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Landslide Susceptibility Analysis in the St. Lawrence Lowlands Using High Resolution Data and Failure Plane Analysis

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Abstract : The St. Lawrence lowlands extend from Ottawa to Quebec City and are known for large deposits of sensitive Leda clay. Leda clay deposits are responsible for many large landslides, such as the 1993 Lemieux and 2010 St. Jude (4 fatalities) landslides. Due to the large extent and sensitivity of Leda clay, regional hazard analysis for landslides is an important tool in risk management. A 2018 regional study by Farzam et al. on the susceptibility of Leda clay slopes to landslide hazard uses 1 arc second topographical data. A qualitative method known as Hazus is used to estimate susceptibility by checking for various criteria in a location and determine a susceptibility rating on a scale of 0 (no susceptibility) to 10 (very high susceptibility). These criteria are slope angle, geological group, soil wetness, and distance from waterbodies. Given the flat nature of St. Lawrence lowlands, the current assessment fails to capture local slopes, such as the St. Jude site. Additionally, the data did not allow one to analyze failure planes accurately. This study majorly improves the analysis performed by Farzam et al. in two aspects. First, regional assessment with high resolution data allows for identification of local locations that may have been previously identified as low susceptibility. This then provides the opportunity to conduct a more refined analysis on the failure plane of the slope. Slopes derived from 1 arc second data are relatively gentle (0-10 degrees) across the region; however, the 1- and 2-meter resolution 2022 HRDEM provided by NRCAN shows that short, steep slopes are present. At a regional level, 1 arc second data can underestimate the susceptibility of short, steep slopes, which can be dangerous as Leda clay landslides behave retrogressively and travel upwards into flatter terrain. At the location of the St. Jude landslide, slope differences are significant. 1 arc second data shows a maximum slope of 12.80 degrees and a mean slope of 4.72 degrees, while the HRDEM data shows a maximum slope of 56.67 degrees and a mean slope of 10.72 degrees. This equates to a difference of three susceptibility levels when the soil is dry and one susceptibility level when wet. The use of GIS software is used to create a regional susceptibility map across the St. Lawrence lowlands at 1- and 2-meter resolutions. Failure planes are necessary to differentiate between small and large landslides, which have so far been ignored in regional analysis. Leda clay failures can only retrogress as far as their failure planes, so the regional analysis must be able to transition smoothly into a more robust local analysis. It is expected that slopes within the region, once previously assessed at low susceptibility scores, contain local areas of high susceptibility. The goal is to create opportunities for local failure plane analysis to be undertaken, which has not been possible before. Due to the low resolution of previous regional analyses, any slope near a waterbody could be considered hazardous. However, high-resolution regional analysis would allow for more precise determination of hazard sites.

Keywords : hazus, high-resolution DEM, leda clay, regional analysis, susceptibility
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