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Climate change impacts on land degradation and food security in shifting cultivation systems in mountainous terrain

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Abstract

Rising precipitation intensities under climate change will likely increase soil erosion, particularly in steep regions, putting pressure on smallholder cultivation systems and food supply in mountainous terrain. However, climate change impacts on the degradation of uphill smallholder farming systems are highly understudied. This study assesses the impact of changing precipitation regimes on soil erosion in uphill shifting cultivation, a centuries-old, extensive, smallholder rotation farming system, practiced by mountain communities in South and Southeast Asia. Due to limited livelihood alternatives, shifting cultivation plays a key role in securing food supply for mountain communities, but is at the same time highly vulnerable to soil erosion.

We apply an interdisciplinary approach combining biophysical process modeling with mixed social science methods to explore risks of soil erosion and implications for the food security of tribal farming communities in the Himalaya region. We use the Environmental Policy Integrated Climate (EPIC) model on six sites in Northeast India with surveyed soil profiles, to simulate erosion dynamics in daily time steps for a near (2021-2050) and far (2071-2100) future period. We consider three climate scenarios, five climate models, fallow periods between one and 20 years, and different slope inclinations. In addition, we conduct quantitative and qualitative interviews with tribal farmers about perceived climate change impacts on shifting cultivation in the study region.

Our simulation results reveal a non-linear relationship between global warming and soil erosion in uphill shifting cultivation systems, with erosion rates increasing by 25%, 50%, 115%, and 190% under warming levels of 1.5 °C, 2 °C, 3 °C, and 4 °C, respectively. Increases in erosion rates are linked to both an increasing frequency and intensity of erosion events, and will mostly occur in particular after sowing in early spring and harvesting in September and October. Beyond quantifying the positive relationship between slope inclination and erosion, our results highlight an increase of erosion rates in cultivation systems with short fallow periods.

Increasing erosion rates in a warmer climate will stimulate uphill land degradation and challenge local food security. By erosion of the nutrient and organic carbon rich top soil, soil aggregate stability is reduced, leading to an increasing cycle of soil and productivity losses. Lower availability of productive lands will likely lead to increasing cultivation intensities and migration of shifting cultivation to higher altitudes. This will further accelerate upland degradation and undermine the food security of tribal farming communities in the Himalaya region.

Keywords

Erosion, Himalayas, land degradation, shifting cultivation