A coupled human and landscape conceptual model of risk and resilience in mountain communities

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Risk and Resilience Cluster: www.risk-resilience.giub.unibe.ch
Background

Mountain communities are exposed to physical and socio-economic shocks

How resilient are mountain communities to these shocks?
Mountain community economic response to physical and socio-economic shocks

- Full Recovery
- Partial Recovery
- Better than Expected Recovery

Background > Approach > Models > Key Linkages > Conclusion
What magnitude and frequency of shocks are buffered by mountain communities? Do socio-economic or physical shocks have a greater affect on mountain communities?
Modelling approach

Spatial simulation of landscape and mountain community processes

Fully coupled model
  - Landscape evolution model (LEM) that replicates floods and debris flows
  - System dynamics model that replicates socio-economic interactions

Develop a generic model that is loosely based on Swiss mountain communities, but is transferable to other mountainous regions
  - Data availability
  - Model calibration possible with historic data
### Mountain communities

**Background > Approach > Models > Key Linkages > Conclusion**

<table>
<thead>
<tr>
<th>Mountain Community</th>
<th>Type</th>
<th>Geographic Size</th>
<th>Income Level</th>
<th>Community Moral</th>
<th>Demand for Local Goods</th>
<th>Vulnerability</th>
<th>Resilience</th>
<th>Sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downward spiral</td>
<td>Peripheral</td>
<td>Small</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Stagnation</td>
<td>Semi-urban</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Upward spiral</td>
<td>Urban</td>
<td>Large</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
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<td>High</td>
</tr>
</tbody>
</table>

**Sources**: thomsonlakes.co.uk, derbund.ch, cbronline.com
Modelling scales

Background > Approach > Models > Key Linkages > Conclusion

Mountain catchment with:

- **Geographic scale**: 20 m resolution topography
  - Representative alpine catchment
  - Area: 450 km$^2$
  - Elevations: 500 - 3700 m
  - Steep slopes and isolated valleys

- **Temporal scale**: Present day to 2060
Landscape model

- Representation of land cover & 3 community types
- Model drivers include rainfall, snowfall, & snow melt
• Model drivers are financial means, population dynamics, local employment,

• Additionally important are accessibility and attractiveness of the community
Linkage: Damage and Loss

Background > Approach > Models > Key Linkages > Conclusion

ECONOMIC DEVELOPMENT
(Demand for products and services)

POPULATION DYNAMICS
(Increases/ Decreases, Migration)

LOCAL EMPLOYMENT OPPORTUNITIES

FINANCIAL MEANS
(Taxation)

INVESTMENT
(Mitigation, Infrastructure, Public Services)

ACCESSIBILITY

ATTRACTIONNESS

LAND COVER AND SETTLEMENT STRUCTURE

ECONOMIC SHOCK

TEMPERATURE

PRECIPITATION
(Rain, Snow)

DAM

LAND COVER

ENGINEERING WORKS

SEDIMENT

WATER

DEBRIS FLOW

FLOOD

HAZARD

SETTLEMENT STRUCTURE

PHYSICAL SHOCK

DAMAGE
**Intensity** of rainfall most important in movement of **sediment and causing floods**
Linkage: Damage and Loss

Background > Approach > Models > Key Linkages > Conclusion

![Flood Hydrograph](image)

Discharge (m$^3$ s$^{-1}$)

Time (days)

![Topographic and aerial images](image)
Linkage: Mitigation

Background > Approach > Models > Key Linkages > Conclusion

- Economic Development (Demand for Products and Services)
- Population Dynamics (Increases/Decreases, Migration)
- Local Employment Opportunities
- Financial Means (Taxation)
- Investment (Mitigation, Infrastructure, Public Services)
- Accessibility
- Attractiveness
- Land Cover and Settlement Structure

- Temperature
- Precipitation (Rain, Snow)
- Engineering Works
- Land Cover
- Sediment
- Water
- Debris Flow
- Flood
- Settlement Structure
- Hazard

- Economic Shock
River Engineering:
Flooding → Levees, Dams
Debris Flows → Check dams, retention basins
Linkage: Landcover

Background > Approach > Models > Key Linkages > Conclusion

Initial State

Settlement Transition

Forested Transition

Land cover
- settlement
- agriculture
- sparse vegetation
- glacier
- grass
- forest
- water
• Our modelling approach will be able to determine the resilience of different mountain communities to **combined physical and socio-economic shocks**

• We consider **linkages** between both systems

• The conceptual model is **generic** and can be applied to most Alpine mountain communities

• Future work will focus on the development of the conceptual model using existing computer models