Identifying a Suitable Location for a Solar Renewable Energy Site within Dufferin County Using a Multi-Criteria Evaluation Model

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Abstract

The global populations' reliance on fossil fuels has increased exponentially, leading to a pandemic of environmental problems and a depletion of fuel reserves. Solar renewable energy is expected to become essential as the world transitions toward sustainable efforts and management practices. Dufferin County is an ideal location to introduce solar renewable energy due to its rural landmasses, absence of solar programs, and priorities concerning the county's *Energy Conservation & Demand Management Plan*. To help meet these initiatives, we created a multi-criteria evaluation model to help identify the most optimal site in Dufferin County to develop a solar facility that renders the non-renewable energy sector in the county obsolete while providing enough electricity to a quarter of the county's dwellings (5608).

Our MCE model was based on environmental, legal, technical, social and economical constraints and factors. The model derived a suitability map that indicated possible sites to develop a solar facility. To find the most optimal site to expend 24.5% market share owned by the non-renewable sector and provide sufficient electricity to power 5608 dwellings in Dufferin County, the facility would need to generate 15MW of power annually. A careful calculation deemed the facility would need to occupy an area of 24.2 hectares to meet these standards. Our findings presented the township of East Garafraxa, located in the Southwest Region of Dufferin County, to be the most optimal location for constructing a solar facility.

Research Objectives

1. To determine relevant factors and constraints with the consideration of technical and legal accessibility necessary for the development of solar renewable energy infrastructure;

2. To develop a multi-criteria evaluation (MCE) model to generate an index of suitability;

3. To apply the model to locate the most optimal solar renewable energy site within Dufferin County;

4. To assess the strengths and weaknesses of the research approach.

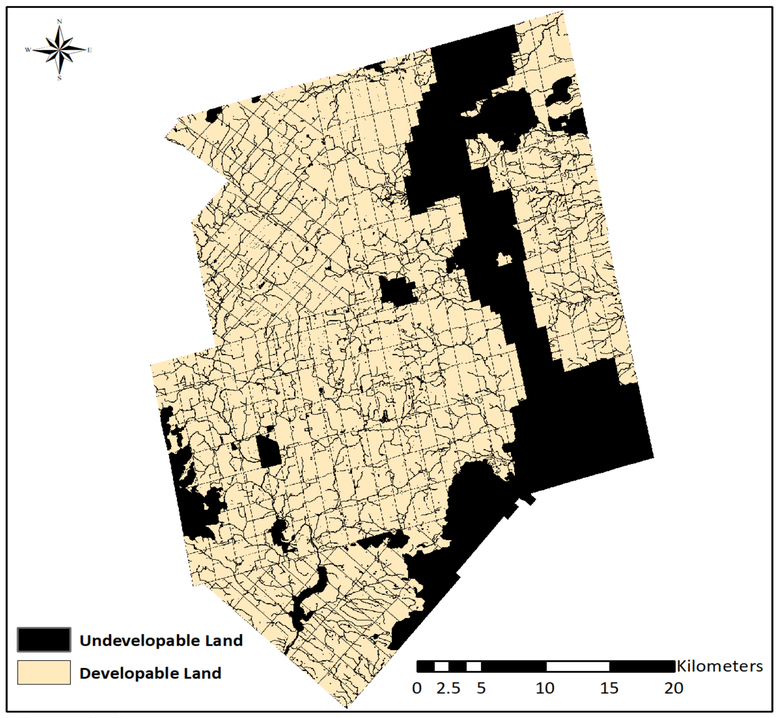

Figure 2. *Constraint map illustrating the undevelopable and developable lands for Solar Renewable Energy in Dufferin County*

Study Area

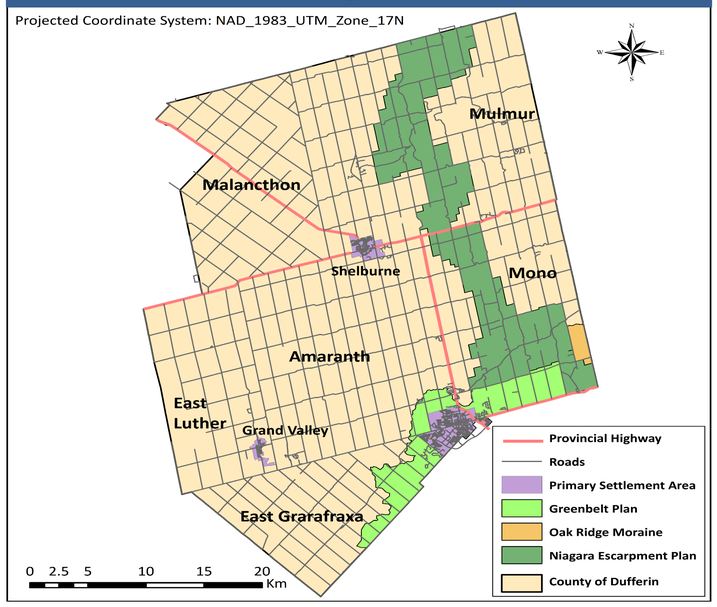

Figure 1. *County Dufferin encompasses by primary settlement areas, Oak Ridge Moraine, Niagara Escarpment Plan and Greenbelt Plan*

Purpose of Research

The purpose of this research is to locate the most suitable site for the development of a solar facility within Dufferin County with the capacity to remove the non-renewable energy sector and power a quarter of all county dwellings.

Methodology

1. Conducted a comprehensive literature analysis on the regulations of the solar industry to ensure that the proposed site satisfies all technical and legal requirements.
2. Accessed open data portals to acquire necessary datasets for the study.
3. Created a multi-criteria evaluation model to generate an index of suitability for solar site development.
4. Identified the most optimal 24.2 hectare site through calculations.
5. Addressed research gaps and potential for future studies.

Table 1. *Pairwise Comparison Table ranking relevance of factors pertaining to solar facilities*

Pairwise Ranks											
	Utility Factor	Roads Factor	Slope Factor	Irridation Factors	ANSI Factors	Aspect Factor	Provincial Parks	Wooded Area	Water Factor	Greenbelt Factor	Agricultural Land Factor
Utility Factor	1	9	3	9	5	3	7	7	7	9	3
Roads Factor	1/9	1	1/9	3	7	9	3	5	7	3	7
Slope Factor	1/3	9	1	7	3	3	7	3	5	7	3
Irridation Factor	1/9	1/3	1/7	1	1/7	1/9	1/3	1/7	1/5	1/3	1/7
ANSI Factor	1/5	1/7	1/3	7	1	1/5	3	1/3	3	5	3
Aspect Factor	1/3	1/9	1/3	9	5	1	7	3	5	7	3
Provincial Park Factor	1/7	1/3	1/7	3	1/3	1/7	1	1/5	1/3	3	1/7
Wooded Area Factor	1/3	1/5	1/3	7	3	1/3	3	1	3	5	1/3
Water Factor	1/7	1/7	1/5	5	1/3	1/5	3	1/3	1	3	1/5
Greenbelt Factor	1/9	1/3	1/7	3	1/5	1/7	1/3	1/5	1/3	1	1/7
Agricultural Land Factor	1/3	1/7	1/3	7	1/3	1/3	7	3	3	7	1
SUM	3.1524	20.7397	6.0730	61.0000	25.3429	17.4635	41.6667	23.2095	34.8667	50.3333	20.9619

Individual Weights												Total Weights
	Utility Factor	Roads Factor	Slope Factor	Irridation Factors	ANSI Factors	Aspect Factor	Provincial Parks	Wooded Area	Water Factor	Greenbelt Factor	Agricultural Land Factor	
Utility Factor	0.3172	0.4340	0.4940	0.1475	0.1973	0.1718	0.1680	0.3016	0.2008	0.1788	0.1431	0.2504
Roads Factor	0.0352	0.0482	0.0183	0.0492	0.2762	0.5154	0.0720	0.2154	0.2008	0.0596	0.3339	0.1658
Slope Factor	0.1057	0.4340	0.1647	0.1148	0.1184	0.1718	0.1680	0.1293	0.1434	0.1391	0.1431	0.1666
Irridation Factors	0.0352	0.0161	0.0235	0.0164	0.0056	0.0064	0.0080	0.0062	0.0057	0.0066	0.0068	0.0124
ANSI Factors	0.0634	0.0069	0.0549	0.1148	0.0395	0.0115	0.0720	0.0144	0.0860	0.0993	0.1431	0.0641
Aspect Factor	0.1057	0.0054	0.0549	0.1475	0.1973	0.0573	0.1680	0.1293	0.1434	0.1391	0.1431	0.1174
Provincial Park Factor	0.0453	0.0161	0.0235	0.0492	0.0132	0.0082	0.0240	0.0086	0.0096	0.0596	0.0068	0.0240
Wooded Area Factor	0.1057	0.0096	0.0549	0.1148	0.1184	0.0191	0.0720	0.0431	0.0860	0.0993	0.0159	0.0672
Water Factor	0.0453	0.0069	0.0329	0.0820	0.0132	0.0115	0.0720	0.0144	0.0287	0.0596	0.0095	0.0342
Greenbelt Factor	0.0352	0.0161	0.0235	0.0492	0.0079	0.0082	0.0080	0.0086	0.0096	0.0199	0.0068	0.0175
Agricultural Land Factor	0.1057	0.0069	0.0549	0.1148	0.0132	0.0191	0.1680	0.1293	0.0860	0.1391	0.0477	0.0804
SUM	1	1	1	1	1	1	1	1	1	1	1	1

Research Findings

The constraint map (Figure 2) provides a detailed overview of areas prohibited from structural development within Dufferin County due to political, economic, technical, and spatial barriers. Additionally, it indicates areas suitable for site development within Dufferin. The study indicates a distinction of environmental and social factors. Furthermore, the MCE model developed a suitability map that we used to narrow down the most suitable location for a solar facility on a scale ranging from 0 to 0.85. The area highlighted in red within (Figure 3), situated in the lower Dufferin County region is the most appropriate area for developing a solar facility. It indicates proximity to utility lines is critical when developing a solar facility. With the aim of producing enough electricity to serve a quarter of Dufferin's homes and sufficiently to offset its non-renewable energy sector, we learned that the planned solar farm would have a minimum scale of 24.2 ha, situated in East Garafraxa Township.

A potential weakness revealed by our results was that we did not consider the impact adjacent counties have on determining the optimal site. For instance, the best location in our model for a solar facility within Dufferin County is within the southwest region. A problem emerges since this corner borders Wellington, it might not be in Wellington's best interests to build a solar facility at this site. The findings inform us that we found the best location for Dufferin County and not an ideal site for the parties involved.

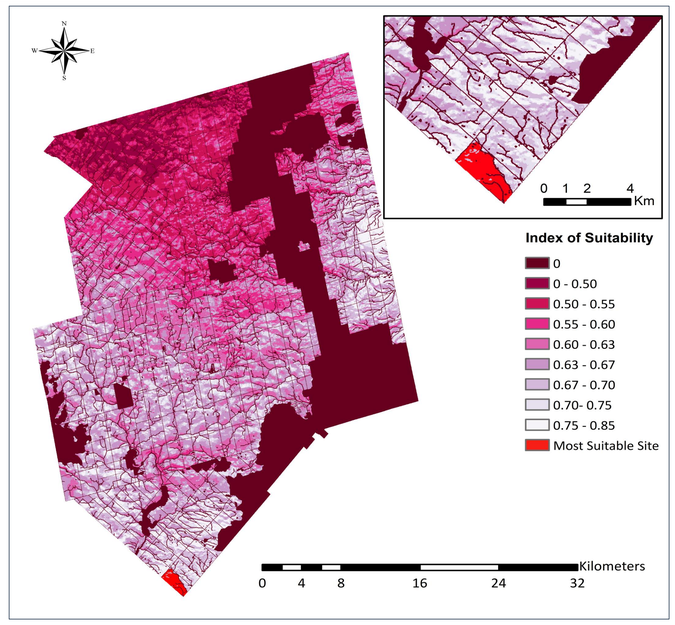

Figure 3. *Index of Suitability for the development of a solar facility within Dufferin County including the highlighted 24.2ha most suitable site.*

Conclusion

This study was conducted with the purpose of identifying the most suitable location within Dufferin County to construct a solar facility with the capacity to generate enough power (15MW) to supply a quarter of all dwellings and eliminate its non-renewable energy sector (Dufferin County, 2020). To comply with such standards, our calculations concluded the site would need to be 24.2ha in size which would be built in the southwest corner of the township of East Garafraxa. The MCE administered this area to host the most suitable site due to it being a densely populated and functioning area within Dufferin county. Townships are within proximity to the most important variables to a solar facility (utility lines, roads) and are generally isolated from important constraints (i.e.. ecological features).

Future studies should choose not to treat Dufferin County as a separate entity, yet a piece of a more complex system. This is due to the fact that decisions made in Dufferin have adverse effects on neighbouring counties. Finally, the potential for solar rooftop implementation should be further examined as accompanying rooftop solar can drastically reduce the area occupied by a solar facility. We omitted finding rooftops for solar panels as the study requires a vastly different analysis and was not appropriate to carry out for a project of our time frame.

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