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# A Multicriteria Evaluation Model to Optimally Place Grid-Connected Photovoltaic Power Plants

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**Abstract.** The grid connected photovoltaic power plant location problem has shown to be really complex over the last few years. Engineers and scientists have shown deep interest in developing an efficient tool able to consider all distinct variables that enter into the problem.

This work designs a model that, using Geographic Information Systems and a Multicriteria Evaluation Methodology, has proven to be a very valuable tool for spatial analysis which is of great help when making decisions about the Optimal Location of grid connected photovoltaic power plants, considering in this decision both electrical and environmental factors.

## Key words

Geographic information systems, multicriteria evaluation, photovoltaic power plant.

## 1. Introduction

The increase of ton of oil equivalent consumption to satisfy world energy demand, caused by the population grow and per-capita energy consumption increase, will impact on the fossil fuel prices. International efforts to promote renewable energy and energy efficiency are mandatory to reduce this tendency.

The main effect that the increase in projected and built grid connected photovoltaic power plants have had is to spot numerous optimal location errors regarding: output efficiency, law observing and costs reduction.

## 2. Model definition

This is a multicriteria evaluation system with one objective and several criteria. Firstly, as the chart indicates, the objective is determined, then the criteria and factors are established, both those of relative importance and those excluding. Defining an appropriate methodology to assign each criterion and factor weights has been the next step.

Once the weights are established, they are introduced in a geographic information system (GIS), using ArcView 3.2 software with the Spatial Analyst extension that includes the Model Builder tool, through which the properly hierarchied layers can be obtained [1].

Using the Model Builder extension the relationship between different information layers falling on the same spot can be studied. Thematic layers included in the model come from commercially available data bases. Other layers of both excluding and positive factors been developed for this work by the authors.

The next step was to group all these layers according to the different factors and to normalise them, by assigning a value within a 1 to 10 scale, being 1 the worst value and 10 the best. These input topics, originally in vector form, have been converted to raster format (via Vector Conversion function), and later, in order to obtain discrete topics have gone through a reclassification process.

Finally, a Weighted Overlay process was applied to all the topics. With this, a combined output topic was created considering all the input topics falling in a certain geographic region.

The territory capacity (to install PV power plants) can be established from knowledge about the territory appropriateness and impact on it; that is, integrating these two elements we could propose different capacity levels for the special units that conform the territory under study from a certain use or activity.

Given that the territory capacity can be understood as the sum of all positive factors minus all negatives (or excluding) factors, the determination of the factors that enter into the process was the first question to tackle.

*A.Multicriteria evaluation*

The Multicriteria Evaluation Method proposed here possesses just one objective, which is none that the land selection to locate grid connected PV power plants, but with certain requirements, that in turn will be determined by the criteria to be described later. The Multicriteria Evaluation Methods can be divided into three groups: Compensatory techniques, non-compensatory techniques and diffuse techniques.

To correctly determine the weight that each criteria or factor has in the final resultant layers output, the Analytical Hierarchies method of [2] within the Multicriteria Evaluation Method has been adopted. It is a pair comparison procedure, that works with a square matrix where the number of columns and rows is defined by the number of criteria to ponder.

*B. Analytical Hierarchies Method*

The fact that the Analytical Hierarchies Method has spread in fields such as fuzzy decision and mathematical programming, is a sign that it is suitable in decision problems in which great fidelity and flexibility are required. The Analytical Hierarchies Method decomposes a complex problem in hierarchies, where each level is in turn decomposed in specific elements. The main objective is on the first level, and from it, the criteria, sub-criteria and decision alternatives are listed in the descending hierarchy levels. The eigenvector of the previously mentioned square matrix associated with this problem is computed. This eigenvector provides a quantitative measure of the consistency of the judge of values between pairs of factors.

*C. Output model*

The final output model is the result of a summation process of the factors, criteria and limiters, via the Arithmetic Overlay methodology. This output model is then normalised and later reclassified, to achieve the final layer.

## 3. Conclusions

The obtained spatial decision model is the result of crossing information from a series of layers regarding weather, environmental, orographic and location, as well as limiting or excluding ones (e.g. Natural Park), where a decision methodology (Multicriteria Evaluation and Analytical Hierarchy) has been followed that analyses the weight assigned to each involved factor.

This model can provide us with very valuable information when trying to select appropriate areas to build photovoltaic power plants, with efficiency as the prime objective (because factors as crucial as daily temperature, hours of sun equivalent or sun irradiance levels are considered), but at the same time showing great respect with the environment selecting lands where impact is negligible (on soil and visual).

Furthermore, the model chooses the location considering best road access and proximity to power substations.
To test the model, it has gone through a validation process consisting in three distinct phases, but complementary at the same time: verification, validation and sensibility analysis.

For the validation phase pixel by pixel, eye and on site checks have been done, concluding that model and real scenario correspond correctly. The uncertainty analysis showed that the proposed model is more stable and thus will have less uncertainty than the other two models.
The sensibility analysis (that studies how output changes when input data or methodology are modified) showed similar results: the most important criteria are those related to weather and environment.

## References


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