Exploiting sUAS, SfM-MVS and a topographic algorithm to quantify the volume of sediments deposited in check dams and understand its spatial variation

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Check dams are structures used to mitigate soil erosion and desertification. These structures allow to quantify the volume of material deposited. Unlike other more classical monitoring methods, small Unmanned Aerial Systems (sUAS) provide high spatial resolution, ideal for estimating soil erosion based on the volume of sediment deposited behind the dams. A sUAS combined with Structure-from-motion photogrammetry (SfM) and MultiView-Stereo (MVS) were used to obtain high resolution aerial photos and Digital Elevation Models (DEMs). A total of 269 check dams were identified, from which 160 were suitable to quantify the deposited sediment volume in an area of 239 ha in SW Spain over a period of 11 to 23 years. The main goal of this work is to estimate the volume of sediments deposited in check dams and to study the spatial variability of the accumulated sediments and its relationships with different environmental variables. The methodology included five steps: 1) fieldwork that included flying the study area with a fixed-wing sUAS to capture high-resolution aerial photographs and acquiring Ground Control Points (GCPs) using a Global Navigation Satellite System (GNSS), 2) SfM photogrammetry processing using the acquired images and the GCPs, 3) edition of the obtained point cloud and DEM to represent the current topography and model the past soil surface, 4) estimating the volume of sediments behind each check dam and 5) exploring the relationship between sediments and different environmental variables. The total sediment volume trapped in the check dams was 424.15 m$^3$ (0.141 m$^3$ ha$^{-1}$ y$^{-1}$) ranging from 0 to 108.35 m$^3$ for individual sites and resulting in an average deposition of 0.133 m$^3$ y$^{-1}$ per check dam. The 77% of the check dams retained less than 1 m$^3$ of sediment.

A large spatial variability of the accumulated sediments within catchments was observed. Large volumes of sediment were accumulated in the lower parts of the basins as compared to the upper parts. The check dams with the highest sediment trapped were those located in highly connected areas. Deposition rate was negatively correlated with drainage area, connectivity, stream power index, upstream channel length and the number of upstream check dams. On the contrary, deposition rate was positively correlated with channel slope. The topographic position and the size of the dam wall played a fundamental role in explaining the differences of total sediment accumulation as well as the deposition rates.

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