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Mapping soil vulnerability to floods under varying land use and climate: A new approach

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Floods can cause considerable damage to property and infrastructure, threaten human lives and cost millions in emergency assistance, clean-up and remediation. Flood prediction requires quantitative knowledge about infiltration and runoff dynamics, which is generally gained at the local scale. When scaling up such local investigations to the catchment scale, account needs to be taken of the catchment's organization (connectivity and patchiness). This study aimed (i) to identify and characterize flow processes at the plot scale, and (ii) to up-scale this knowledge to the catchment scale in order to map zones with a predisposition to excess surface runoff. Excess surface runoff was scaled up by means of Terrain Analysis using Digital Elevation Models (TauDEMs) calibrated with in-situ sprinkling experiments of three irrigation intensities carried out on 57 plots under grassland and forest that dominate in the investigated area. The marked differences in textural and structural porosities between forest and grassland plots appear to control runoff processes. On the one hand, forest soil has a higher storage capacity than grassland soil, probably caused by a high unsaturated hydraulic conductivity and root water uptake, and resulting in lower surface runoff. On the other hand, fine material in the topmost ten centimetres of grassland soil helps to build a structure that impedes vertical downward percolation and thus enhances surface runoff. However, within each soil category, slope plays an important role in generating surface runoff. In addition, raising the irrigation intensity from 24 to 48 mm/h increases the risk of predisposition to surface runoff from middle to high in major parts of the catchment under grassland, whereas forest soils show vertical percolation in all cases except on slopes steeper than 31.3 degrees. Scaling up runoff processes using TauDEM based on sprinkling experiments provided new quantitative insights into flow processes and enabled us to trace the hydrological connectivity between zones of various predisposition to excess surface runoff under different land uses. These promising results indicate that the approach is suited for mapping soil vulnerability to floods under varying land use and climate at any scale.