



The impact of communal irrigation systems on long run-out landslides triggered during the 28th September 2018 Palu earthquake, Indonesia

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The devastating M_B7.5 earthquake of 28th September 2018 north of Palu, Indonesia, caused devastation dominated by secondary effects, leaving thousands dead, missing and displaced in central Sulawesi. While much international attention has been paid to the tsunami that affected coastal areas, a remarkable set of landslides in suburban parts of the city translated fields and buildings over 1 km down slopes of less than 2°, contributing significantly to the casualty and damage statistics, yet they have been given little attention. We show that the largest and most destructive of these landslides formed exclusively in an area of communal irrigation. They detached on a shallow liquefied decollement rooted upslope in a canal that supplied water to the entire irrigation network. Using very high resolution satellite imagery from before and after the earthquake, we mapped the irrigation infrastructure on gently sloping distal alluvial fans that form the suburban outskirts of Palu city, identifying conveyance canals, distribution channels, valve systems controlling water holding, distribution boxes and turnouts. The landslides, of high displacement translation/lateral-spread character, are characterised by upslope zones of extension and downslope zones of thrusting. Translation was sufficient to expose the liquefied sub-horizontal basal detachment in their central sections. In all of the high run-out landslides and zones of incipient landsliding, the extensional domain shows a close association with irrigation infrastructure both laterally and longitudinally. Upslope of the irrigation network there were no slope failures, despite greater topographic gradients, highlighting the primary influence of water introduced to the liquefied layer by the irrigation network. This study highlights the risks of large irrigation projects in areas of active seismicity, and identifies large, partly urban areas of minor or incipient landsliding that may be critically unstable during future earthquakes in central Sulawesi.