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Impacts of land use changes on floods: A hydrodynamic perspective

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The frequency of major floods seems to be increasing in many countries around the world. Climate change may be a significant driver of changes in flood frequency, which has been widely investigated. Land degradation due to land use – for example, soil compaction from crop farming, intensified grazing, or urbanization – is another potential driver of the increase in flood frequency. But although land use change may have a major effect on floods, given that it frequently implies heavy modification of natural landscapes, only few studies have investigated the role of land use change in modifying peak discharge at the catchment scale.
The high root water uptake in structured soils (e.g. forest soils) can be viewed as an important factor enhancing soil storage capacity and, consequently, reducing the generation of surface runoff. However, these flow processes are difficult to assess, because the heterogeneity of soil hydraulic properties causes natural soils to respond to rainfall in many different ways.
At the small catchment scale, experimental evidence showed that changes in the soil properties of the few topsoil layers due to land use play a dominant role in controlling surface runoff. In fact, the dense few topsoil layers resulting from land use limit water flux into the underlying macropores and may reduce the soil's storage capacity and enhance surface runoff generation. At this scale, floods are mostly generated by the infiltration excess mechanism from high-intensity and short-duration storms. At larger scales, where floods are often produced by the saturation excess mechanism from lower-intensity, longer-duration storms, the effect of land use (e.g. soil compaction) on flood peaks is less obvious, and most studies are model-based. A catchment can be represented as a mosaic of tiles with different land uses, land management, and soils. Causal links vary across the mosaic with the physical properties of the land and the drainage channel network, with management practices, with spatial and temporal variations in rainfall and soil moisture. Careful land use planning taking into account these processes and their impacts on soil structure and functions, illustrated here with different cases studies, can help to better manage land and water resources at different scales.