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 economic 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.

Problem Context

Problem Definition and Significance of the Research Problem:

The renewable energy sector has experienced tremendous growth in recent decades due to immediate threats such as climate change, resource scarcity, and rapid population growth. These circumstances have amplified energy requirements necessary for supporting quality of life and economic growth. Society's reliance on fossil fuels has increased, leading to a pandemic of global environmental impacts (Richter, 2010). This has led policymakers, planners, political authorities, and stakeholders to reassess the uses and potential benefits of renewable energy. Diverting from primary energy resources to alternative energy technologies enables development practices that achieve both sustainability and environmental balance (Wekerle et al., 2007). The province has yet to invest in the wide-scale development of solar renewable energy; thus, Ontario is not capitalizing on this valuable renewable energy source (Etcheverry, 2004). Opportunities to develop sources of renewable energy should be a major priority for the government and local municipalities in order to meet emission goals and enforce sustainability.

The County of Dufferin contains prime real estate for renewable energy development due to its rural nature yet has not been capitalized. Dufferin is adamant in supporting sustainable growth of major urban and agricultural areas within proximity to the Greater Toronto Area. Unfortunately, the county is burdened with two seemingly contradictory notions: growth management and environmental conservation (MMM Group, 2017). Renewable energy may assist in creating a coexisting relationship between these two variables by considering economic needs while also assessing environmental limitations. A recent study supports the notion that renewable energy is just as capable as non-renewable sources in meeting energy demands (Sütterlin & Siegrist, 2017). Solar renewable energy is the most efficient in terms of its longevity and reliability resulting from its sustainable production properties (Smitherman, 2008). Though such alternative forms of energy are sustainable, the potential environmental and social consequences cannot be discredited. If the constraints and relative benefits of construction are not assessed, development can have detrimental impacts upon the local environment (Kiker et al., 2009). Therefore, various conditions and criteria must be assessed before a site can be deemed suitable for development.

Current State of Knowledge and Research Gaps

In determining suitable sites for solar renewable infrastructure, development must be compliant with federal, provincial, and municipal guidelines and regulations. For example, there are various considerations concerning the *Green Belt Plan, County Official Plan,* along with Municipal/Provincial building and zoning laws. Lands exempted from site development to comply with regulations and guidelines are federally protected lands, provincial parks, prime agricultural land (Class 1 2 3 lands and Specialty Crops) and Areas of Natural and Scientific Interest (ANSI). There are also areas within the County of Dufferin that are not protected by law but are strongly opposed to development. This includes areas where large scale infrastructure is present such as built-up areas, primary settlement areas, and roads.

Solar facilities have many guidelines and regulations they must adhere to, to protect certain areas from development. Under the *Ontario Heritage Act*, a solar facility may not be developed within 250m of archaeological sites, or 30m within a river, coastline or waterbody; this includes lakes, permanent streams, intermittent streams, and seepage areas (Government of Ontario, 2012). Moreover, there are areas within Dufferin County that are economically unfeasible and ecologically unsustainable for solar farms. For example, to develop on areas of woodland, contractors must deforest the land in order to build the solar facility. This costs significantly more than developing on currently accessible land and avoids environmental damages. Research in analyzing the adverse effects of building within proximity to ecological ecosystems has displayed primarily negative impacts such as point-source pollution, loss of biodiversity, and habitat destruction (Cameron, 2014). For that reason, the further away development is from sensitive ecological communities and effective grounds the better (Cameron, 2014). Additionally, areas facing north at greater than 10° are economically unfeasible for development as panels at these slopes do not receive an adequate amount of solar irradiance for the costs of implementation (Calvert, 2019).

A barrier with our analysis is that it is unknown which areas will be impacted by shadow overcasts. Overcasts from clouds, trees, and buildings can render photovoltaic panels relatively ineffective (Choi et al., 2019). A research gap of past studies has been that land determined optimal for solar development being denied for development due to the land already generating revenue (e.g. 5 agricultural land), and servicing an ecosystem (Deambi, 2016). Not knowing areas municipalities are not willing to convert to a solar farm is a significant hurdle Lastly, a major gap was that our analysis did not observe the potential of solar rooftop energy. There is minimal urban construction within Dufferin County, so it was decided to exclude this from our study. Further research could be conducted to determine whether implementing solar rooftops would be an efficient route for the county.

Importance of GIS Applications in Our Study

GIS applications have proven to be an essential asset in assisting the development of the *County Official Plan*, *Local Municipal Official Plans*, and the *Municipal Comprehensive Review* within Dufferin County. These applications provide an effortless way to store, check and manipulate massive datasets that humans cannot handle. Furthermore, the application also allows for the modelling of complex relationships between environmental, spatial, economic, and technical variables, making it invaluable in solving complex problems such as locating the most suitable site for the development of renewable energy sources (ESRI, 2010). Overall, GIS applications accelerate the decision-making process and provide essential insight necessary for planning and development practices.

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.

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.

Study Area

Dufferin County sits on the outskirts of the Greater Toronto Area residing just 100 km outside of Northwest Toronto. The county is largely rural with much of the land designated for development and municipal growth. Moreover, the county contains only three major settlement areas (Grand Valley, Orangeville, and Shelburne) (Figure 1). Based on a recent 2016 consensus, the population of this vast area (149,667 ha) is rather minimal, supporting 61,735 residents and a total of 22889 dwellings (Statistics Canada, 2016). Primarily rural landscapes are very appealing locations for the implementation and development of renewable energy due to the widespread availability of developable land, remoteness (lack of urbanization), expansion opportunities, and the ability to trigger rural economic growth.

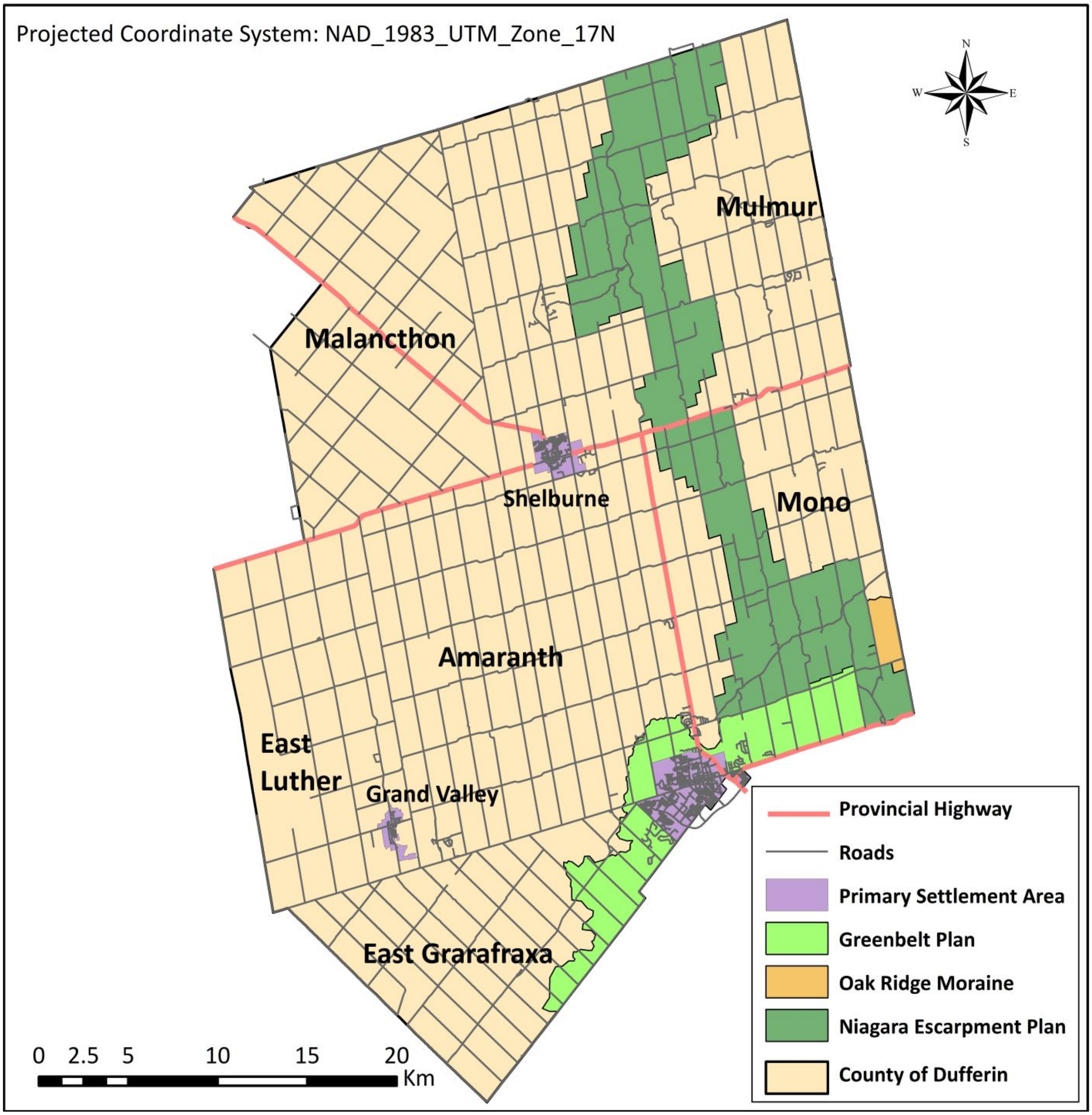


Figure 1: County Dufferin encompasses primary settlement areas, Oak Ridge Moraine, Niagara Escarpment Plan and Greenbelt Plan

Research Approach

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

Criteria and constraints that arise when implementing renewable energy facilities can fall within four groups: environmental, legal, technical, and economical (Szurek, Blachowski, & Nowacka, 2014). A comprehensive literature review of legislation and political documents on a national, provincial, and municipal scale was conducted to help govern guidelines critical for site establishment in a legal manner and find areas within Dufferin county undevelopable due to lawful infractions (Government of Ontario, 2012) (Table 1). Additionally, an extensive literature review on the solar industry's regulations was revised to ensure the proposed site met technical and legal requirements. This enabled the creation of criteria such as the further away the solar facility is built from ecological ecosystems or productive grounds, the better because it reduces the adverse effects. Inversely, building a solar farm closer to utility lines and roads is optimal. It reduces the cost spent on infrastructure to transfer the generated electricity to the power lines and allows for easier access to the facility for maintenance reasons (Cameron, 2014; Calvert, 2019). With regard to slope and aspect, a flat area facing south optimized Global Horizontal Irradiance while trending away lowered the solar farm's energy production (Deambi, 2016). GHI was minimal in determining the best site because its values did not vary, resulting in very similar electricity production (Calvert, 2019).

Table 1: Contains information on what type of constraint each variable is and if building the solar facility closer or father from the variable is good. It also contains information on if the variable is a spatial or not.

Variables	Legal Constraint	Economic Constraint	Technical Constraint	Social Constraint	Better to develop solar facility closer to variable or farther	Standardization Method	Spatial Features
Provincial Park Regulated	✔	—	—	—	Farther	Benefit Factor	Yes
Ontario Road Network: Road Net Element	—	✔	—	—	Closer	Cost Factor	Yes
Ontario Hydro Network (OHN) Watercourse	✔	—	—	—	Farther	Benefit Factor	Yes
Ontario Hydro Network (OHN) Waterbody	✔	—	—	—	Farther	Benefit Factor	Yes
Greenbelt Outer Boundary	✔	—	—	—	Farther	Benefit Factor	Yes
Agricultural Class1,2,3 and Specialty Crops	✔	—	—	—	Farther	Benefit Factor	Yes
Built Up Area	—	✔	—	✔	Farther	Benefit Factor	Yes
Wooded Areas	—	—	—	—	Farther	Benefit Factor	Yes
Slope and Aspect	—	✔ developing on north facing slopes above 10° or slopes steeper than 35° cost more	✔ Output of energy is not worth developing on north facing slopes above 10° or slopes steeper than 35°	—	—	Slope: Cost Factor Aspect: Trigonometric equation followed by Cost Factor	Yes
Areas of Natural and Scientific Interest	✔	✔	—	✔	Farther	Benefit Factor	Yes
Utility Line	—	—	—	—	Closer	Cost Factor	Yes
Global Horizontal Irradiance	—	—	—	—	—	Cost Factor	No

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

There were many steps in developing an MCE model that produced an index of suitability map (Figure 2 and 3). Firstly, all datasets relevant to the study were downloaded and screened through a rigorous quality check. The accuracy and precision of the spatial datasets were checked by comparing them to images in Google Maps, Pocket Earth and Bing Maps. The attribute table of each dataset was analyzed, any incorrect, corrupt or duplicate data found and removed. The quality check removed any wrong lingering datasets that passed the comparison check and helped create new datasets using the select by location and select by attribute tool. Datasets covering Canada and Ontario were then clipped to the extent of Dufferin and created buffers around the rivers, water bodies, and ANSI shapefiles to mark areas legally inaccessible for development. With the Provincial Digital Elevation Model (PDEM), the Mosaic to New Raster tool was used to merge the tiff files covering parts of Dufferin county, the slope and aspect tools were used to obtain slope and aspect. The derived aspect was standardized using a trigonometric standardization formula, $\left(sin = \frac{\theta}{2}\right)$due to it being a directional variable, then clipped to the extent of Dufferin; finally, new break values were set to define compass directions (Figure 4). With the clipped slope and newly defined aspect, a Boolean overlay was converted, making north-facing slopes above 10 degrees unsuitable for development. Next, all vector constraints were converted to a raster using the Polygon/Polyline to Raster tool. Each constraint was reclassified into a binary format, the raster calculator was used to multiply the constraint maps to produce a final constraint map (Equation 1).

Next, we began the procedure of creating criteria maps (Figure 3). Our GHI dataset contained sparse polygons. Polygons were converted to points using the Feature to Point tool and assigned values to areas missing data, through a Thiessen Polygon interpolation. Next, the interpolated data was clipped to the extent of Dufferin and converted from a polygon to a raster. To continue, the Euclidean distance tool was used on all spatial features excluding slope and aspect, each dataset was standardized with the benefit factor equation and the cost factor equation (Equation 2 & 3). The standardized data was clipped to the extent of Dufferin, all the spatial features were standardized again (Figure 5 and 6). With the factors and constraints established, a set of weights was developed for the criteria by establishing the relative importance of each criterion to the research. In order to eliminate user-bias to a certain degree, studies and literature sources were considered to ensure our weighting scheme produced legitimate results (Graymore et al., 2012). This allowed us to create a pairwise comparison table (Table 2). Using these established weights, and constraint and criteria maps, the index of suitability map was developed for solar facility development at various locations through a raster calculation (Equation 4). The map displays how suitable a location is to develop a solar facility through a scale stretching from 0 to 0.85.

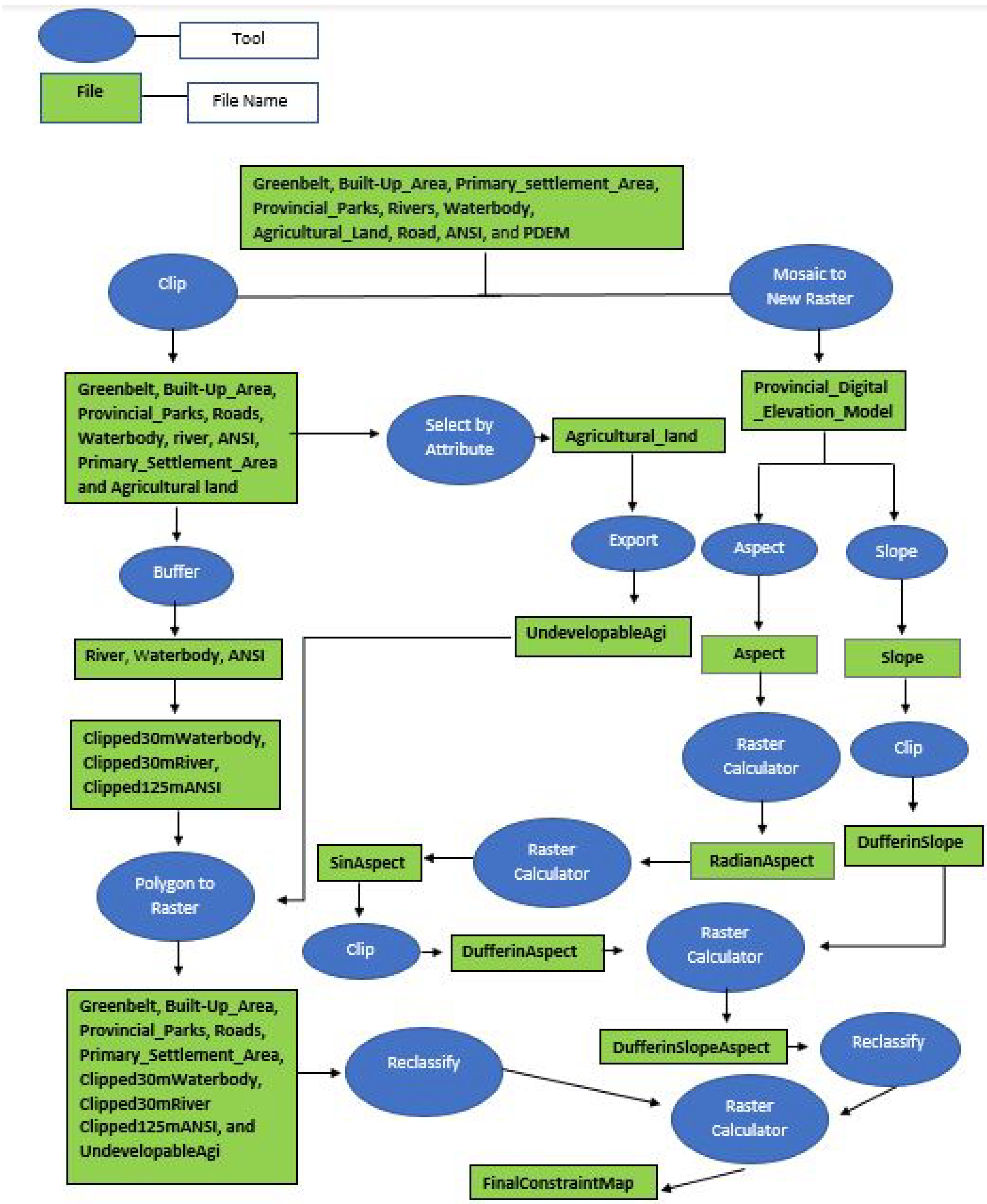


Figure 2: Workflow of creating a constraint map. The blue ovals indicate a tool and the green rectangles indicate a file

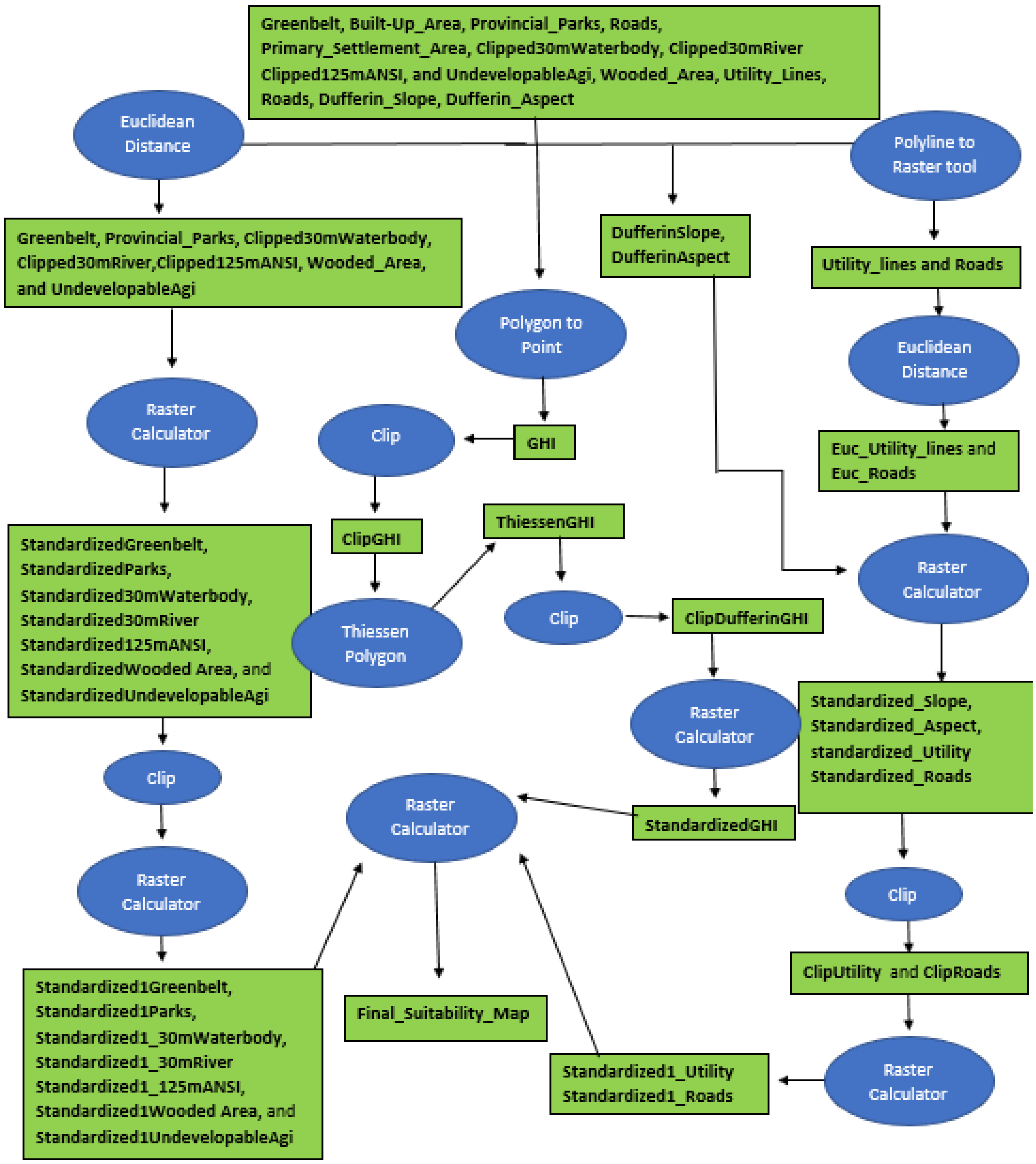
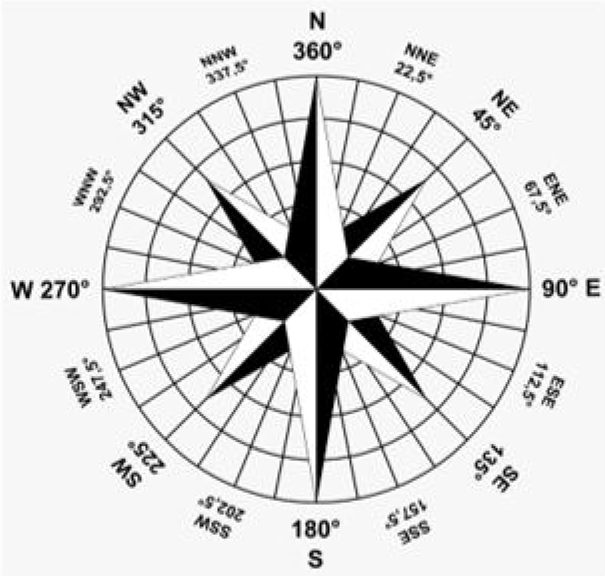


Figure 3: Workflow of creating a suitability map. The blue ovals indicate a tool and the green rectangles indicate a file



Compass Bearings	
North	0-0.17
Northeast/Northwest	0.17-0.57
East/West	0.57-0.81
Southeast /Southwest	0.81-0.98
South	0.98-1

Figure 4: Directional variable aspect standardized using Sin(θ/2) followed by bearings being defined

Equation 1: Formula used in raster calculator to produce a final constraint map

$$M = C_1C_2C_3C_4C_5C_6C_7C_8C_9C_{10}$$

C – Constraint (Binary)

M – Final Constraint Map

Equation 2: Benefit factor equation used to standardize certain variables in Table 1

$$x'_{ij} = \frac{x_{ij}-x_{min}}{x_{max}-x_{min}} \qquad Benefit\ Factor - Higher\ Score = better$$

Equation 3: Cost factor equation used to standardize certain variables in Table 1

$$x'_{ij} = 1 - \frac{x_{ij}-x_{min}}{x_{max}-x_{min}} \quad Cost\ Factor - Higher\ Score = worse$$

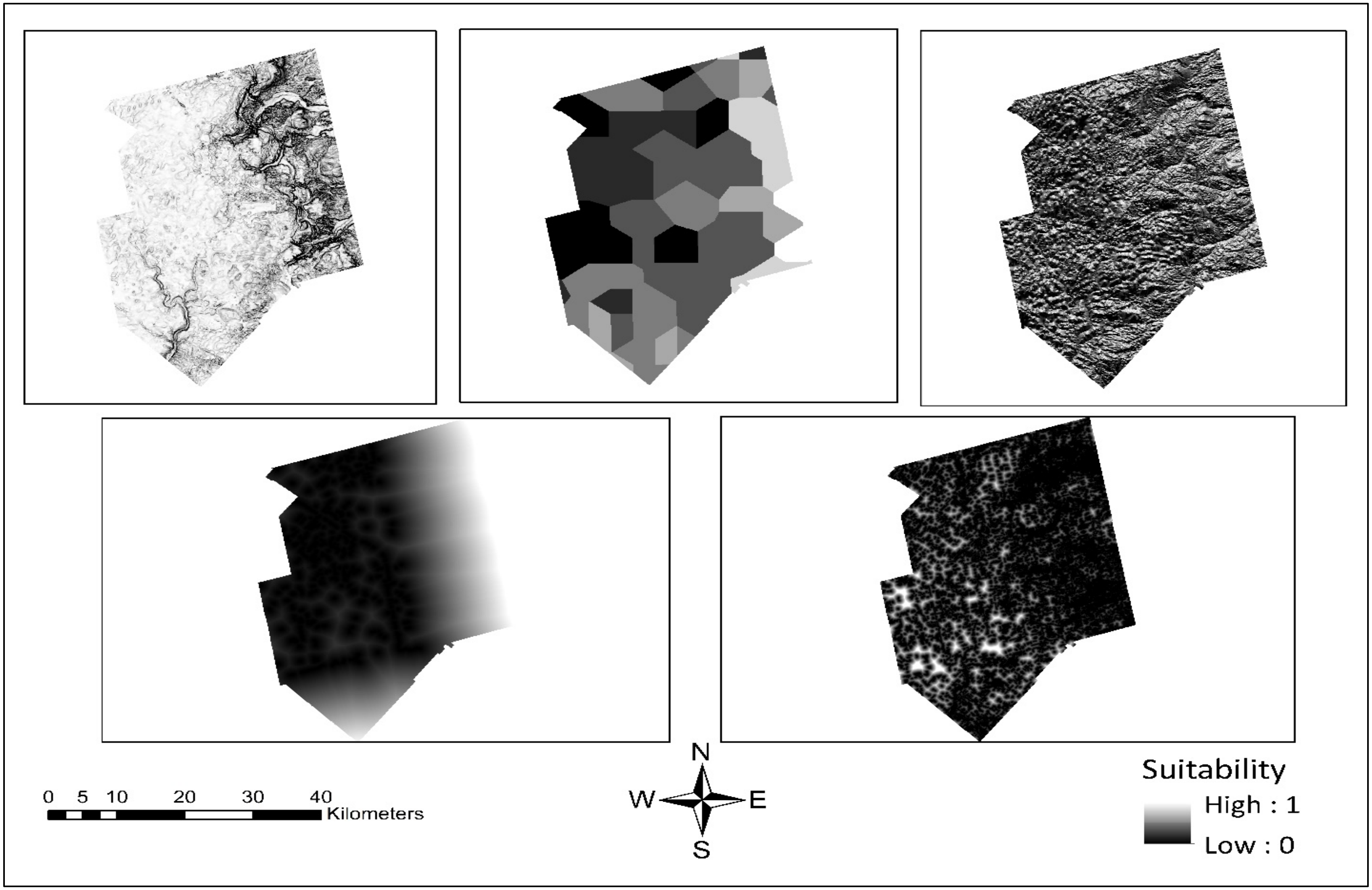


Figure 5: Map of slope, GHI, aspect, agricultural land and wooded area standardized and clipped to the extent of Dufferin

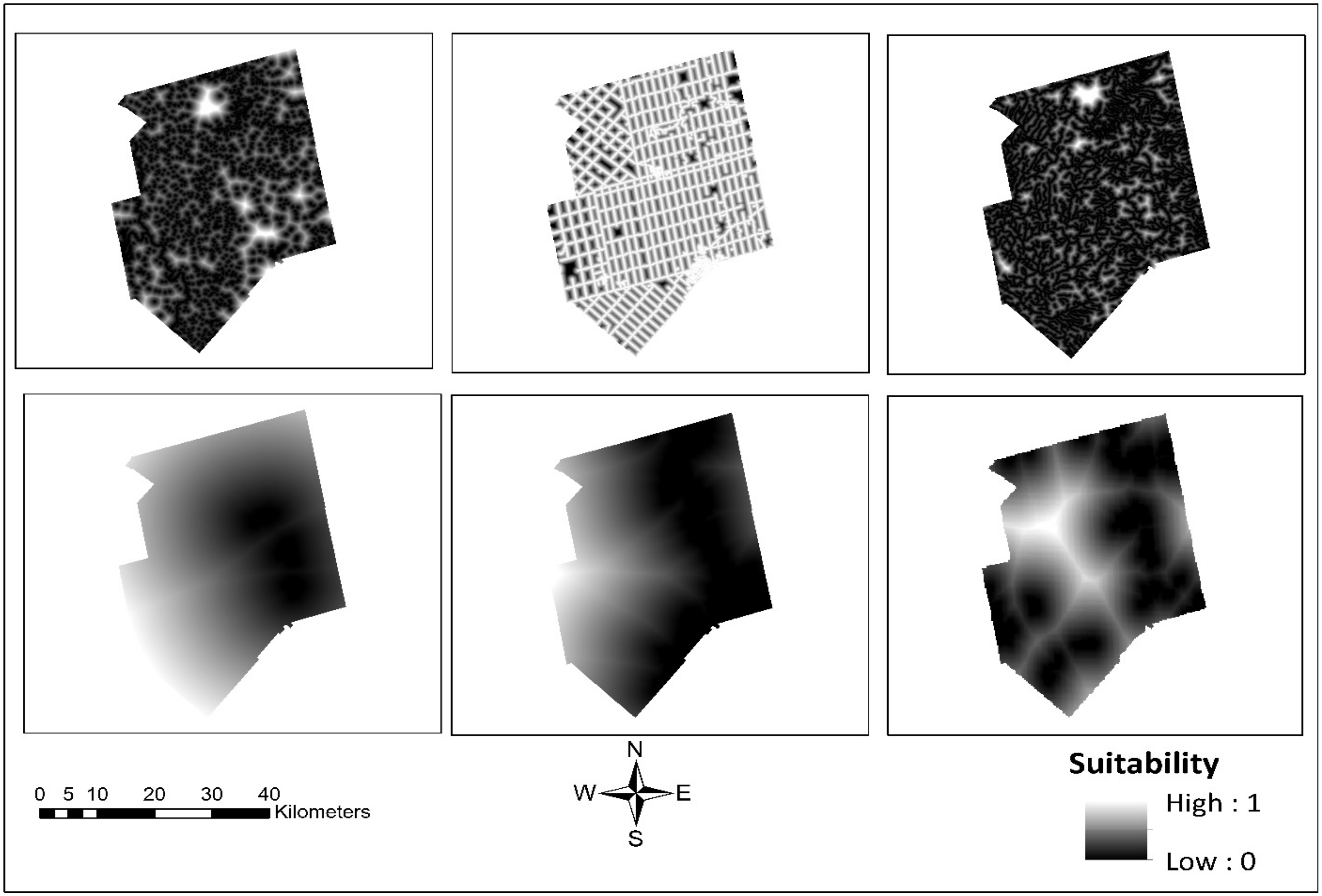


Figure 6: Map of water, road, river, provincial park, greenbelt and ANSI standardized and clipped to the extent of Dufferin

Table 2: Pairwise comparison table. A table ranking the 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

Equation 4: Equation used to produce a suitability index

$$S = M\,(F_1W_1 + F_2W_2 + F_3W_3 + F_4W_4 + F_5W_5 + F_6W_6 + F_7W_7 + F_8W_8 + F_9W_9 + F_{10}W_{10} + F_{11}W_{11} + F_{12}W_{12})$$

S – Suitability Score

W – Assigned weights for each factor

F – Factors

M- Final Constraint Map

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

The size of the proposed solar facility must be able to produce enough power to supply a quarter of Dufferin's dwellings and enough to replace its non-renewable energy sector (Equation 5). The dataset area of the suitability map was calculated and divided by the size of the solar facility to retrieve the number of intervals (Equation 6). That value was used as a parameter in the slice tool to reclassify cells within the suitability map into zones of equal area. The reclassify tool was used again on the generated map to change the highest value zone to 1 and all other values to No Data. This identified the best areas of land to build a solar facility. To identify the best 24.2ha of continuous land to build a solar facility, a Region Group was conducted on the reclassified map, and a Zonal Statistic as a Table on the map produced by Region Group and joined the two outputs together (Figure 7). Then the sum field was reclassified, changing the highest value to 1 and all other values to No Data. This produced a raster of the best site to develop a solar facility within Dufferin County.

Equation 5: Formula used to derive the acre requirement for the optimal location

$$A = N*P*(Q/15000) * (10800*/E)$$

A – Acres

N – Number of Dwellings

P – Percentage of Dwellings Supplied by non-renewable energy

Q – Quantity of energy required to supply 15000 homes (MW)

E – Energy required to supply an area of 10800 acres (MW)

Equation 6: Calculations to locate the best site

Cell Area = (Cell Size) * (Cell Size)
Number of Cells = (Number of Columns) *(Number of Rows)
Dataset Area = (Cell Area) *(Number of Cells)
Number of Intervals = (Dataset Area/24.2ha)

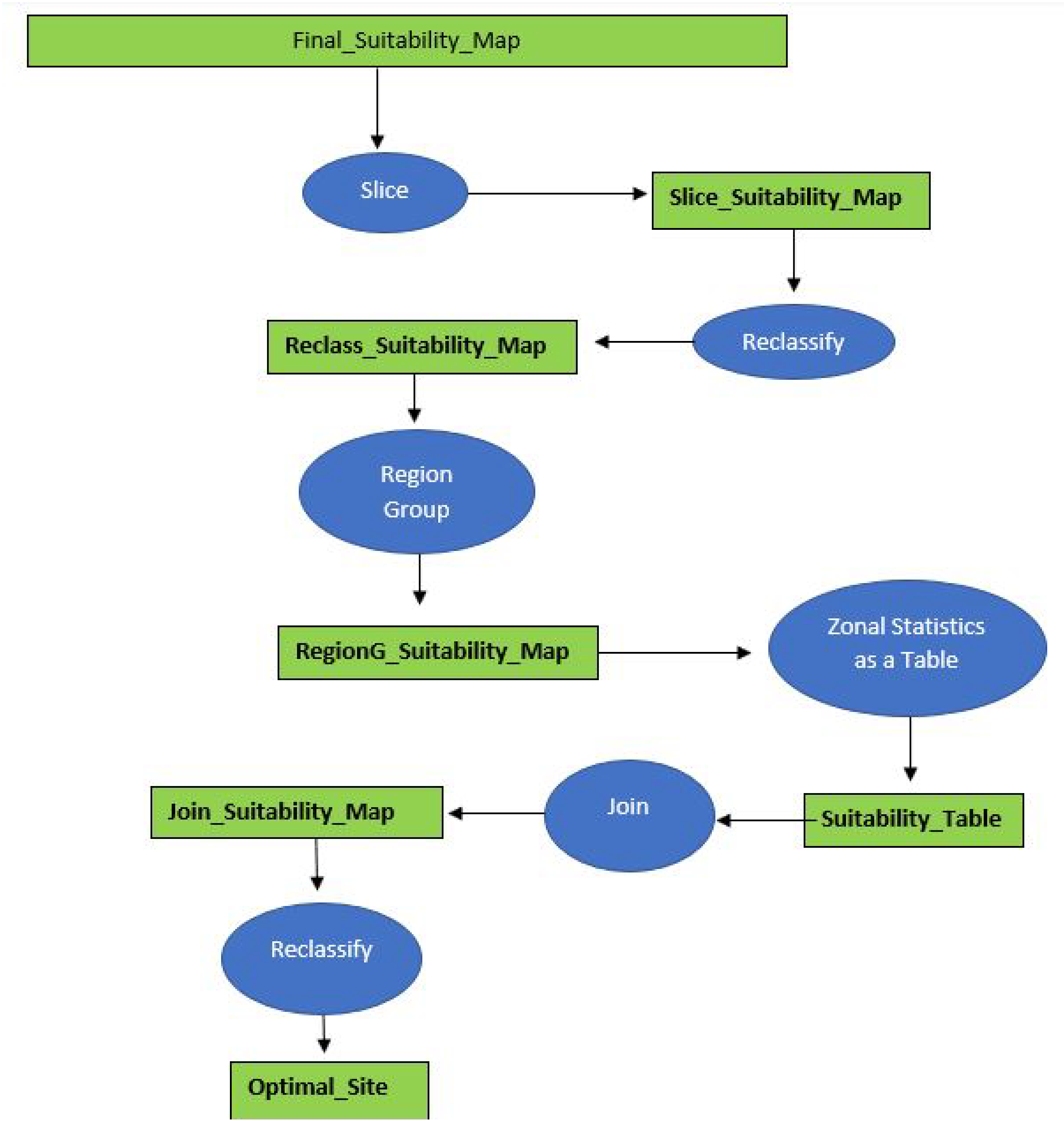


Figure 7: Workflow for locating the most optimal site

Objective 4: To assess the strengths and weaknesses of the MCE model:

There are many strengths with our MCE model. The model is variable rich, containing information on constraints and factors from a legal, economic, spatial and environmental scale to derive the most optimal location for solar facility development. However, there are small weaknesses in the approach that can be attributed to data, software, and model limitations. For example, our GHI dataset was very sparse and needed to be interpolated. This ultimately led to a less accurate depiction of GHI data.

A software limitation was represented through the absence of conducting a shading impact analysis. This analysis provides vital information on shades brought forth by buildings and vegetation that will render solar panels futile (Choi et al., 2019). Moreover, there is a weakness of using an MCE itself. The results are highly dependent on the subjective process of establishing weights and therefore results will vary. Additionally, different MCE equations can constitute different results; thus, our overall analysis may vary under distinct circumstances (Wood, 2009). Furthermore, certain variables in the study are continuous such as GHI, they will yield different results in the MCE daily. To alleviate these weaknesses multiple MCEs with varying weights can be conducted; alternatively, MCE methods like ideal point analysis and concordance-discordance analysis could be utilized to formulate relative risk and alternative approaches that would amplify the legitimacy of research.

Research Findings

Figure 8 enables a comprehensive understanding of areas within Dufferin County prohibited from structural development due to legal, environmental, technical, and spatial barriers. It also displays areas within Dufferin available for site development. This analysis of differentiation is essential as it shows us the lands needed to undergo critical analysis to discover what is the best site.

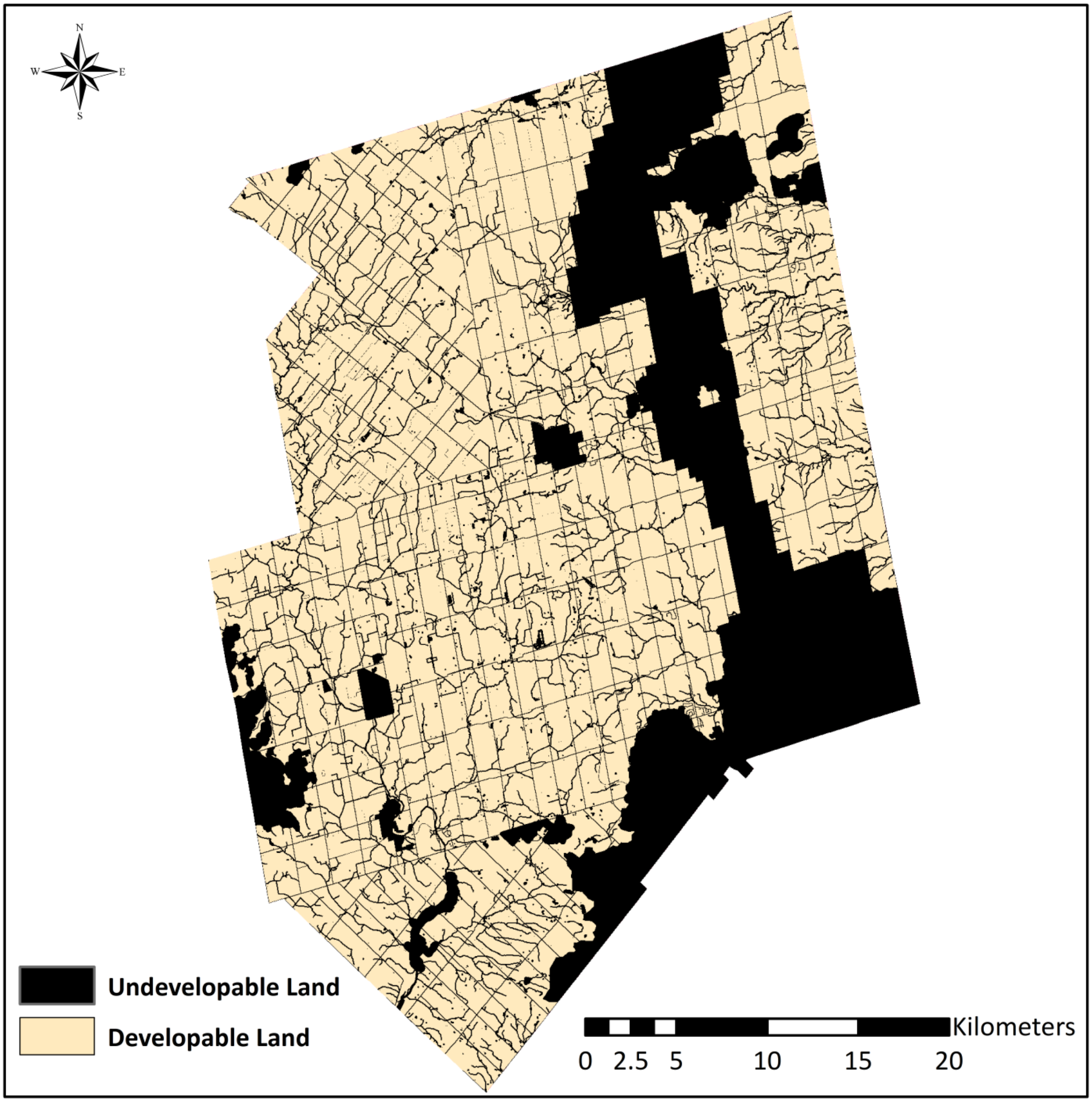


Figure 8: Constraint map illustrating developable land and undevelopable land within Dufferin County

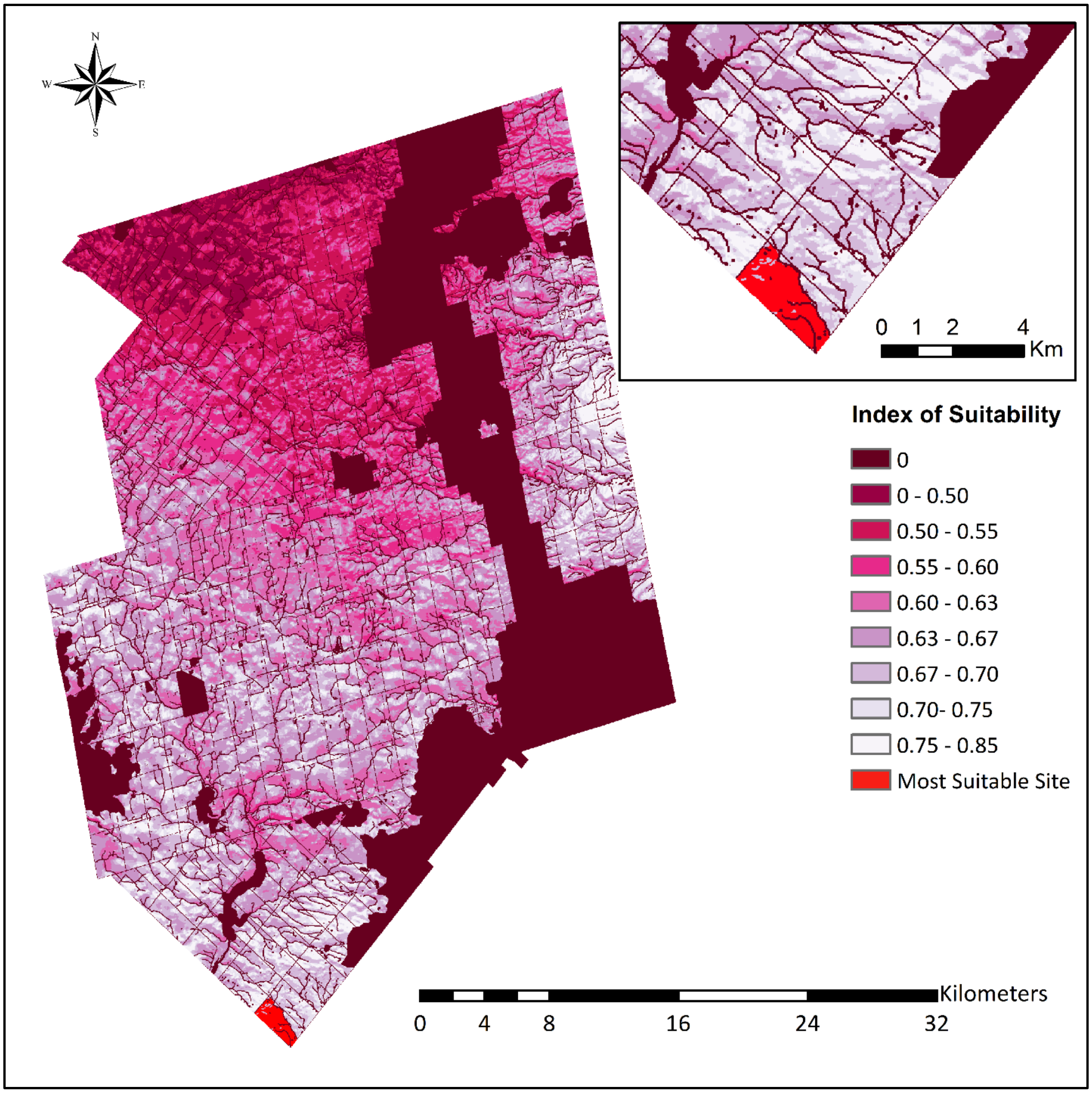


Figure 9:Index of Suitability for the development of a solar facility within Dufferin County including the highlighted 24.2ha most suitable site

Figure 9 displays an index of suitability and the most suitable location for the development of a 24.2-hectare facility. The best areas are located closely along the path of utility lines. This is because it held the highest weight in our pairwise comparison and is only found in the major towns of Dufferin. As distance gradually increases from these highly suitable areas of development, the map gets darker and less suitable for solar farms. This indicates the importance of proximity to utility lines.

With the goal of generating enough power to supply a quarter of Dufferin's dwellings and enough to replace its non-renewable energy sector, it was discovered the proposed solar facility had to be a minimum size of 24.2ha (equation 5). Such a facility would expend 24.5% market share owned by the non-renewable sector and provide enough electricity to power 5608 dwellings. Figure 9 shows the best site to develop a solar facility encompassing 24.2ha of land. The proposed facility location is in the township of East Garafraxa. The proposed location indicates the heavy indirect influence of townships on solar facility development. Townships are where utility lines are erected, ecological features are limited, and lands have already been manipulated for construction. These are highly suitable conditions for developing a solar facility and can be an essential factor in situating the most optimal site.

The best site encompassed areas not intended for solar facility development. To compensate the model derived other more optimal areas for energy production to satisfy the area requirement. It is unrealistic to think a developer will avoid these patches of functioning land for more optimal pieces of land that require more funds to acquire. A lapse depicted by our findings was that the effects that neighbouring counties have in determining the optimal site were not considered. For example, the best site for a solar facility in our model is in the south-west corner of Dufferin. A problem emerges since this corner borders Wellington, and the implementation of a solar facility at this location may not be in the best interest of Wellington. A careful review of the findings indicated the most suitable site for the County of Dufferin is not the optimal for all affected parties.

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 but a piece of a more complex system. This is because decisions made in Dufferin have adverse effects on neighboring 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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Appendix

Data Information

Dataset	Source of Data	Date Data was Last Modified	Brief Description
Provincial Park Regulated.shp	Ministry of Municipal Affairs and Housing	12-20-2019	Displays areas of provincial parks and conservation reserves in Ontario that are permanently protected under the Provincial Parks and Conservation Reserves Act, 2006. Data were derived from regulation plans
Ontario Road Network: Road Net Element.shp	Ontario Ministry of Natural Resources and Forestry - Provincial Mapping Unit	09-27-2019	Displays province-wide road network of Ontario derived from high-resolution satellite
Ontario Hydro Network (OHN) Watercourse.shp	Ontario Ministry of Natural Resources and Forestry - Provincial Mapping Unit	10-10-2019	Displays locations of flowing surface water throughout Ontario with a linear feature. This data was derived from high-resolution satellite
Ontario Hydro Network (OHN) Waterbody.shp	Ontario Ministry of Natural Resources and Forestry - Provincial Mapping Unit	07-12-2018	Displays location of water body water body features (Lakes, ponds, kettle lakes) throughout Ontario. This dataset was derived from high-resolution satellite

Greenbelt Outer Boundary.shp	Ministry of Municipal Affairs and Housing	02-24-2005	Displays area of the Greenbelt established by Ontario Regulation 59/05. Encompasses over 800 000 hectares of land and includes portions of the Oak Ridge Moraine and the Niagara Escarpment. This dataset was derived from previous maps of municipal boundaries.
Agricultural Resource Inventory.shp	Ontario Ministry of Agriculture, Food and Rural Affairs	10-10-2018	Projects areas of different agricultural land (farm, rough lands, fencerows, fields) across Ontario. This dataset was derived from ortho imagery
Built Up Area.shp	Ontario Ministry of Natural Resources	09-04-2019	Projects areas in Southern Ontario that contain anthropogenic features. Dataset derived from Orthophotography
Wooded Areas.shp	Ministry of Natural Resources and Forestry	04-10-2019	Depicts areas within Ontario covered by trees and forestry
Provincial Digital Elevation Model.shp	Ontario Ministry of Natural Resources and Forestry - Provincial Mapping Unit	10-15-2018	Dataset provides information on ground elevation across Ontario
Areas of Natural and Scientific Interest.shp	Ministry of Natural Resources	07-12-2018	The dataset contains information on highly regarded features and natural landscapes that are principal to protection, education, natural heritage, appreciation, or scientific study

Utility Line.shp	Ontario Ministry of Natural Resources and Forestry - Provincial Mapping Unit	4- 24- 2019	Display linear utility features within the county that provide power, water, communications, or fuel heating services.
Solar Irradiation.shp	National Renewable Energy Laboratory	12-29-2016	The dataset contains information on global horizontal irradiance values across North and South America.

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