GIS-Based Multi-Criteria Decision Analysis of Site Selection for CSP Plants in Chile

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INTRODUCTION

The increasing energy demand due to rapid population growth poses a significant challenge in finding sustainable energy alternatives to mitigate the environmental impacts of fossil fuel consumption and their eventual depletion. **Renewable energy sources provide a viable solution.** The site selection for solar power plants is critical for ensuring financial viability and long-term energy production. Chile, with its high Direct Normal Irradiance (DNI), limited fossil fuel resources, and a stable business environment, is an ideal location for solar energy development, particularly Concentrated Solar Power (CSP) technology. This study employs an integrated approach combining **Geographic Information Systems (GIS)** and **Multi-Criteria Decision Analysis (MCDA)** to identify optimal CSP plant sites in the Antofagasta region. The methodology incorporates the **Analytical Hierarchy Process (AHP)** within GIS software to analyze maps of terrain slope, DNI, roads, and transmission lines. By processing these maps and applying AHP to weight each criterion, the study pinpoints the most suitable areas for CSP installation while excluding restricted lands. This approach provides a **systematic and data-driven method for site selection**, which is essential for the successful deployment of renewable energy projects in the region.

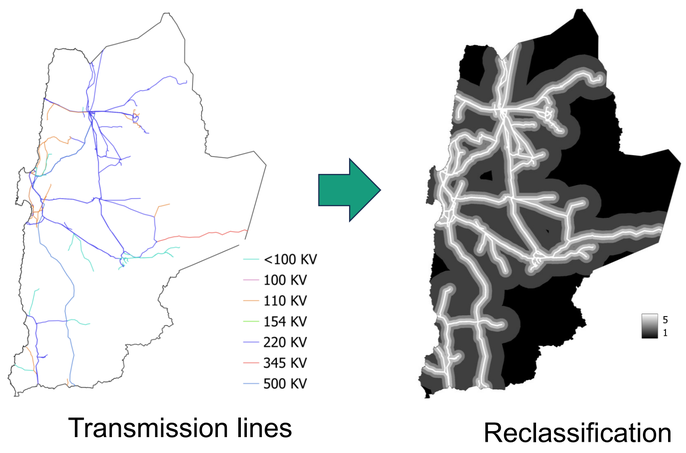
METHODOLOGY

The comparison matrix with the selected criteria and their corresponding relevance is presented below, **highlighting Direct Normal Irradiance (41%) and Slope (23%) as the most critical factors** for site selection.

Table 1: Comparison Matrix of Criteria and Weights for Site Selection

Factors	DNI	Water availability	Distance to grid	Distance to roads	Slope	Aspect	Final weights
DNI	1	5	4	4	3	5	**0.41**
Water availability	1/5	1	1/2	1/2	1/3	3	**0.08**
Distance to grid	1/4	2	1	2	1/3	2	**0.12**
Distance to roads	1/4	2	1/2	1	1/3	2	**0.10**
Slope	1/3	3	3	3	1	4	**0.23**
Aspect	1/5	1/3	1/2	1/2	1/4	1	**0.05**

Once the maps were processed, they were combined using the derived weights, and **unsuitable lands were excluded** to generate the final suitability map.



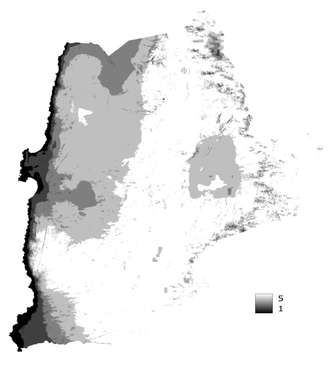
Transmission lines

Reclassification

Below are the processed maps prior to their combination. **The DNI map, identified as the most significant parameter**, reveals extensive white areas indicative of high irradiance.

The slope and aspect maps exhibit a more irregular pattern, derived from a high-resolution Digital Elevation Model (DEM). The distance-to-roads map highlights a concentration around the road network, with distances exceeding 8 km receiving an index of 1.

Aspect



DNI

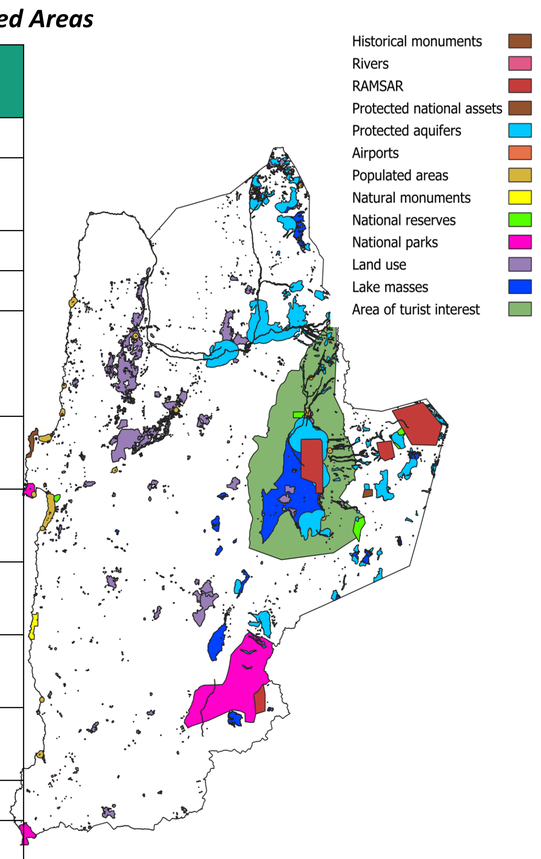
Slopes

Roads

Additionally, **20% of the land in Antofagasta was classified as restricted** due to various factors, which are detailed below along with the corresponding safety distances. Notably, for airports, a significant safety distance is required due to the high reflectivity associated with CSP plants.

Table 2: Buffer Zones for Restricted Areas

Restriction Area	Buffer [m]
Airports	5000
Area of turist interest	100
Rivers	100
RAMSAR	200
Protected national assets	200
Protected aquifers	200
Populated áreas	2000
Natural monuments	200
National reserves	200
National Parks	200
Land use	200
Lake masses	100
Industrial Mining	200
Historical monuments	200



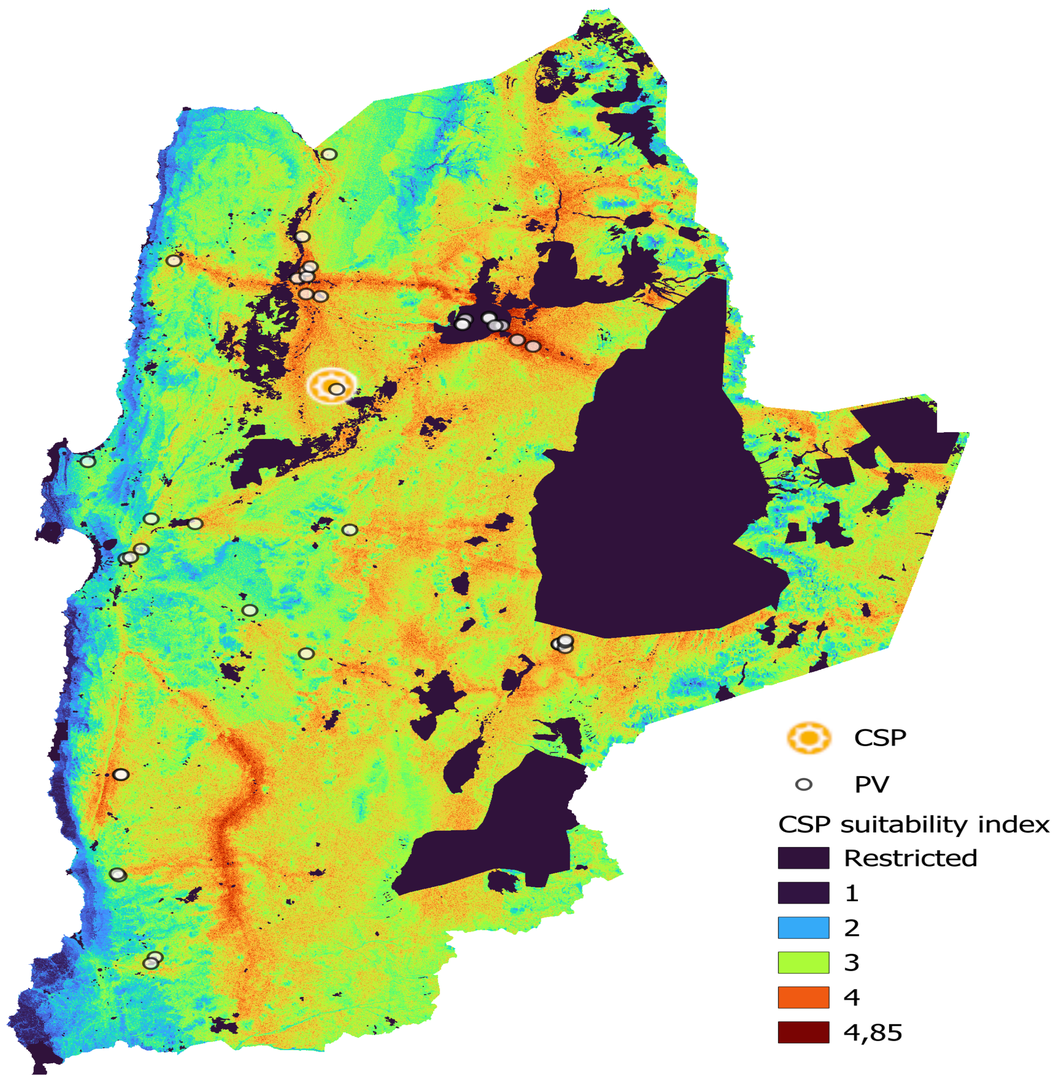
RESULTS AND CONCLUSIONS

- A suitability map for utility-scale CSP installations was obtained, showing significant potential for the Antofagasta region. The map indicates that 43% of the land has a suitability index between 3 and 4, and 1% has an index between 4 and 5 on a scale of 1 to 5, where 1 is very low feasibility and 5 is ideal. Additionally, the table below shows that approximately 20% of the land was excluded from the analysis due to various considerations.

Table 3: Suitability Distribution

Suitability index	Area [%]
Restricted	20.4
1 – 2	3.6
2 – 3	31.6
3 – 4	43
4 – 5	1.4

- It is important to note that the only CSP plant currently installed in Chile Cerro Dominador, has a terrain suitability index of 3.86.
- Furthermore, the best-suited areas are concentrated in the municipalities of Taltal, Maria Elena, and Calama.
- These findings offer key insights for CSP development, guiding decision makers on investment priorities in renewable energy infrastructure.



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