places approximately equal numbers of features into each class. However, the spatial clustering of high-suitability parcels is meaningful and highlights priority zones for solar investment.

4.3. Interpretation

The concentration of high suitability sites around transportation corridors and grid infrastructure illustrates the strong influence of accessibility and interconnection on solar feasibility. The presence of EJ communities within high-priority regions also indicates opportunities for equitable solar deployment, aligning with Massachusetts' clean-energy and environmental-justice policies.

5. Discussion

5.1 Planning Implications

The results suggest that Worcester County contains extensive areas suitable for solar deployment, both for rooftop and ground-mounted systems. Municipal planners, utility companies, and policymakers can use these findings to:

- Identify clusters for community solar projects
- Reduce grid interconnection costs
- Target EJ communities for distributed solar programs
- Guide land-use planning and zoning decisions
- Support state-level renewable energy allocation programs

5.2 Limitations

Although robust, the analysis has limitations:

- No solar irradiance raster (no direct assessment of sunlight availability)
- No slope or aspect factors (e.g., roof orientation, terrain slope)
- No tree canopy analysis (shading conditions unknown)
- No zoning restrictions included

Future research project should integrate Lidar-based tree canopy, a high-resolution DEM, and detailed building attributes.

6. Conclusion

This study provides a comprehensive spatial assessment of solar development suitability across Worcester County using a GIS-based multi-criteria Evaluation framework. Despite data limitations, the results successfully identify priority areas for solar energy infrastructure by combining risk exposure, grid accessibility, road proximity, and environmental justice considerations.

The findings demonstrate that significant portions of Worcester County are highly suitable for solar deployment, underscoring the county's potential contribution to Massachusetts's clean-energy and decarbonization goals. The analysis also highlights the importance of integrating equity considerations in renewable energy planning to ensure inclusive and just energy transitions.