Potato Land Suitability Dynamics in Future Climate Scenarios for Ontario, Canada

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Background

Climate change projections expect temperatures to increase and cause erratic precipitation, raising concerns for agricultural producers[1]. Cropping systems depend on specific climatic and landscape variables to ensure food availability locally and abroad[2]. As such, crop growth variables impacted by climate change such as daylight hours, soil characteristics, precipitation, growing degree days, and frost may subsequently affect agriculture production[3]. These anticipated consequences of climate change suggest negative implications for horticulture crops, like the potato.

Potatoes are grown in temperate regions as a cash crop during the long, frost-free summer months and are Ontario's top fresh vegetable crop[4,5]. Potato production is often problematic due to particular environmental and landscape growth requirements that significantly influence yield and quality[6]. The projected climatic changes may affect where potato crops can be grown due to climatic stressors or changing pest pressures[7].

Climate modelling research has not assessed Ontario potato land suitability before, providing an opportunity to be proactive in planning and addressing land suitability limitations under climate change.

Research Question and Objectives

How will climate scenarios SSP1-26, SSP3-70, and SSP5-85 influence the distribution of suitable land for potato production across Ontario compared to current potato production areas? Will the projected climate scenarios force potato production to migrate to new regions of Ontario?

- **Objectives**
  1. Create a growth suitability index for potato production in Ontario.
  2. To determine potentially suitable land between 2081-2100 in Ontario for potato production under SSPs 1-26, 3-70 and 5-85 climate scenarios.
  3. Estimate the potential migration of potato production in Ontario as a reference in future climate scenarios and land development strategies.

Methodology

- The Ontario Potato Suitability Index was created by adapting the Canada Land Inventory and Land Suitability Rating System to suit Ontario potato production season. Five growth criteria were examined: soil texture, soil drainage, landscape slope, temperature, and precipitation[8,13,14].
- QGIS 3.16 and GRASS GIS 7.8.6 were used to view, edit, run analyses, and create maps for projected climate scenarios[9].

Study Site

- Ontario has half of Canada's Class 1: Prime Land for Agriculture and is expected to have milder winters, early and longer growing seasons, and unpredictable or extreme weather events with the changing climate[7].

Ontario Maps & Climactic Data

- Ontario Land Cover Compilation V.2, offered a near-complete spatial map of Ontario.
- Soil criteria data was downloaded from Soil Survey Complex V.5[11].
- Present and future climactic data was downloaded from Global Climate Database, WorldClim V2.1 Canadian Earth System Model V.5.

Analytical Hierarchy Process

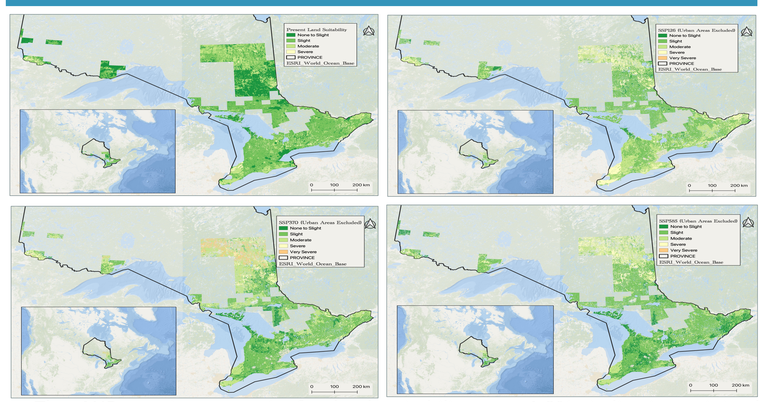
- AHP was used to analyze the multi-criteria decision-making for growth criteria to determine suitable potato grounds in Ontario[12].
- The r.mcda.ahp GRASS add-on generated maps with analytical hierarchy process[9].

Ontario Potato Suitability Index

Class	Description	Soil Texture	Soil Drainage	Slope
1	None to slight	Loam, Sandy Loam, Very Fine Sandy Loam	Very Rapid	0-3.0%
2	Slight	Coarse Sandy Loam, Fine Sandy Loam, Silt Loam	Rapid	3.1-4.0%
3	Moderate	Clay Loam, Silty Clay Loam	Well	4.1-5.9%
4	Severe	Loamy Fine Sand, Loamy sand, Loamy Very Fine Sand	Relatively Well	6.0-8.0%
5	Very Severe	Silty Clay	Imperfect	8.1-10.0%
6	Extreme	Sandy Clay	Poor	10.1-12%
7	Non-arable	Clay, Sand, Silt, Gravel	Very Poor	12.1%+

Precipitation	Temperature
Climatic variables were ranked based on optimal growth conditions for each growth stage and current weather patterns between May-September on the 1-7 suitability scale.	
Optimal season rainfall is 16 inches.	Optimal vegetative growth 20-25°C.
September was unique as precipitation increased, suitability decreased.	15-20°C is ideal for tuberization.

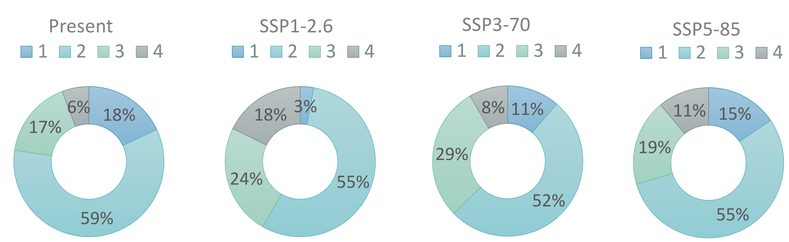
Findings



- The AHP consistency ratio for land suitability was 1.3%, indicating minimal inconsistency within the relative intensity of importance pairwise comparison.
- Present OPSI land suitability was compared to 2021 Ontario potato production density to support the analysis of identified current suitable areas accurately.
- The four-doughnut graphics demonstrate the percent distribution of 1-4 land suitability classes of present and future scenarios.
- Land suitability for SSP1-26 saw an 84.06% decrease in land with none to slight production limitations compared to the present.
- SSP3-70 regional rivalry decreased land suitability classifications none to slight by 40.47% and slight by 17.79% compared to the present. Whereas moderate and severe land suitability increased compared to present land suitability distribution. SSP5-85 climate model production had the most negligible effect on suitability lands none to slight and slight production limitations by a 14.01% and 7.60% decrease, respectively.
- Comparison of future models to each other, SSP1-26 to SSP3-70 increased land of none to slight suitability class by 273.45%. SSP1-26 to SSP5-85, all areas of land suitability classes decreased in percent area and SSP3-70 to SSP5-85 overall increased land with none to slight, slight, and severe production limitation classes.

Takeaways and Recommendations

- The sustainable future SSP1-26 resulted in the loss of highly suitable land with none to slight production limitation.
- SSP5-85, the fossil fueled development, resulted in the best scenario for increasing land suitable for potato production within Ontario based on five growth parameters: temperature, soil drainage, soil texture, precipitation, and landscape slope.
- This research offered a starting point for future research to investigate additional potato growth parameters, increase the demand for modelling and present soil data in Ontario, and offer proactive insight into how climate change could affect Ontario potato producers' ability to continue having a harvestable crop.
- In future research, expanding the inclusion of potato growth criteria and integrating future soil modelling would improve the validity and accuracy of land suitability within Ontario for future potato production.
- Research should investigate the social and economic viability and potential impacts of introducing potato production into new regions of Ontario to ensure the farmers can sustainably develop. For instance, if SSP5-85 becomes our reality, potato producers may move into northern regions of Ontario that currently do not have the infrastructure available.



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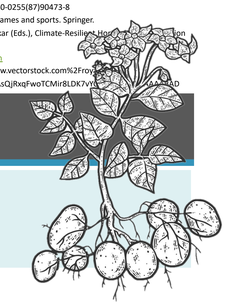
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