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## Unmanned Aerial Vehicle surveys for monitoring and managing river system: a case study in Valsassina (Northern Italy)

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Hundreds of thousands of people live and work in areas at risk of flooding, especially into deep valleys over the Italian territory. Floods cause fatalities and considerable economic damages to infrastructures and to private and public properties, besides impacting on fluvial-geomorphic landforms. During the last decade, these extreme events are occurring more frequently, contributing to increase the public awareness on the potential damaging consequences, and on the demand of monitoring and post-event assessment procedures. However, an efficient, systematic and accurate framework of post-event actions aiming to document the impacts of such disasters in terms of flooded areas, meteorological controls, geomorphological and vegetation change, is rare.

On this background, the role of the post-event surveys is fundamental to provide information/data and to increase knowledge for improving forecasting and designing the countermeasures. Flood events documentation consists in a series of field- and desk-based activities that request considerable consuming resources (time and human) and a high level of technical expertise. The post-event analyses, then, should correctly balance the different activities and efforts to reduce time and costs and then become a part routine post-event procedure.

The present study shows the results of a field campaign carried out after a flash flood occurred on June 12th 2019 along a 2 km stretch of Pioverna torrent in Valsassina (Lombardy, Italy). The survey consisted in collecting meteorological data, and video and pictures taken by inhabitants and rescuers for reconstructing field evidences of flood and the peak discharge. Few weeks after the flood, an Unmanned Aerial Vehicle (UAV) captured multiple images that were processed by Structure from Motion (SfM) photogrammetric algorithms, together with permanent Ground Control Points (GCPs) positioned on the riverbed and the streambanks, in order to obtain a high-resolution topography data. The methodology is likely to be truly effective if a pre-event photogrammetric survey is available for the same stretch, as in the present case.

The UAV photogrammetric surveys expected to be able to detect: (i) the geomorphological changes including streambank erosion, sediment deposition and the general stream evolution; (ii)

the flood-damaged areas including buildings and roads (useful for estimating economic losses) and hydraulic structures (useful for giving a priority to the restoration works); (iii) the change in vegetation patterns that strongly influence the fluvial geomorphological processes.

In such a perspective, a simple methodology has been developed and applied to obtain a good balance between accuracy, time-consuming, efforts and collected data. In addition, it has been showed how the post-flood campaign has a strategic significance for a wide spectrum of multidisciplinary aspects (damage assessment, hydraulics, and ecology) and allows to rapidly reconstruct the flood event and its consequences. Standardizing such procedure should be extremely important to collect similar data, useful to improve specific guidelines and post-emergency management plans.