Spatial Decision Support System: Controlled Tile Drainage—Calculate Your Benefits

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1. INTRODUCTION

Climate projection studies suggest that extreme heat waves and floods will become more frequent, affecting future crop yields by 20%-30%, globally. Managing vulnerability and risk begins at the farm level where best management practices can reduce the impacts associated with extreme weather events. A practice that can assist in mitigating the impact of some extreme events is controlled tile drainage (CTD). With CTD, producers use water flow control structures to manage the drainage of water from their fields, which allows producers to maintain soil water on their fields during periods of crop demand or allows free drainage to facilitate field trafficking and earlier spring seeding. Within this context, the main objective of this study is to assist farmers and other stake holders in decisions related to the implementation and management of tile drainage systems by the development of a spatial decision support system that will:

a. **allow farmers and other stakeholders to explore potential sites for implementation of tile drainage systems (CTD or UCTD);**
b. **show predicted yield benefits of crops (corn and soybean) from CTD fields compared to crops under UCTD management, during varying growing season precipitation.**

2. STUDY AREA

The study was conducted for the province of Ontario, Canada. The study fields are located within an experimental micro watershed in Eastern Ontario, Canada (45.26 N, 75.18 W) (Fig. 1). From 2005 to 2016, different field pairs with confirmed water drainage practices were selected and studied. Each pair consisted of one field under CTD and one field under UCTD management. All other agriculture practices and variables (fertilizers, nutrients, varieties, etc.) were constant within a pair. Slopes are <1% and the fields are dominated by soils that drain poorly or imperfectly.

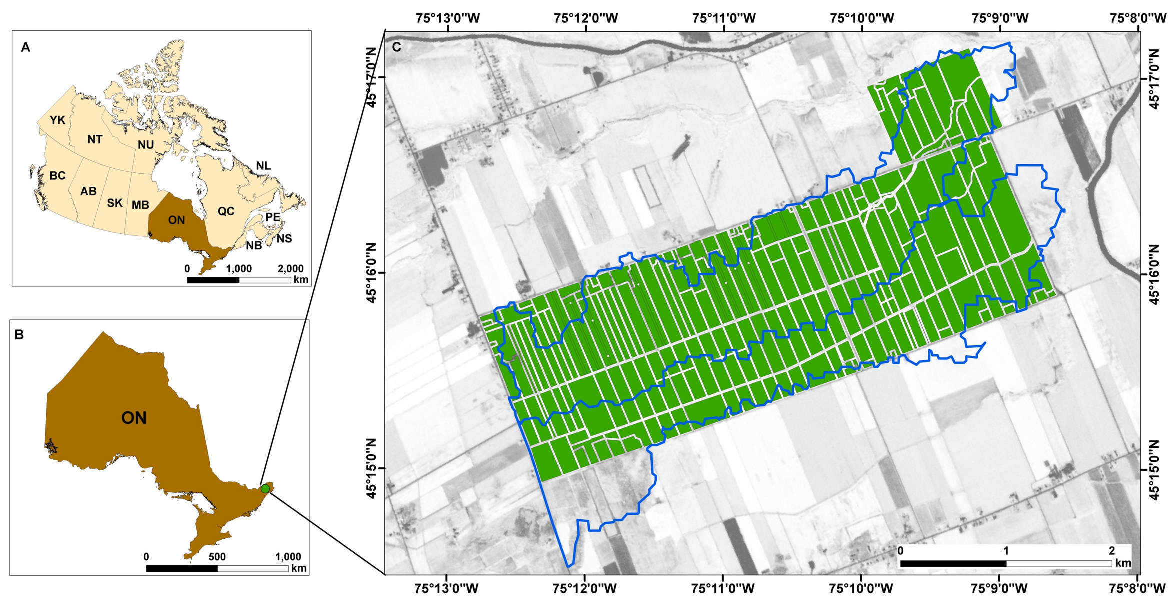
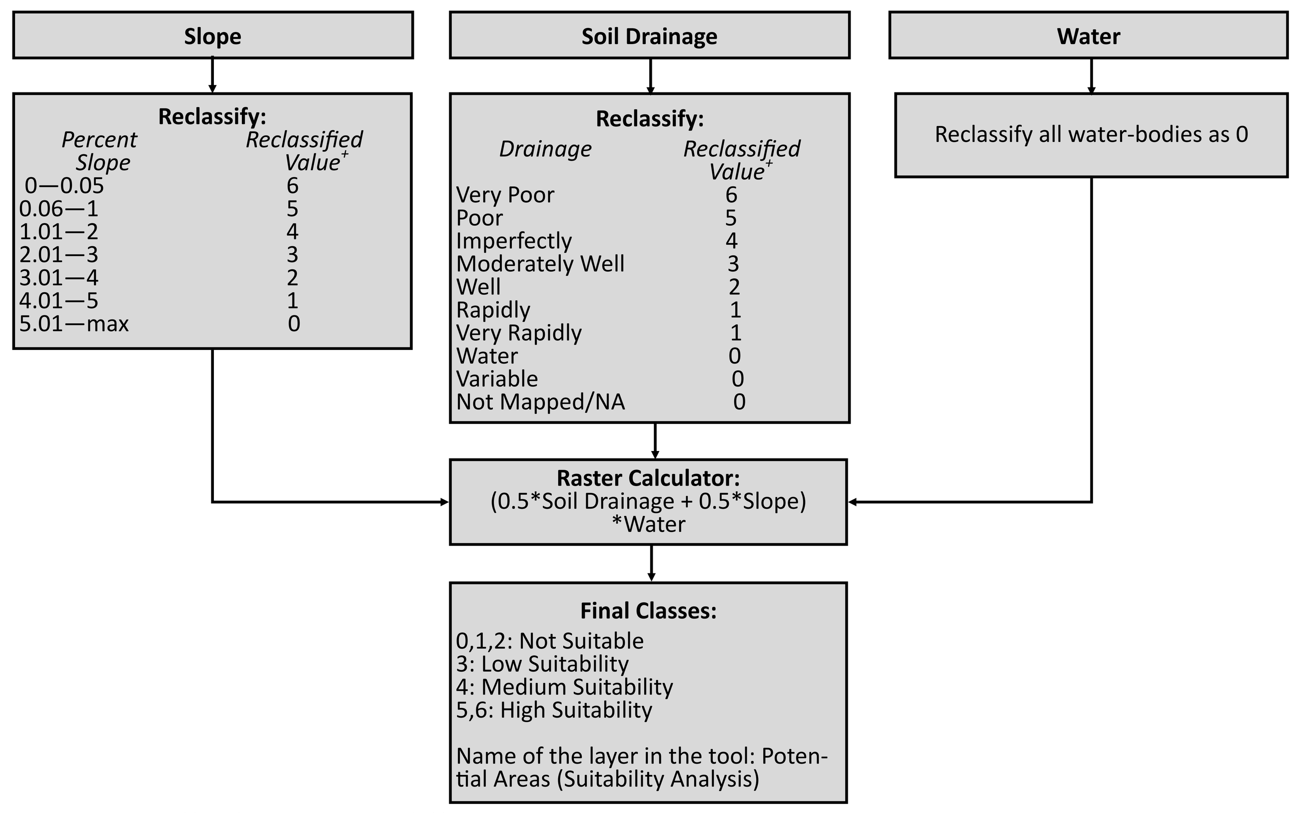


Fig. 1 Map of study area. a. Location of Ontario in Canada; b. Location of study area within Ontario. c. Location of study fields within the experimental watersheds in Eastern Ontario, Canada. Green represents the study fields and watershed boundaries are in blue.

3. METHODS AND ANALYSIS

3A. Suitability Analysis

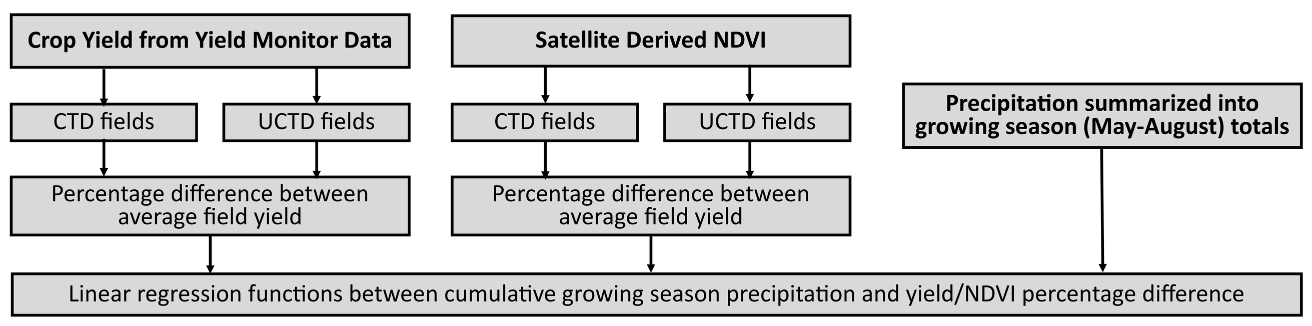
A Multi-Criteria Suitability Analysis was performed in ArcMap 10.3.1 to determine potential sites for the implementation of tile drainage systems. Soil drainage and slope were selected as two main factors. Water was selected as a constraint.



+ Here, 0 represents Least Suitable and 6 represents most suitable

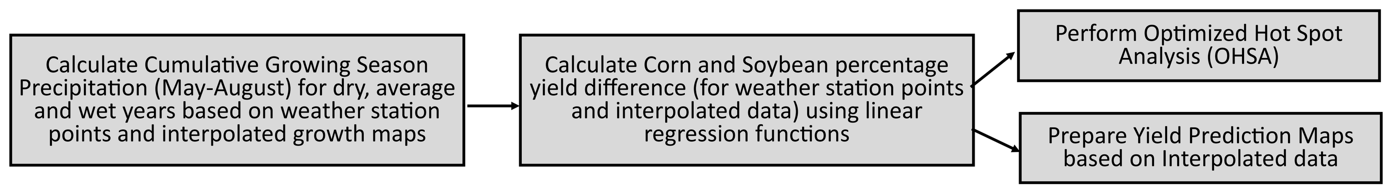
3B. Yield Difference Prediction

Crop yield was characterized by ground yield measurements and satellite-derived Normalized Difference Vegetation Index (NDVI). Yield benefits from CTD fields were determined as the difference between ground yield measurements/NDVI values from CTD compared to UCTD fields and related to precipitation data to enable the creation of yield benefit prediction scenarios.

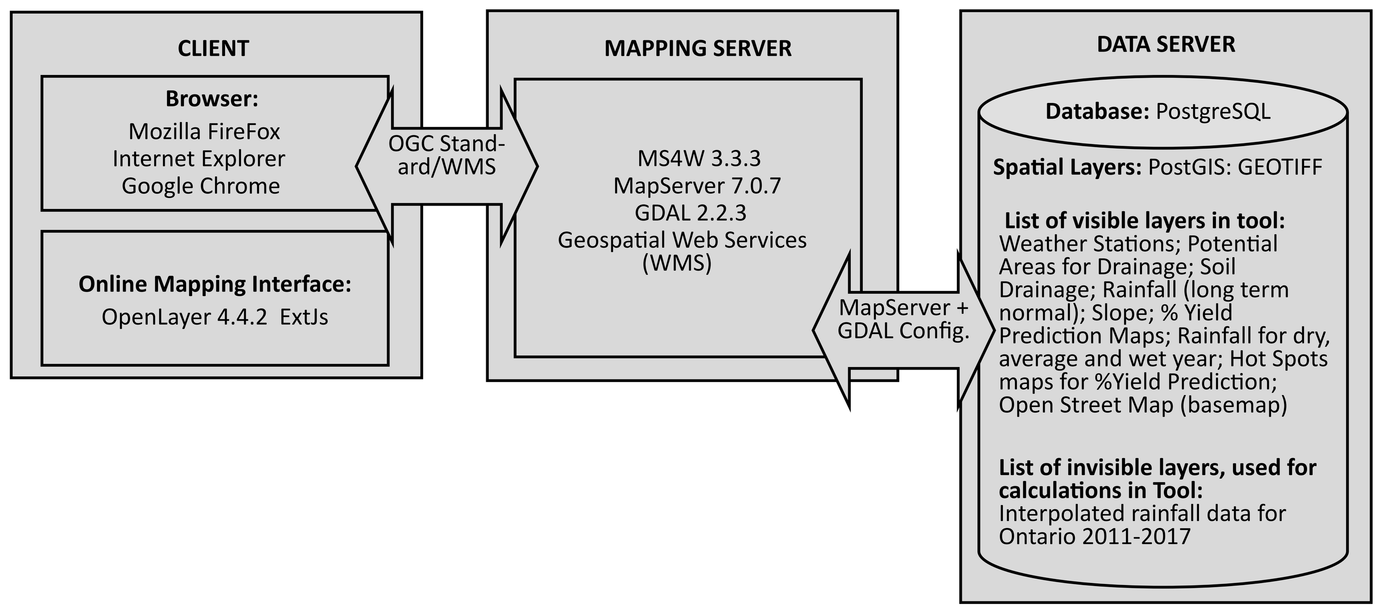


3C. Yield Difference Prediction Maps

Yield prediction maps were prepared to demonstrate different scenarios of percentage yield difference under different precipitation conditions (dry vs. wet).



3D. Tool Architecture



4. RESULTS

4A. Suitability Analysis

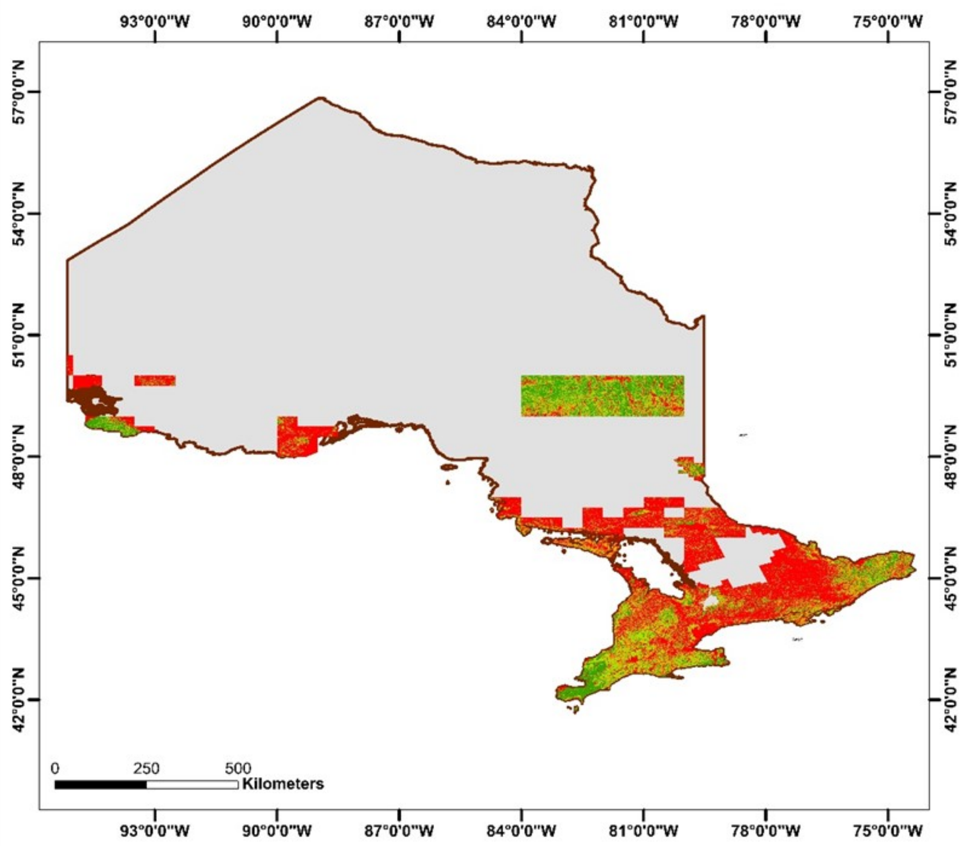


Fig. 2 Map representing areas with varying levels of suitability for the installation of tile drainage systems. Grey represents areas with no information of potential sites. Red represents areas that are ``Not Suitable`` for the installation of tile drainage systems, orange represents areas with ``Low Suitability``, light green represents areas with ``Medium Suitability`` and dark green is for areas ``Highly Suitable`` for the implementation of tile drainage systems.

4B. Yield Difference Prediction

The following table summarizes the relationship between total growing season precipitation and percentage difference yield or NDVI.

	Crop Type	Linear Regression Functions	P-values
% Difference Yield	Corn	-0.0224*(Total Growing Season Precipitation) + 8.3514	0.318
	Soybean	0.0101*(Total Growing Season Precipitation) - 0.5865	0.801
% Difference NDVI	Corn	-0.0048*(Total Growing Season Precipitation) + 1.1588	0.058
	Soybean	0.0069*(Total Growing Season Precipitation) -2.6313	0.079

4C. Yield Difference Prediction Maps

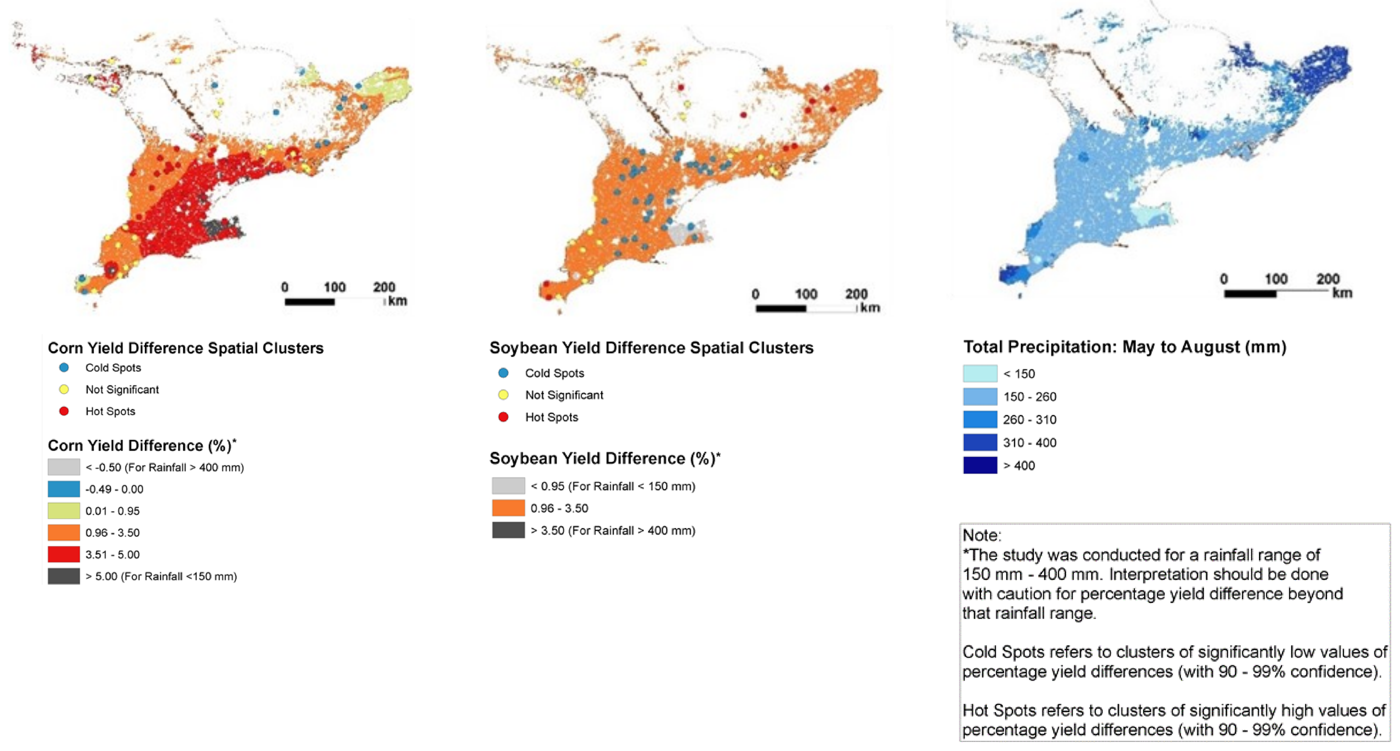


Fig. 3 Maps depicting spatial clusters of yield difference percentage for corn and soybean in dry year, Southern Ontario.

4D. Tool

The online tool (https://demo.gatewaygeomatics.com/ctd/) represents the summarized results of the suitability analysis and the yield benefit characterization. The tool was developed using Open Source software that follows the common Open Geospatial Consortium (OGC) technology standards (Fig. 4).

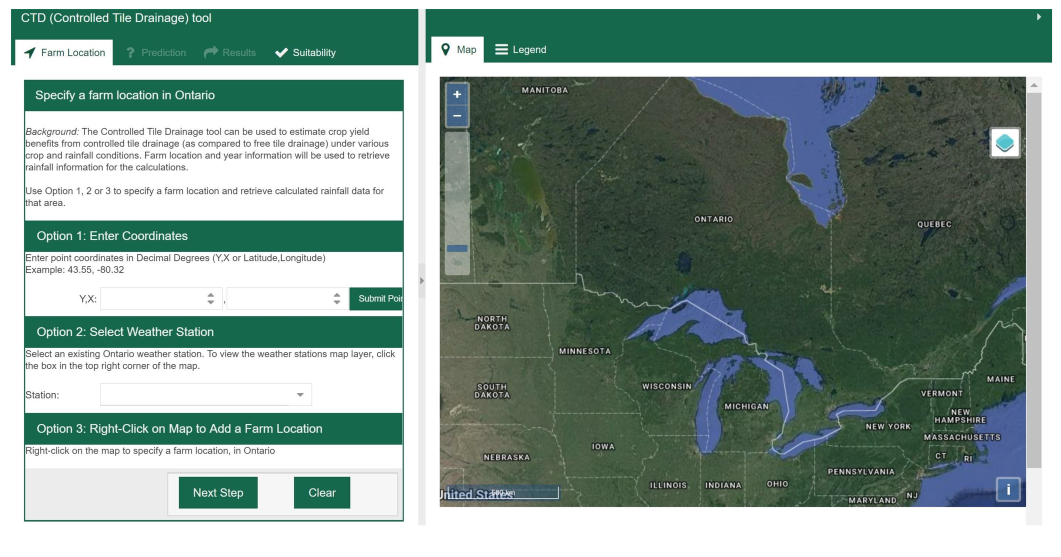


Fig. 4 Screenshot of the tool

5. LIMITATIONS

- The crop yield and crop vegetative health differences are based on a small number of sample points and interpretation should be done with caution. It would be beneficial to include longer time series precipitation and more sample points/study areas to provide more robust relationships between the variables.
- Moreover, the regression functions in this study were developed for a small study area with slopes of approximately <1% and soils that drain poorly or imperfectly. It is recommended to include more sites that cover different slopes and soil drainage types into the analysis and the final tool.
- Crop yield and NDVI differences were summarized for each year. This included multiple paired fields maintained by different farmers, having potentially different agricultural practices such as use of different varieties of crop, fertilizer types and application etc. This increases the variability of crop response to CTD.
- The CTD systems in the study area are managed conservatively, where they are opened during winters and closed during summers. However, more intensive management of these systems could result in higher yields.

6. CONCLUSION

The online tool was built as a pilot project for Ontario. The potential areas for the implementation of tile drainage were based on soil drainage classes and surface slopes where areas with low slopes and poorly drained soils were defined as the most suitable for implementation of tile drainage systems. On further analysis, it was found that the areas that already have installed tile drainage systems in Ontario correspond to the suitable areas in the map. However, there are still crop fields that do not have installed tile drainage systems.

The relationship between crop yield and precipitation was established from ground and satellite-derived crop yield indicators and growing season precipitation measurements. Though NDVI is primarily an indicator of crop vegetative health, it can be used as an indirect indicator of crop yield.

The farmers can use the tool to determine suitable areas for the installation of tile drainage systems as well as to obtain information on crop yield differences under CTD and UCTD management which would help them in choosing an appropriate drainage system for their fields.

7. ACKNOWLEDGEMENTS

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