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Effects of the projected changes in land use and climate on soil vulnerability in Europe

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Soil degradation threatens ecosystem stability and global food security by undermining soil health and functionality. Certain soil degradation processes can be further intensified under changing climate and with land use alterations. Here we combine projections from 18 global climate models under two emission scenarios (SSP2-4.5 and SSP5-8.5) with land use fractions from the Land Use Harmonization (LUH2) dataset, to assess future soil vulnerability to degradation across Europe. Utilizing a machine learning framework, we linked the Soil Vulnerability Index (SVI), to topography, soil texture, climate, and land use factors. Our SVI projections for the near future (2031–2060) and far future (2071–2100) show that northern European countries, such as Estonia and Latvia will experience increments in SVI by up to 16% driven by climate factors. Conversely, southern countries such as Spain and Italy may experience declines in SVI, reflecting potential improvements in soil health conditions associated with land use changes. Moreover, our results show that land use changes in arid zones may lower SVI for 45% of observations under SSP2-4.5 scenario. Meanwhile, in colder regions, change in climate factors heightens SVI in 55% of observations under SSP5-8.5 scenario. Our findings highlight the need for targeted soil management strategies that address both land cover management and climate change adaptation to mitigate negative impacts on soil health under future climate scenarios.