# A SPATIAL DECISION SUPPORT SYSTEM FOR WIND FARM SITE SUITABILITY IN NORTHWEST OHIO

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## Abstract

The siting of new wind energy farms is a complex spatial problem that involves the consideration of a large number of decision alternatives and varying opinions of multiple decision makers. The decision makers involved in the decision process will likely value the importance of criteria differently, thus producing a range of solution alternatives. The ambiguous nature of this process combined with the multi-criteria evaluation, necessitates a spatial decision support system (SDSS). SDSS's are interactive, computer-based systems designed to support a user or group of users in achieving a higher effectiveness of decision making. The SDSS presented here considers environmental and economic decision alternatives that are intended to develop a comprehensive and sound regional plan for wind farm siting in northwestern Ohio. The prototype system was tested with a group of undergraduate and graduate students and final outputs were generated using the Borda ranking method (each student ranks criteria from best to worst) and Copeland's pairwise aggregation method that is based on the majority of votes. Sensitivity analysis was also conducted to examine the effects of changes in factor weights on the solutions.

## Methodology

The multi-criteria SDSS framework integrates environmental and economic criteria and builds a hierarchy model for wind energy farm siting. The Simple Additive Weighting (SAW) method is used to calculate the suitability score for each grid cell in the multiple layers.

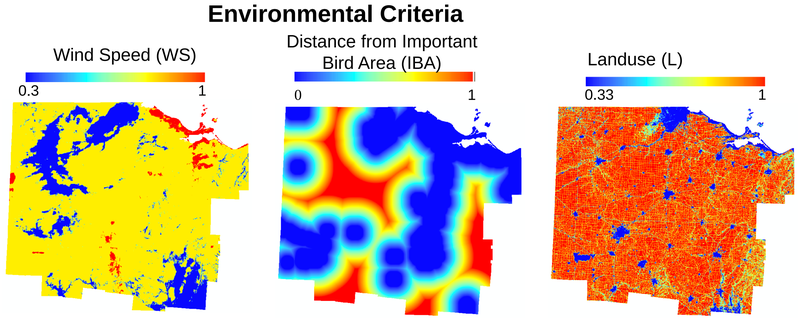
$$v_i = \sum_{j=1}^{n} w_j v_{ij}$$

where $V_i$ is the suitability index for area $i$, $w_j$ is the relative importance weight of criterion $j$, $v_{ij}$ is the grading value of area $i$ under criterion $j$, $n$ is the total number of criteria. The SDSS outputs include different decision alternatives derived by the Borda ranking method and Copeland's pairwise aggregation of environmental suitability, economic suitability, and a combined multi-objective suitability of the two. In addition, a sensitivity analysis was implemented to examine the effects of change of multi-criteria weights on the final solutions.

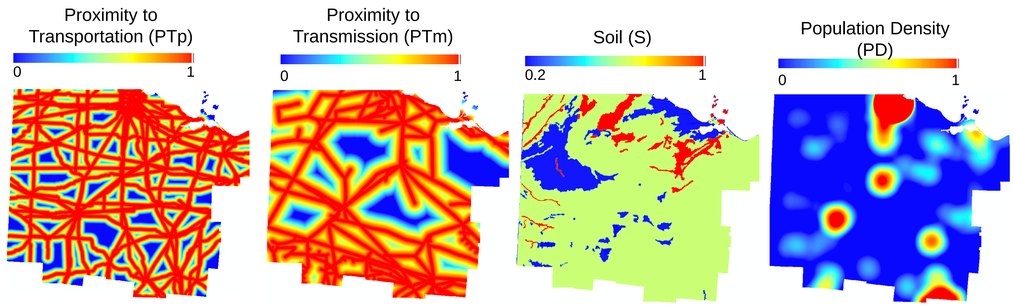
## Decision Factors

The data is standardized on a scale from 0 to 1 using a linear increasing fuzzy function.

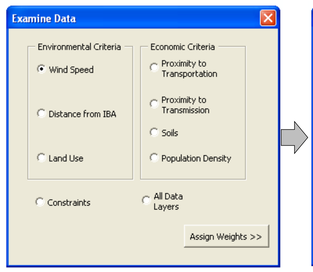
### Environmental Criteria



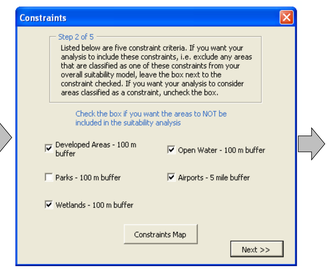

### Economic Criteria



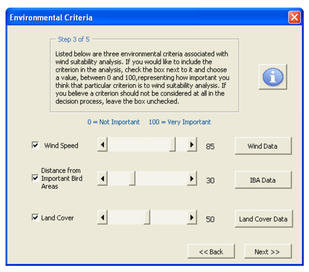

## SDSS Interface



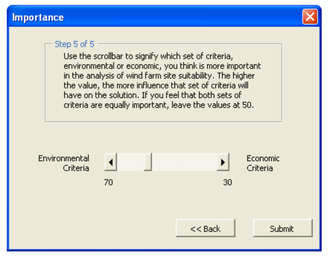

Examine spatial data



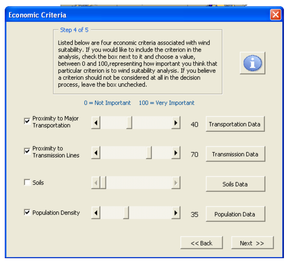

Choose the constraints to include




Select environmental factors and assign importance values




Importance of each set of criteria

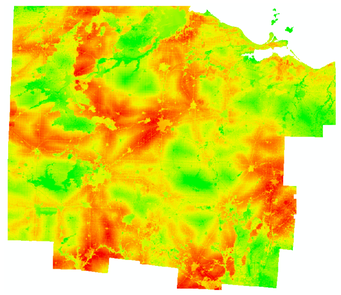



Select economic factors and assign importance values

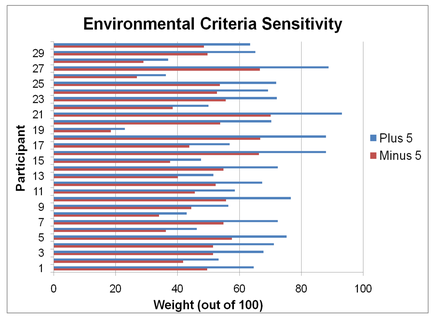
## Results from Borda Ranking and Copeland Aggregation

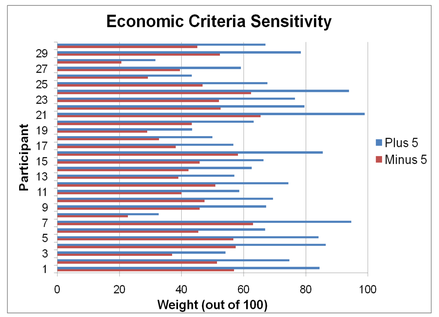
| | Factor | Score | Weight |
|---|---|---|---|
| ENV weight 0.50 | WS | 156 (1) | 0.46 |
| | IBA | 86 (3) | 0.25 |
| | L | 97 (2) | 0.29 |
| ECON weight 0.50 | PTp | 143 (2) | 0.28 |
| | PTm | 157 (1) | 0.31 |
| | S | 114 (4) | 0.20 |
| | PD | 120 (3) | 0.21 |

Borda scores and respective weights. Rankings shown in parenthesis.



Borda Ranking

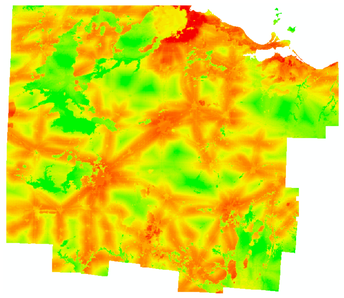


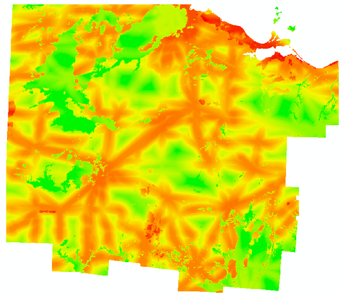

Sensitivity analysis is used to examine the robustness of the solution by applying small changes to the factor weights.

| | Factor | >50% | >60% | >70% |
|---|---|---|---|---|
| ENV weight 0.50 | WS | 0.86 (1) | 1.0 (1) | 1.0 (1) |
| | IBA | 0.0 (3) | 0.0 (2) | 0.0 (2) |
| | L | 0.14 (2) | 0.0 (2) | 0.0 (2) |
| ECON weight 0.50 | PTp | 0.31 (2) | 0.44 (1) | 0.25 (2) |
| | PTm | 0.35 (1) | 0.44 (1) | 0.75 (1) |
| | S | 0.11 (4) | 0.0 (4) | 0.0 (3) |
| | PD | 0.23 (3) | 0.12 (3) | 0.0 (3) |

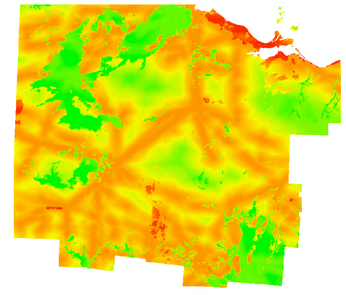
Copeland weights at different levels of consensus. Rankings shown in parenthesis



Consensus > 50%



Consensus > 60%



Consensus > 70%