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Questioning models of land degradation in arid and semi-arid regions: a re-assessment based on evidence from northern Jordan

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Assessments of land degradation in arid and semi-arid regions frequently employ models calculating annual erosion rates from the size of sediment bodies, assuming grain-by-grain transport and constant processes of deposition. It is often attempted to connect historic sediment bodies to past land use and climate by correlations with demographic estimates and reconstructions of past precipitation averages. In addition, mass transport is often equalled with soil loss and fertility degradation, based on the idea that humus-rich topsoils store the greatest part of soil nutrients. However, such concepts are based on premises transferred from temperate regions, and their suitability for arid and semi-arid regions is questionable. For example, dryland soils usually contain very small amounts of organic matter, which means that their fertility is mostly a function of texture, and a limited loss of topsoil is rather irrelevant for agricultural productivity. Part of the sediments deposited in valleys come from soft, easily erodible rocks, which means that they reflect slope denudation and not soil erosion. As well, erosion-sedimentation processes do often not take place by continuous transport of single grains. This is illustrated with a valley fill in northern Jordan: sediments were deposited discontinuously, mainly by slumping and earth flows, and the largest parts of the fill accumulated in time frames of ~100 years during the two Little Ice Ages (6th and 14th century AD/CE). Due to a dominance of smectites, the clay-rich Red Mediterranean Soils in the vicinity shrink and form cracks during the dry period. Because of the cracks and underlying limestone karst, they can swallow strong rains without erosion risk. However, when water-saturated, soils expand and may move in slump flows. Soil-covered geoarchaeological features like a buried ancient cemetery illustrate that such viscous flows created new land surfaces, sealing cavities but not filling them. This suggests a major role of rare but intense rainfall events in erosion-deposition processes. Analogies with modern rainfalls, including record levels of precipitation during the winter 1991/1992, indicate that levels of soil moisture triggering similar slump flows have not been reached during times of modern rainfall monitoring. That ancient land use played a minor role for erosion is supported by intense surveys of archaeological material on fields surrounding the valley, which indicate that the periods of most intensive land use coincided with very limited sediment deposition. Concepts of land degradation in semi-arid and arid regions should be reconsidered, respecting the more irregular environmental setting, the specific soil properties, and traditional land use systems which evolved in constant adaptation to this environment. Rare but extreme rainfall events as potential main drivers of land degradation should be considered more: they are difficult to control or mitigate, but may increase due to climate change.