EGU24-8675, updated on 31 May 2024
https://doi.org/10.5194/egusphere-egu24-8675
EGU General Assembly 2024

Assessment of flash flood impacts in a mountain basin: an integrated approach for the management of channel control works

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In mountain basins, the predominant approach to control the supply and transport of large volumes of sediment involves the installation of hydraulic structures within the channel network. While torrent control works are fundamental in reducing flash flood impacts, their effectiveness during time need regular monitoring and maintenance. However, few studies have proposed a workflow based on simple factors and criteria collected in the field to prioritize management interventions of torrent control works in a mountain basin. In this work, the aims are to assess the effectiveness of the hydraulic structures and to quantify their impact on sediment continuity in the Vegliato mountain basin (Italy), affected by a flash flood event occurred on the 30th July 2021. First, rainfall data from 2019 to 2022 are analyzed to detect and characterize the event that caused the flash flood. The assessment of post-event status and functionality of the control works is done using a novel Maintenance Priority index (MPi), distinguishing the structures that no longer fulfil their role and providing an overview on the maintenance and re-planning of the management system. These results integrate the analysis of multi-temporal High Resolution Topography (HRT) data deriving from LiDAR surveys. DEMs of Difference (DoDs) are generated to map the geomorphic changes occurred during the event, quantifying the sediment fluxes impacting on the control works and viceversa. The role of torrent control works is also analyzed in terms of continuity of the sediment cascade applying a novel parameter, the Sediment (dis)Continuity Ratio (SCR), which assesses the capability of the torrent control works system in intercepting and storing a sediment mass fraction constituting the cascade (obtained by DoD) and identifies the hydraulic structures that contribute or limit the sediment (dis)continuity along the channel network.

The application of the MPi indicates that the 16% of the control works should be given the highest maintenance priority (MPi = 1). The 45% of the hydraulic structures exhibit $0.63 \leq MPi \leq 0.88$ and are in need of intervention to ensure the durability of the structures themselves. On the other hand, 12% of the control works require re-planning operations ($0.25 \leq MPi \leq 0.50$) due to their good structural condition but low functionality. Eventually, the 25% of the structures show MPi = 0 and are in the lowest range of priority for the interventions. These results were also corroborated by the DoD results, which supported the MPi. The analysis of the SCR shows how several torrent control works, especially the ones located in the upper part of the catchment, promote continuity

(SCR from -100 to -0.1). On the other hand, several structures in the middle part of the main channel show positive SCR values, therefore promoting discontinuity. The highest values of SCR are found in the downstream and wider part of the main channel.

Finally, the workflow composed of different methodologies adopted in this work provides a detailed overview of the interaction between sediment dynamics and torrent control works and represent a useful tool to develop effective management decisions and plans.