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Identification of thresholds to conduct efficient soils and water conservation strategies against erosion impacts: new insights from a modelling prospective in Normandy (France)

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Erosion is recognized as a major threat worldwide and can be dramatically observed in Northwestern France as a consequence of water runoff. Recent regional studies in Normandy suggested that off-site erosion and runoff impacts led to significant economic costs over the last 25 years. Even if the regional planning strategy against erosion and runoff impacts could be seen as effective with a cost-benefice balance greater than 1, this strategy will no longer be as effective by 2050 due to climate change effects in the near future. To address this issue and conduct efficient land and water degradation neutrality strategies, local stakeholders now have to identify complementary strategies based on the deployments of nature-based solutions. However, there is a lack of references on the effectiveness of these complementary strategies.

In this study, we conducted a modelling exercise with the WaterSed model at the regional scale (12,318 km²) aiming to: (i) quantify the hydro-sedimentary transfers reaching the karstic systems throughout the 15,000 sinkholes distributed across the territory, (ii) established the first regional cartography of vulnerability of sinkholes to runoff and erosion, and (iii) to evaluate the effectiveness of strategies considering nature-based solutions to prevent land and ground water degradation.

The model was calibrated and validated using data of hydro-sedimentary transfer monitoring station on a local catchment. Multiples scenarios were explored (impacts of different nature-based solutions densities, localization of grasslands, ploughing of grass lands, soil and water conservation techniques, etc.) using semi-automatic positioning algorithm.

The WaterSed model provided specific outputs like volume of runoff (m^3) and volume of sediments (t) reaching the karstic system for different designed storms. The mean runoff per sinkhole was estimated between 7,700 and 23,200 m^3 and the mean volume of sediment reached between 0.8 and 4.7 t per sinkhole.

Our results suggest that increasing the density of nature-based solutions from 2 to 8 per km² can reduce from 0.5 to 1.3 % the runoff volume and from 5 to 15 % the sediment load reaching the sinkholes. Our results also suggest that a complement of 20 m to 250 m of grassland upstream a

sinkhole can reduce the sediment load from 5 to 13 % and the runoff from 0.5 to 1.5 %. Our results suggest that the localization of ploughed-up grasslands can have a significant impact on the generation of hydro-sedimentary transfers (up to 10 % more sediment discharge).

The results of this modeling exercise provided: (i) the first regional cartography of vulnerability of the 15,000 sinkholes to runoff and erosion, and (ii) local thresholds and valuable references to build and conduct efficient land and ground water degradation neutrality strategies with stakeholders.