Interactive Web-Based Approach for Spatial Modeling of Landslide Susceptibility with R-Shiny (NH25D-0483)

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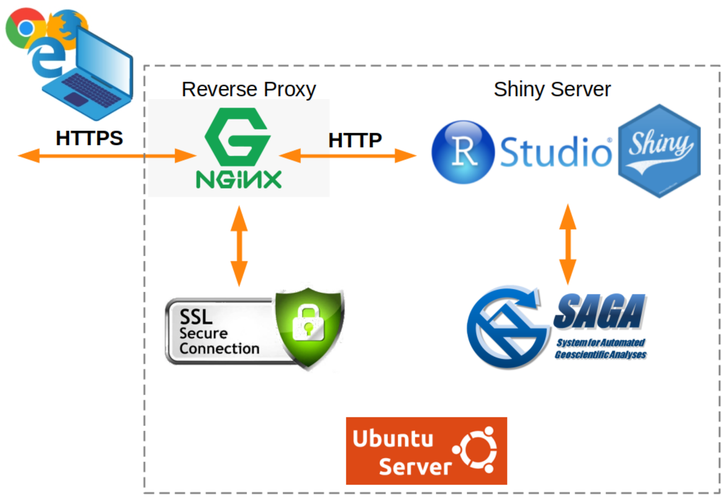
Abstract

The research explores the application of an interactive web-based prototype for modeling landslide susceptibility using GIS Free Open Source Software (FOSS). The combined approach links the shallow slope stability model (SHALSTAB) from the System for Automated Geoscientific Analyses Geographical Information System (SAGA GIS) with R-Shiny using R programming environment. The client-server architecture of the framework integrates multiple components where Nginx with R-Studio Server provide computing-intensive services which are delivered to the client (i.e., Chrome or Firefox). Specifically, the Shiny web app prototype consists of consecutive and easy-to-follow steps organized in a modeling and a validation pages. The modeling page is used for model development and represents a graphical interface for interactive parameter manipulation and running SHALSTAB model using a single upload of a georeferenced digital elevation model (DEM). On the other hand, the validation page is used for model tuning and assessment that is accomplished by different measures of accuracy (i.e., F1-score, accuracy and kappa) derived from a confusion matrix associated with the binary classification of the landslides (i.e., presence, absence). The mapping results from the modeled susceptibility are generated by customizable widgets and Shiny components through interactive visualization, modeling, calibration, printed reports and raw file format downloads for external software such as Google Earth Pro or SAGA GIS. The value of this approach is that allows a real-time implementation using site-specific datasets that are applied to different areas of interest. In addition, the prototype expands its usability to a wider community (i.e., non-R, non-GIS users) such as classroom teaching activity that can enable research-informed learning. The prototype with an example of datasets from the Clearwater National Forest, Idaho can be accessed through the website https://geogis.bgsu.edu/apps/shalstabcv.

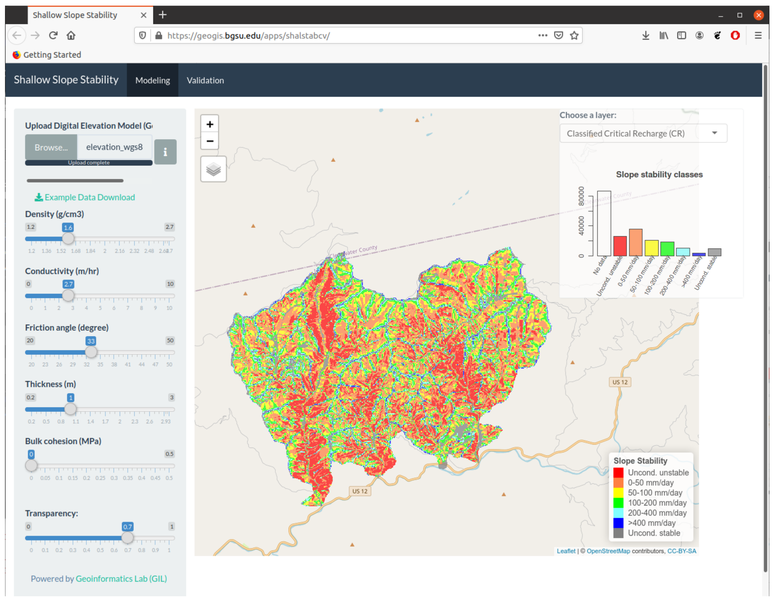
System Architecture

This project implements a client-server architecture based on open source software using Ubuntu operating system (https://ubuntu.com). The Hypertext Transfer Protocol Secure (HTTPS) communication is used to exchange data between client(s) and web server(s) through Hypertext Markup Language (HTML) content of files, images, and query results.

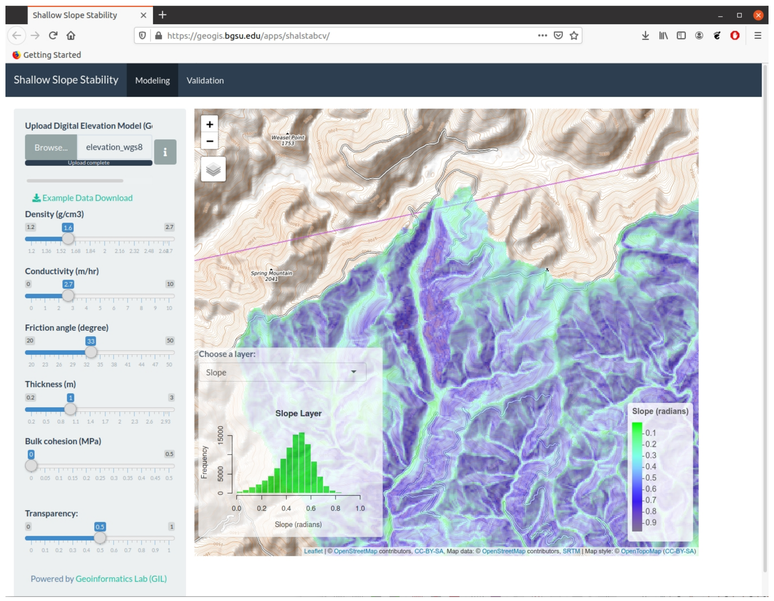


SHALSTAB web-based interface

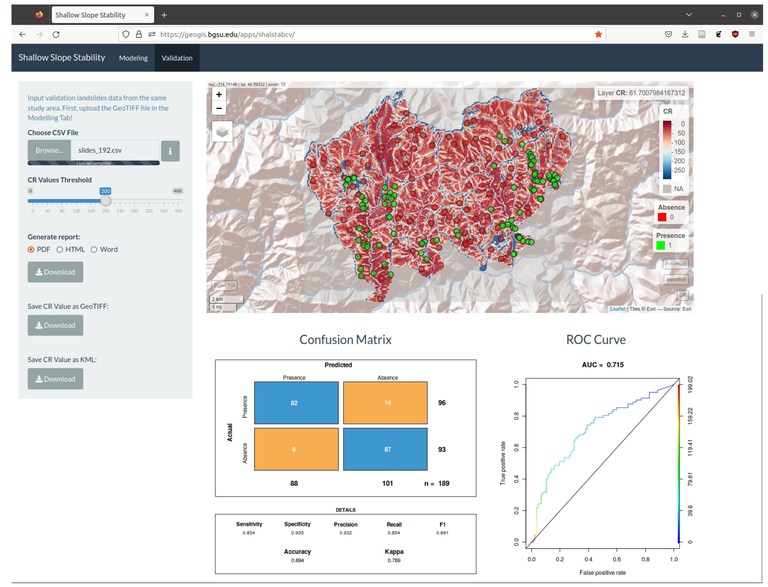
The web-based interface can be accessed by web browsers such as Internet Explorer, Chrome or Mozilla Firefox. The main components that comprise the prototype are organized under two different themes, including a modeling page and a validation page.



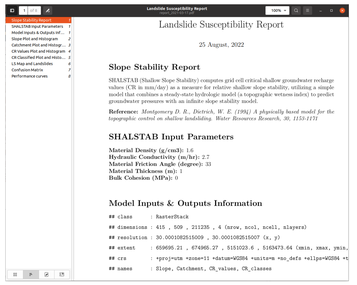
Visualization of slope layer overlayed on a topographic map with shaded relief. For better clarity histogram panel can be moved by clicking and dragging so obstructed areas can be exposed for exploration and visualization of slope patterns.

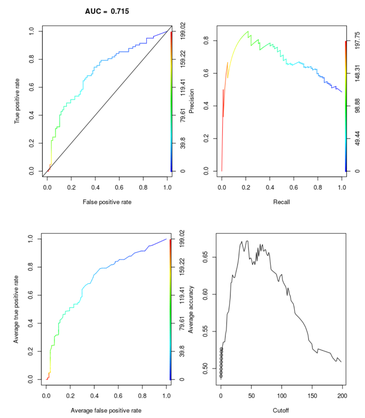


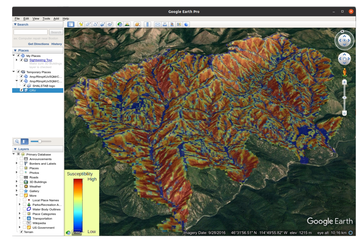
Results from the validation module include continuous critical rainfall (CR) map overlaid on a topographic shaded relief basemap, the landslides are overlaid on the top of the CR map as points where red color represents absence and green color represents presence, a confusion matrix and a ROC curve.



The web-based GUI provides a module for generating detailed dynamic reports from the SHALSTAB analysis that can be converted to different output formats, including PDF, HTML and Word files.







Visualization of the results of the landslide susceptibility mapping (Continuous Critical Recharge) in Google Earth Pro.

The web-based approach for modeling rainfall-induced landslide susceptibility using FOSS was tested in a case study on the Clearwater National Forest, Idaho and the results from the validation showed an overall accuracy of of 0.894, kappa of 0.789 and 0.715 (AUC). The modeled landslide potential may be used as a decision-support tool for local planning.