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Prioritising watersheds on the basis of regional flood susceptibility and vulnerability in mountainous areas through the use of indicators

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Settlements in peri-urban areas of many cities in mountainous areas such as in the Andes are susceptible to hazards such as flash floods and debris flows. Additionally these settlements are in many cases informal and thus vulnerable to such hazards, resulting in significant risk. Such watersheds are often quiet small, and generally there is little or no information from gauges to help characterise risk. To help identify watersheds in which flood management measures are to be targeted, a rapid assessment of risk is required. In this paper a novel approach is presented where indicators of susceptibility and vulnerability to flash floods were used to prioritize 106 mountain watersheds in Bogotá (Colombia). Variables recognized in literature to determine the dominant processes both in susceptibility and vulnerability to flash floods were used to construct the indicators.

Susceptibility was considered to increase with flashiness and the possibility of debris flow events occurring. This was assessed through the use of an indicator composed of a morphometric indicator and a land use indicator. The former was constructed using morphological variables recognized in literature to significantly influence flashiness and occurrence of debris flows; the latter was constructed in terms of percentage of vegetation cover, urban area and bare soil. The morphometric indicator was compared with the results of a debris flow propagation algorithm to assess its capacity in indentifying the morphological conditions of a watershed that make it able to transport debris flows. Propagation was carried out through the use of the Modified Single Flow Direction algorithm, following previous identification of source areas by applying thresholds identified in the area-slope curve of the watersheds and empirical thresholds. Results show that the morphometric variables can be grouped in four categories: size, shape, hypsometry and energy, with the energy the component found to best explain the capability of the watershed to transport debris flows. The combination of the morphometric and land use indicators resulted in a susceptibility indicator that was compared with the available records of past floods in the area. This showed that the use of the land use indicator significantly improves the susceptibility assessment.

Vulnerability was assessed in terms of indicators representing physical exposure, fragility of the socio-economic system and lack of resilience to cope and recover. Principal component analysis was subsequently applied to reduce variables and provide a representation of each of their facets by a component. This resulted in a composite indicator of susceptibility and vulnerability for each of the 106 watersheds. The indicator was compared with the history of flash flood damage in the watersheds. Results show that the indicator is useful in applications at regional scales for preliminary assessment to differentiate at spatial level the degree of flood susceptibility and vulnerability. This provides an initial and qualitative risk outlook in the study area and can be used for planning and prioritization of further more detailed studies.