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Large-scale soil conservation measures contribute to water insecurity in NW China

Lulu Zhang (1), Karl-Heinz Feger (1), and Kai Schwärzel (2)

(1) Technische Universität Dresden, Institute of Soil Sciences and Site Ecology, Tharandt, Germany (zhang@forst.tu-dresden.de, karl-heinz.feger@tu-dresde), (2) United Nations University. Institute for Integrated Management of Material Fluxes and of Resources. Dresden. Germany (schwaerzel@unu.edu)

The Loess Plateau of NW China is one of the most degraded environments worldwide with an annual soil loss rate of ∼20,000 t/km^2. To improve the situation, a national policy against erosion has been implemented in this region since 1950s. This policy includes biological (tree and grass plantation) and engineering (terrace and check-dam construction) measures. However, subject to enormous alteration in land cover / form, an undesired drastic reduction of runoff has appeared hampering economic growth, agricultural production and thus threatening social stability. As a consequence, adaptive innovative management strategies are necessary for mitigating water use conflicts and ensuring regional sustainable development. For successful implementation of such strategies, an improved understanding and quantification of hydrological response to land use and climate change across different scales is essential. For this purpose, the hydrological response to different land cover / form and climate change in the past 50 years was analyzed in small and medium-scale catchments using the upstream of Jing River (Gansu province) as a case. It appears that the driving factors of runoff reduction at different scales are different in terms of land use and climate change. Our study gave evidence that in a small catchment (19 km^2), land cover / form change and precipitation variability are the major factors reducing runoff. After separating their contribution, we found that land use change was responsible for 74% of runoff decline while decreased precipitation accounted for 26%. Surprisingly, the annual runoff exhibits a good correlation with precipitation and the percentage area of various land use. Notably, with increasing catchment size the impact of land use on runoff attenuates, while the role of climate ascends. In addition to land use and precipitation, energy supply (evaporative demand of the atmosphere) becomes another dominant climatic factor affecting runoff on the larger scale (3,080 km^2). This indicates that the roles of land use and climate change in controlling runoff across different scales are not identical. According to sensitivity analysis, runoff appears more sensitive to precipitation than a comparable change in potential evapotranspiration. To quantify the hydrological response of runoff to a change in the studied factors, we developed an empirical statistical approach that incorporates temporal changes in land cover / form and climatic parameters for predicting annual runoff of this region. This approach has proved to have higher predictive ability than other models in reproducing annual and long-term runoff. It provided evidence that enlarging afforestation and terracing may cause a significant decline in runoff. Both measures may cause a more significant runoff reduction in relatively humid catchments than in relatively dry catchments in absolute terms. However, in terms of percentage, it is probably more critical for drier catchments, due to their more limited water availability. Our analysis demonstrates that the implementation of planning for ecosystem restoration on the Loess Plateau needs a comprehensive assessment that includes on-site effects on soil retention and off-site effects on runoff. Adaptive water-saving measures are urgent for ensuring water supply security in this dryland region of China.