Development of WebGIS interface for a Territorial Landslide Early Warning System in India

Md Shoaib Akhtar (SPA2326804)

Under the supervision of : Prof. Srikrishnan Siva Subramanian
Centre of Excellence in Disaster Mitigation and Management, IIT Roorkee

Abstract

Landslides are a significant hazard in the Himalayas, necessitating the implementation of effective early warning systems to mitigate the risk to life and property. This study focuses on the development of a framework for a Territorial Landslide Early Warning System (Te-LEWS) in the Himalayas, with a specific emphasis on Uttarakhand, India. Traditional systems rely on rainfall intensity-duration thresholds, which fail to consider terrain conditions. To address this limitation, a Soil Water Index (SWI) threshold is used to incorporate terrain factors such as slope angle and soil type. By analyzing historical landslide occurrences and corresponding rainfall intensities derived from satellite data, the critical SWI threshold is determined. The approach is based on a three-layer tank model and builds upon the Japanese Territorial Landslide Early Warning System (Te-LEWS). For the development of the Territorial Landslide Early Warning System (Te-LEWS) framework in the Himalayas, a user-friendly webGIS interface has been created to facilitate the analysis of the Soil Water Index (SWI) for a specific region. This interface allows users to upload a shape file of the desired region, enabling them to visualize and explore the SWI data. By integrating the SWI calculations within the framework, the webGIS interface provides a convenient tool for users, enabling them to assess the potential landslide risk in their selected areas.

Introduction

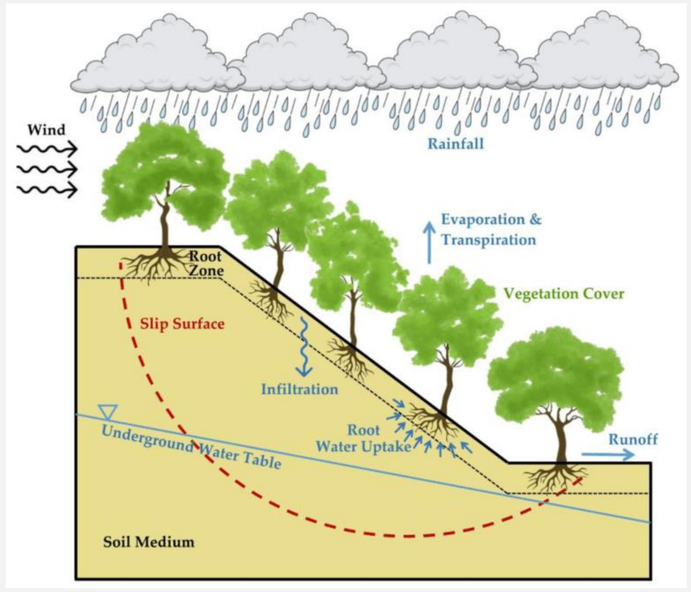


Fig. 1. Schematic of slope stability analysis. (A modeling platform for landslide stability, Emadi-Tafti, Mohsen et al- 2019.**)**

- Early warning systems for natural disasters are important tools for disaster risk reduction and for achieving sustainable development and livelihoods.
- Traditional landslide early warning systems use rainfall intensity-duration thresholds, but these methods do not incorporate the terrain conditions.
- A new framework has been developed to test the SWI threshold to predict shallow landslides and debris flows in the Himalayas.
- The SWI threshold is a complex rainfall threshold that takes into account the terrain conditions, such as the slope angle and the soil type.
- In this study, we employ a three-layer tank model (as illustrated in Figure 3) to calculate the Soil Water Index (SWI), utilizing variables and constants derived from the Japanese Territorial Landslide Early Warning System(Te-LEWS).

Methodology

Data Collection — 01

- **Precipitation data obtained from the GSMaP/v6/reanalysis dataset using Google Earth Engine.**
- **Study area : Uttarakhand, India**
- **Time Period : 2013-06-10 to 2013-06-19**
- **Temporal Resolution : 60 mins**
- **Spatial Resolution : 0.1 × 0.1 degree (11.1 km × 11.1 km).**

Processing & Analyzing — 02

- **The calculation of the Soil Water Index (SWI) was performed using a three-layer tank model, as illustrated in Figure 2.**
- **The model uses constants from the Japanese Territorial Landslide Early Warning System (Te-LEWS).**
- **Further, the Soil Water Index (SWI) was computed by processing the data of each pixel using Python**

Web GIS Interface — 03

- **Store the collected TIF files in a directory on the server.**
- **Develop a webGIS to visualize and analyze the Soil Water Index (SWI) of specific regions .**
- **Provides a user-friendly interface for exploring and interpreting SWI data for landslide risk assessment and early warning purposes.**

Level 1 : The amount of rainfall may exceed the amount to expected cause debris-flows and slope-failure disasters within 3 hours. It is advisable to inform residents.

Level 2 : The amount of rainfall may exceed the amount to expected cause debris-flows and slope-failure disasters within 2 hours. It is advisable to tell residents to move a designated safe place.

Level 3 : Coming disasters within 1 hours. It is advisable to confirm that residents in dangerous area have moved to a designated safe place.

Level 4 : The amount of rainfall may exceed the amount to expected cause debris-flows and slope-failure disasters. Conditions are expected to be very dangerous.

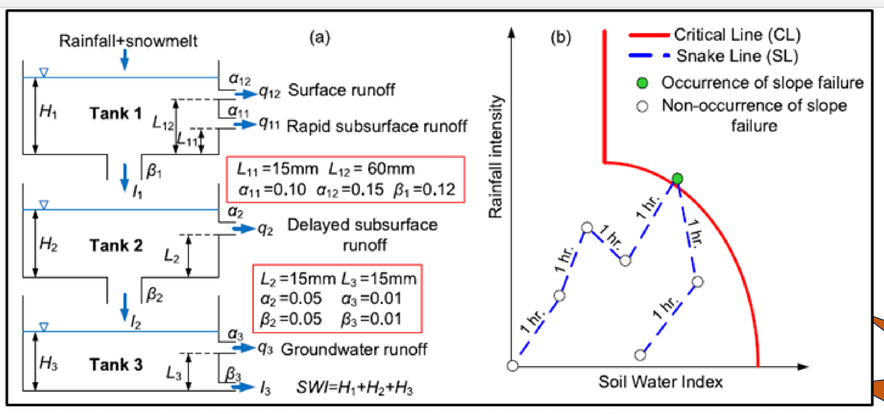
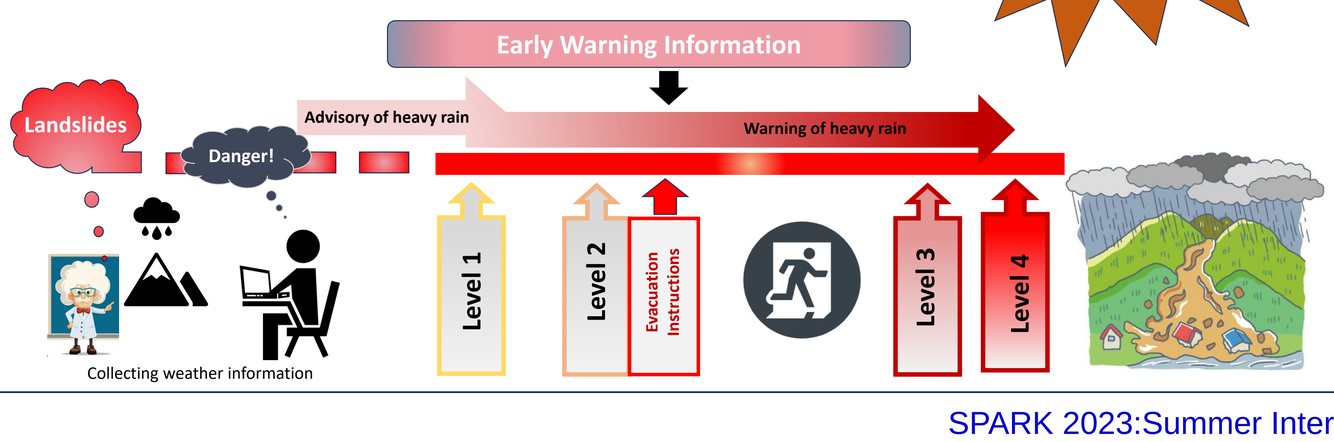


Fig. 2. Three-layer tank model for calculating Soil Water Index and (b) Prediction of occurrence of slope failure based on Critical Line (CL) and Snake Line (SL) (Siva Subramanian et al., 2018; Zhu et al., 2021)

Disaster Outbreak



Results

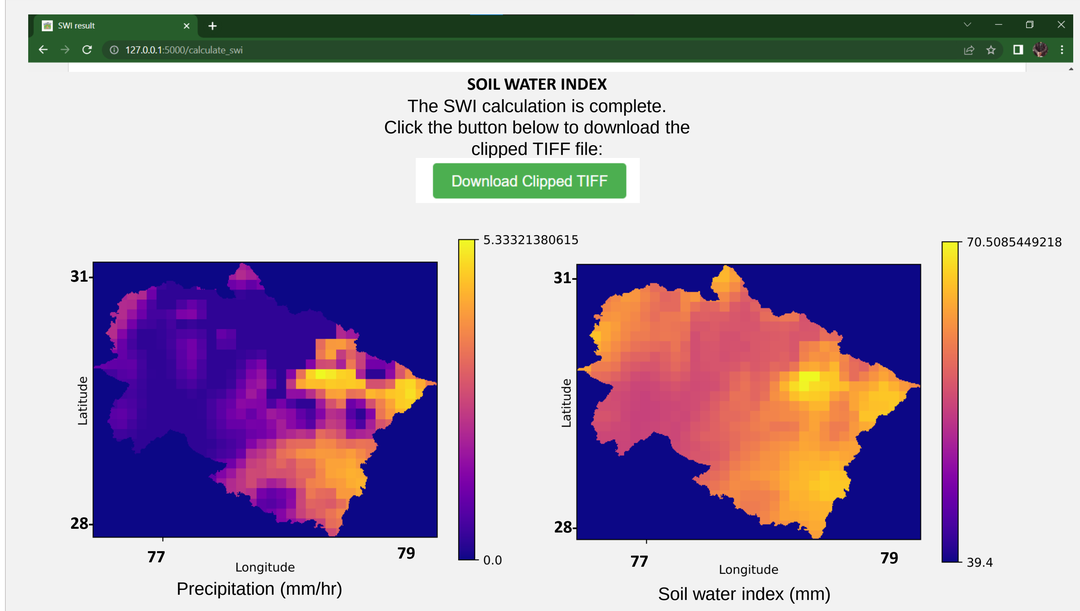


Fig. 3. a)GUI of Spatial variation of rainfall intensity b) GUI of spatial variation of soil water index in Uttarakhand

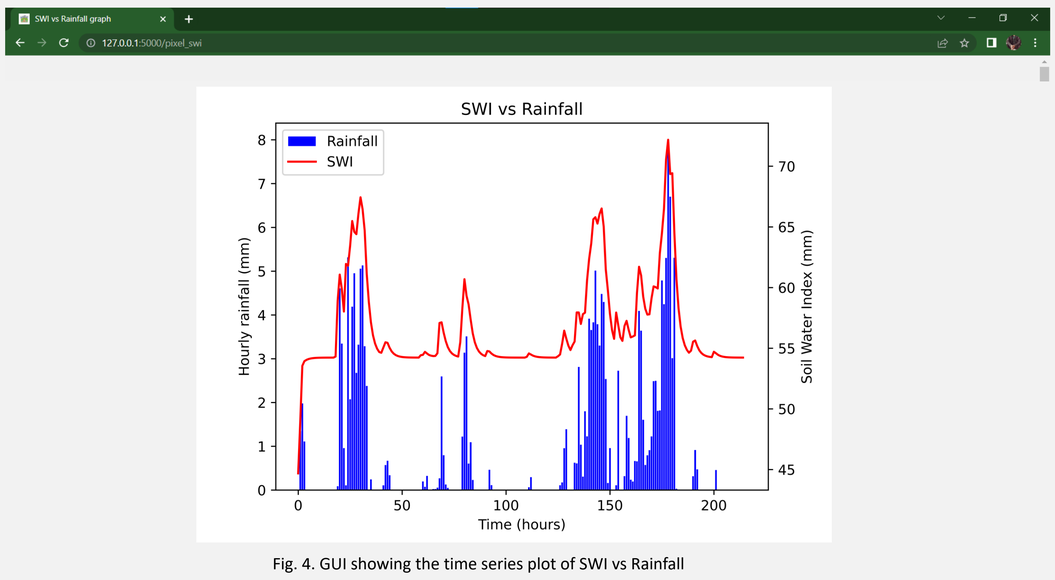


Fig. 4. GUI showing the time series plot of SWI vs Rainfall

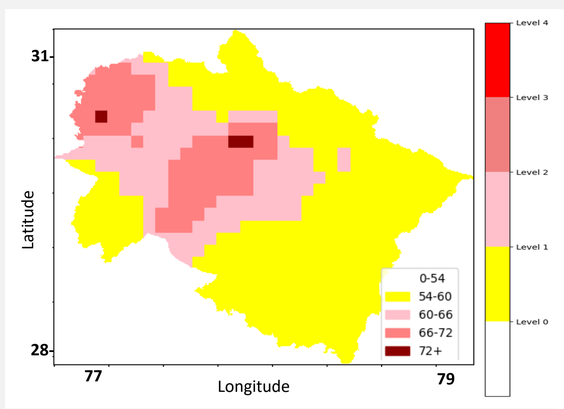


Fig. 5. The colors are coded to show the condition indicated by the danger level.

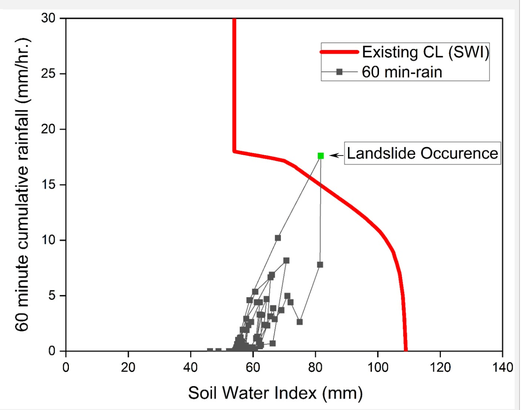


Fig. 6. Snake line depicted based on the rainfall and timing of disasters occurrence (Kedarnath Coordinates : 30.7346° N, 79.0669° E)

Expected Outcome

- The parameters in SWI have to be identified for the Uttarakhand region through the statistical analysis of the relationship between rainfall and discharge.
- The web interface and the GEE would be linked, in order to process the precipitation data online for longer time periods, without downloading the data.
- Establishing the failure criteria for debris flows and validating using historical landslide data
- Developing a Te-LEWS based on Soil Water Index approach for Uttarakhand region

Reference

1. Subramanian, Srikrishnan Siva, Sumit Sen, and Ali P. Yunus. Applicability of complex rainfall thresholds for Territorial Landslide Early Warning Systems (Te-LEWS) in the Himalayas. No. EGU23-16763. Copernicus Meetings, 2023.
2. Osanai, Nobutomo, et al. "Japanese early-warning for debris flows and slope failures using rainfall indices with Radial Basis Function Network." Landslides 7 (2010): 325-338.
3. Emadi-Tafti, Mohsen, and Behzad Ataie-Ashtiani. "A modeling platform for landslide stability: A hydrological approach." Water 11.10 (2019): 2146.
4. Images/Icons sources : Internet.

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