This project models a hillslope or mountainous terrain experiencing rainfall-induced landslides. The model captures the interaction between rainfall, soil saturation, terrain stability, sediment movement, and vegetation loss. By simulating how rain destabilizes soil and causes cascading terrain failure, we aim to explore the conditions that lead to landslide initiation and spread.

② What are the principal components or actors involved in this system?

Patches (terrain units)

Represent discrete sections of land with properties including elevation, soil saturation, sediment load, and landslide status (failed or stable)

Turtles (trees)

Represent individual trees rooted on terrain patches. These can be destroyed if a nearby landslide occurs

Global variables

Track overall system state, including total rainfall, number of landslides, sediment displacement, and the number of surviving trees

The system is modeled using an Agent-Based Model (ABM) in NetLogo:

- **Patches act as environmental agents with localized state variables**

- **Turtles (trees) act as individual agents affected by patch conditions**

- **The environment evolves based on local interactions (e.g., slope comparison, neighbor selection) and external forcing (rainfall input)**

④ What actions (or behaviors) can the agents/actors take?

Patches:

- Absorb rainfall and increase local soil saturation
- Evaluate slope stability to determine the potential for failure
- Trigger landslides if a stability threshold is breached
- Transfer sediment to neighboring lower-elevation patches upon failure

Turtles (trees):

- Remain stationary unless affected by a landslide
- Are removed from the model if a landslide occurs on or near their location

Environment Type: 2D Spatial Grid

- **The environment is a patch-based grid representing a sloped terrain**

- **Each patch has an elevation forming a pseudo-slope (elevation decreases along the x-axis)**

- **Trees are only initialized on higher-elevation patches**

- **Each patch interacts with its 8 immediate neighbors for processes like sediment flow and failure propagation**

- **The environment simulates natural terrain dynamics under rainfall**

Each simulation tick represents one discrete time step. The following sequence occurs:

- **Rain: All patches receive rainfall, increasing saturation**
- **Saturate: Caps saturation to 100% to avoid overflow**
- **Flow sediment: Sediment from failed patches flows to lower neighbors**
- **Check for landslides: A vulnerable patch is selected and triggered if stability (slope - saturation/2) falls below the threshold**
- **Trigger landslide (if applicable): Changes patch color, removes trees, increases sediment, and lowers elevation**
- **Update monitors and plots: Recalculate totals and plot rainfall, landslides, and sediment**
- **Stop condition: Simulation stops when all patches have failed**

(7) What are the inputs to the model? Identify all relevant inputs.

- **rainfall-rate: Rate of rainfall per tick (in mm)**

- **landslide-threshold: Minimum stability index before failure; lower values cause more frequent landslides**

- **sediment-flow-rate: Determines the ease with which sediment is transported downhill**

- **number-of-trees: Initial number of trees placed on the terrain**

Test different environmental resilience scenarios by adjusting the landslide-threshold

- **Evaluate how sensitive the system is to small changes in stability thresholds**
- **We can observe it through the following:**
  - **Time and frequency of landslide events**
  - **Tree survival rate over time**
  - **Terrain condition (visually and via failure count)**
- **Track the timing and frequency of landslide events.**

- **Assess how sediment flow impacts downstream stability and triggers additional failures**
- **Analyze vegetation loss patterns across terrain gradients**
- **Monitor the spatial spread and clustering of landslides over time**
- **Record tree mortality rates due to nearby landslides**
- **Measure total sediment movement over time**
- **Determine how tree placement and density affect system resilience**
- **Provide a visual and interactive tool to teach the mechanisms of landslides**

THANK YOU