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Understanding landslide occurrence and distribution in North-western Rwanda

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In Rwanda, landslide fatalities, damages and property loss have tremendously increased in recent years with high rate in Western and Northern parts of Rwanda. The landslide fatality inventory from 2011 to 2018 indicated 195 loss of lives and 172 injuries with 81% death recorded in Western and Northern provinces of Rwanda identified as the most landslide prone area. This research aims to understand and quantify the landslide occurrence and distribution in North-western Rwanda. Based on satellite and field-based landslide inventory, 563 landslides aged from 1990 to 2018 comprised of active and inactive landslides were recorded with 34%, 26%, 17%, 15% and 7% classified as rotational slide, flow, translational slide, fall and complex type of mass movement respectively and involving mainly debris and earth materials. These landslides are mainly deep (>5m depth) involving the movement of the weathered bed rock and the overlaid soil regolith indicating their main linkage to the geologic and lithological factors rather than solely rain storm. The geology is mainly made of metamorphic and igneous rocks and the lithological units in landslide area includes mainly mica schists and pegmatite rocks which are unstable due to rapid weathering, easy splitting along the joints and bedding planes and loss of strength induced by the high content of mica. The landslide areal extent varies from $2.8\times10^{1}\mathrm{m}^{2}$ to $4.4\times10^{5}\mathrm{m}^{2}$ with an intensity of failure volume (V_{L}) estimated between $1.3\times10^{1}\mathrm{m}^{3}$ $<\mathrm{V}_{L}$ $<5.8\times10^{6}\mathrm{m}^{3}$ associated with a total landslide mobilization rate of about 21mm year^{-1}. The main type of soils involved include acrisols characterised by high clay content in deep layers acting as an impermeable layer creating perched ground water and thus high pore water pressure in the overlaying soil layers. Despite the government effort in land use planning and hazard risk reduction, the land use change may also be one of the landslide causes in the area with high deforestation rate for the sake of agricultural land. The Landsat-8 images (1990-2016) indicated a forest land decrease from about 71% to 16% while agricultural land raised from about 25% to 72% inducing an estimated change in cumulated landslide intensity (volume) from $7\times10^{5}\mathrm{m}^{3}$ to $2.3\times10^{7}\mathrm{m}^{3}$ in 8 years from 2000 to 2018. The most critical period with the highest landslide intensity $2\times10^{7}\mathrm{m}^{3}$ equivalent to 89% of the total slope failure volume was in 2000-2010 period which is probably linked to the highest deforestation rate observed in years between 1990-2000 with a decrease in forest land from about 71% to 32%. The gradual decrease in shear strength caused by the decaying and uprooted trees'roots and the changes in hydrological processes triggering landslide mainly infiltration, percolation, soil water content and ground water level fluctuations after deforestation could be among the sources of increasing landslide hazards and need to be confirmed based on either field observation or modelling process.

Key words: *Landslide classification, distribution, intensity and mobilization rate*