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Landslides

Causes, consequences, and adaptation measures

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1. Introduction

Already today, the impacts of climate change are increasingly evident. Alongside efforts for climate change protection, the significance of building resilience to its effects is growing. In comparison to the preindustrial period, there has been a notable global temperature rise of 1.1°C. The temperature increases faster over land than over water, which results in a 1.59°C increase over land compared to 0.89°C over the oceans (IPCC, 2021).

Despite many advancements in policymaking as well as technological progresses regarding the energy transition, most nations are not on track to reach the Paris Agreement objectives. Year by year, the CO_2 concentration in the atmosphere is rising. However, global GHG emissions are not only cumulatively rising, but also annual CO_2 emissions are continuously increasing (exceptions are global crises such as the Covid-19 pandemic) (Statista, 2024).

In the year 2022, 37.5tGt of CO_2^e were emitted (Statista, 2024), which leaves us according to MCC with a budget of 5 years and four months if we keep this track until we reached the 1.5°C global warming (MCC, 2024). This does not only highlight the importance and necessity of a rapid decarbonisation of the energy system but also emphasizes the relevance of climate change adaptation. Adaptation measures to climate change impacts can help to reduce the risks and vulnerabilities.

The impacts and consequences of climate change are versatile and differ vastly between countries and regions. Climate change affects people, the environment as well as economies. The impacts as well as the intensity vary across regions. That is why it is important that adaptation measures are implemented on the regional level. In the latest IPCC report risks to climate change are measured by looking at hazards, exposure to them, vulnerability of communities and their adaptive responses to them (IPCC, 2021).

Rising global temperatures caused by climate change lead to more frequent and intense weather events, which in turn can aggravate the likelihood of landslides. Landslides involve the downslope movement of earth materials—such as rock, debris, or soil—at rates ranging from a few millimetres per year to several metres per second. They represent a widespread geohazard worldwide, responsible for loss of life, property destruction, and lasting socioeconomic consequences. The extent of their impact depends on factors such as the landslide’s velocity and size, as well as the vulnerability of the elements located in its path (European Commission, 2025; USGS, 2025).

2. Causes and Mechanisms

Hydrological triggers (rainfall and snowmelt): Intense or prolonged precipitation that increases pore water pressure and reduces shear strength is the dominant short-term trigger for most nonseismic landslides worldwide. Storms, prolonged monsoon rainfall, and rapid snowmelt commonly precede failures (European Commission 2025; USGS 2025).

- **Seismic shaking:** Earthquakes cause widespread slope failure where shaking reduces material strength and dislodges rock and soil.
- **Anthropogenic drivers:** Deforestation, slope undercutting for roads and construction, unwise land-use change, and poor drainage practices substantially increase slope susceptibility and the area at risk.

While many factors affect slope stability (geology, slope angle, vegetation, drainage), heavy rainfall is the most frequent immediate trigger — a key point for planning and early warning.

Climate change can exacerbate the landslide risk, by increasing the frequency and intensity of extreme weather events, such as intense rainfall and rapid snowmelt, which can trigger landslides. Further, deforestation and land-use change can contribute to soil erosion, which can destabilize slopes and increase the likelihood of landslides. They can have ecological impacts and result in economic losses due to property damage and infrastructure repair costs (Mauran, Knevels, & Misha, 2022)Climate change is increasing the intensity and/or frequency of many heavy precipitation events in many regions, raising the potential for rainfall-triggered landslides where exposure and susceptibility already exist. The IPCC and recent reviews identify stronger extremes as a plausible pathway for increased landslide activity in many contexts (Calvin et al. 2023).

3. Adaptation and mitigation strategies

Risk reduction regarding landslides can be implemented twofold. Once, they can be used to reduce the risk of landslides and secondly, they can be used to monitor movement or rainfalls to enable early warning systems.

For adaptation in regards to reducing the risk of landslides, nature-based solutions such as reforestation and afforestation can help to enhance the stability of slopes. Another possibility are technical or structural aspects such as retaining walls and drainage control.

Remote sensing & near-real-time systems: Satellite data (soil moisture, precipitation, InSAR deformation) feed models and operational systems — e.g., NASA's LHASA (Landslide Hazard Assessment for Situational Awareness) provides near-real-time, global indications of rainfall-triggered landslide hazard and can be integrated into operational monitoring (NASA, 2025).

Early warning systems (EWS): Community-oriented rainfall thresholds, automated sensor networks, and multi-hazard early warning frameworks reduce fatalities when coupled with clear communication, evacuation planning, and local capacity.

4. Further information

https://www.bgs.ac.uk/geology-projects/landslides/national-landslide-database/

https://esdac.jrc.ec.europa.eu/themes/landslides

https://www.earthdata.nasa.gov/topics/human-dimensions/landslides

https://gpm.nasa.gov/landslides/projects.html#LHASA

5. References

Calvin, Katherine, Dipak Dasgupta, Gerhard Krinner, et al. 2023. IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (Eds.)]. IPCC, Geneva, Switzerland. First. With Hoesung Lee. Intergovernmental Panel on Climate Change (IPCC). https://doi.org/10.59327/IPCC/AR6-9789291691647.

European Commission. 2025. “Landslides.” Joint Research Centre - European Soil Data Centre (ESDAC). https://esdac.jrc.ec.europa.eu/themes/landslides.

IPCC. (2021). Summary for Policymakers. In Climate change 2021: The physical science basis. Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change. Cambridge University Press.

Mauran , D., Knevels, R., & Misha, A. N. (2022). A severe landslide event in the Alpine foreland under possible future climate and land-use changes. Commun. Earth Environ.

MCC. (2024, 03). Mercator Research Institute on Global Commons and Climate Change. Retrieved from Verbleibendes CO2-Budget: https://www.mcc-berlin.net/forschung/co2-budget.html

NASA. 2025. “Landslide Hazard Assessment for Situational Awareness (LHASA) Model.” https://gpm.nasa.gov/landslides/projects.html#LHASA.

Statista. (2024, 03). Statista. Retrieved from CO2-Emissionen weltweit in den Jahren 1960 bis 2022: https://de.statista.com/statistik/daten/studie/37187/umfrage/der-weltweite-co2-ausstoss-seit-1751/

USGS. 2025. “Landslide Basics.” USGS - Science for a Changing World. https://www.usgs.gov/programs/landslide-hazards/landslide-basics.