Onshore Wind Farms Suitability Analysis Using Spatial Analytic Hierarchy Process: A case study of Fukushima prefecture, Japan

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(1) Motivation: Fukushima was the most damaged prefecture by the nuclear crisis as a result of the powerful earthquake of March 2011. Its government adopted a strategy to focus on renewable energy to drive its energy structure into a safer and more self-sufficient status. Wind energy stands firm as one of the important renewable energy sources in Japan and plays an important role regarding energy vision goals of Fukushima prefectural government. However, various obstacles are on the way of such approach, mainly because the dispersal of onshore wind farms implies many negative impacts on the environment as well as the communities neighboring such facilities. The aim of this study is to develop a Geographical Information System (GIS) model to identify and evaluate the optimal locations for the siting of onshore wind facilities that combines multi-criteria analysis with geographical information systems.

(2) Methodology: The model incorporates a set of environmental, economic and social criteria. Using a newly designed and developed web application, we apply the Analytic Hierarchy Process (AHP), where a group of wind energy experts and stakeholders was asked the pairwise comparison of the criteria in order to judge their relative importance in site evaluation. The methodological framework applied in this study is illustrated in Figure 1. Adapted from Tegou (2010), the methodology main idea is to identify and extract two areas: excluded and rated. The first one refers to the area which will be excluded from the analysis due to unsuitability based on factual or legal reasons such as urban areas, water bodies and natural parks. The former corresponds to a spatially rated area based on key criteria for finding optimal wind farm sites. Value scores will be assigned to each criterion based on experts' survey results using AHP approach.

(3) Results: Figure 2 shows the exclusion area. After the exclusion of the restricted areas, approximately 11% of the area remains available for wind energy development, which corresponds to 1,564 km² (out of a total size of 13,780 km²). The 3 existing wind farms are all located outside the restricted area.

(4) Future directions: Using the newly developed website ahpcalculator.com, an undergoing experts' survey will be used to calculate the weights of each criterion and subsequently extract the rated area.

(5) Data: All GIS data used in this study were collected from Japan Ministry of Land, Infrastructure, Transport and Tourism unless otherwise specified.

- Wind Data: dat files of 500 m mesh. Source: NEDO;
- Electricity network: kmz file Source: Fukushima power generation Co., Ltd.;
- Road Network: GSI of Japan;
- Slope: Source: SRTM;

(6) Acknowledgments: I would like to thank my supervisor, Prof. Yuji Murayama, for the patient guidance, encouragement and advice.

(7) References:

Tegou, L. I., Polatidis, H., & Haralambopoulos, D. A. (2010). Environmental management framework for wind farm siting: Methodology and case study. *Journal of Environmental Management,91*(11), 2134-2147.

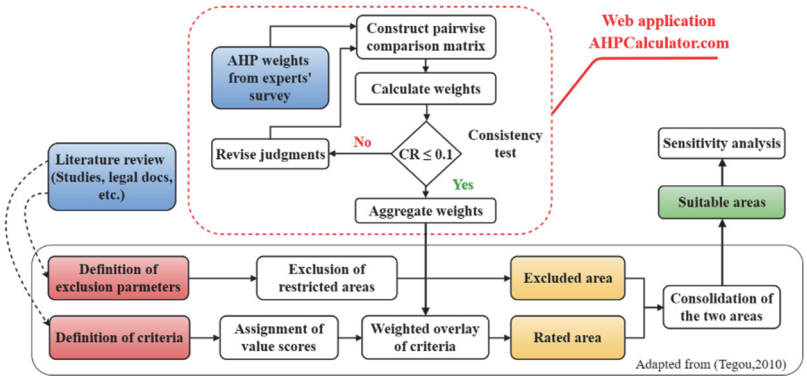

Figure 1: Methodology

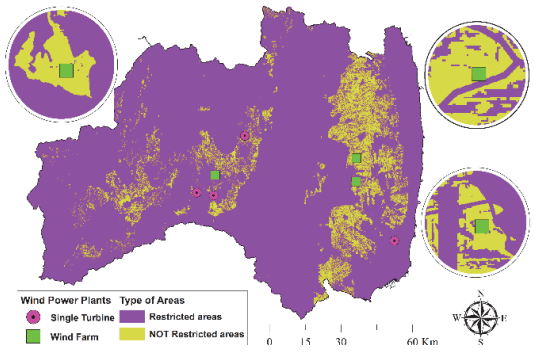

Figure 2: Excluded area