Towards a comprehensive land degradation risk assessment – building on the concept of ecological resilience

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Motivation

Land degradation (examples in Fig. 1) negatively impacts the well-being of 3.2 billion people and results in a loss of about 10% of annual GDP (IPBES, 2018). According to the IPCC (2019), land degradation represents "one of the most urgent challenges for humanity". In the Millennium Ecosystem Assessment (MEA, 2005), 60% of the examined ecosystem services were being degraded.
Land degradation dynamics are often creeping, occurring over long time scales, but can also be non-linear, involving tipping points (Fig. 2).

- ➤ As a result, damages and risks of land degradation are often not directly perceived and hard to quantify.
- ➤ Land degradation is usually not perceived as a stand-alone natural hazard and consistent risk assessment approaches are still lacking.

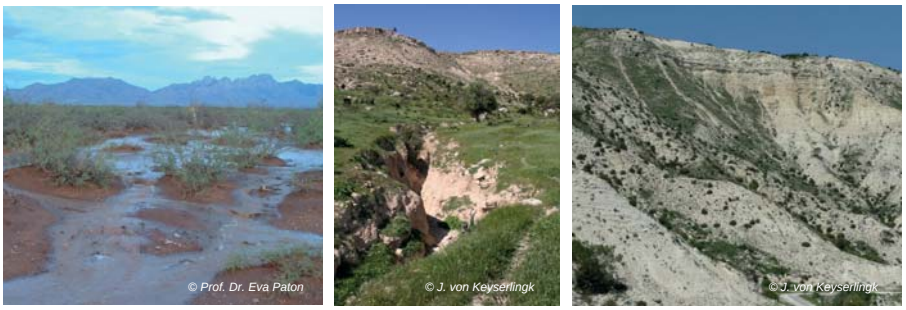

Figure 1: Examples of land degradation: overland flow, gully erosion, soil erosion and loss of vegetation cover (from left to right).

Systematic literature review
identified shortcomings in existing land degradation risk assessment approaches

(1)"Risk" used with colloquial meaning & Risk terminology not consistent within and among studies
(2) Risk assessment frequently confused with degradation status assessment OR with vulnerability assessment
(3) Damages & temporal dynamics rarely explicitly considered
(4) No consensus about what the hazard land degradation contains
(5) No distinction between processes and drivers, cause and effect, hazard and vulnerability

- ➤ This hinders implementation of risk mitigation measures

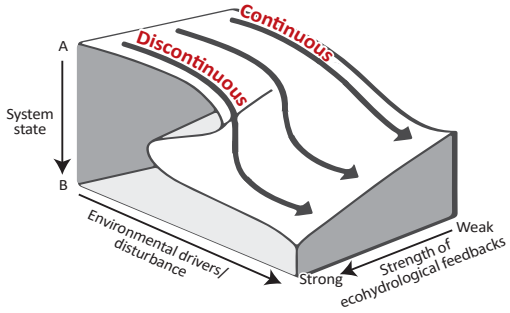

Figure 2: Cusp catastrophe model; adapted from Turnbull et al. 2008

Towards a comprehensive framework for land degradation risk assessment

The proposed framework for land degradation risk (Fig. 3 and Table 1) combines the concept of ecological resilience with the theoretical risk framework developed within disaster risk research. In disaster risk research, risk is described as a function of hazard, exposure and vulnerability. The hazard is usually expressed in form of a probability of occurrence and the intensity of the process, while vulnerability is described by a combination of susceptibility and resilience to the hazard.

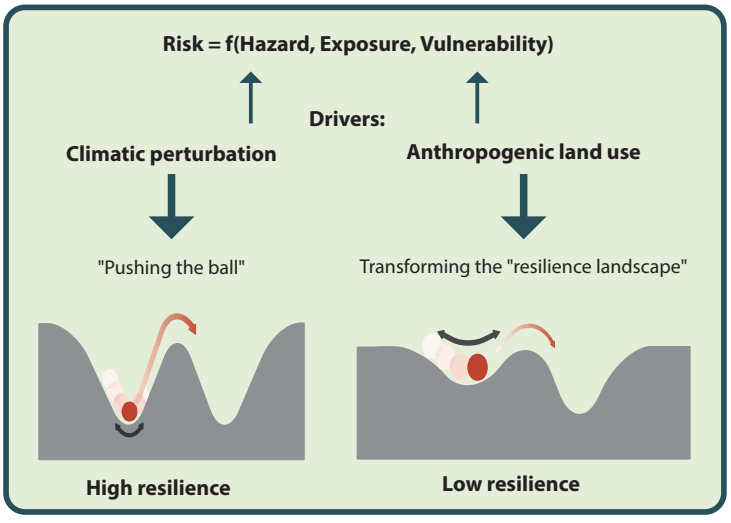

Figure 3: Conceptualization of the proposed risk-resilience model for land degradation; based on a combination of the "ball-in-a-cup" model for ecological resilience and the classical risk function developed within disaster risk research. Figure adapted from von Keyserlingk, 2021.

- Fast climatic perturbations trigger degradation processes, such as erosion.
- Slow drivers transform resilience landscape.
- The concept promotes a clear distinction between hazard and vulnerability.

- ➤ For a given probability of hazard occurrence several land management scenarios can be compared and the effct on the total risk can be estimated.

Risk Component		Sub-components	Indicators
Exposure		**Area of interest** on local or regional scale	Total size of AI or % of agricultural land of total area, depending on the goal of the risk analysis
Hazard		**Key geomorphic degradation processes**; e.g. shrub encroachment, overland flow, wind- and/or water erosion	Frequency of fast climatic events triggering these geomorphic processes + Predictions based on past rates and trends of the geomorphic processes themselves (i.e. trend in erosion rate
Ecological Vulnerability	Ecological resilience	**Ecological resilience** to natural climate variability and extreme events, i.e. to fast climatic drivers triggering the key geomorphic degradation processes (hazards)	Quantification of ecological resilience to climate variability for different scenarios of slow land degradation drivers, i.e. land use and climate scenarios
	Bio-physical Susceptibility	**Relatively stable ecosystem properties** relevant for the susceptibility to the specific hazards	E.g. terrain slope steepness and aspect, soil type, vegetation type, water quality index

Table 1: Proposed Identification of risk components and indicators for land degradation risk on ecosystem level. Adopted from von Keyserlingk, 2021.

References

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