Geophysical Research Abstracts, Vol. 7, 01668, 2005
SRef-ID: 1607-7962/gra/EGU05-A-01668

Relating remotely sensed land-use and land-cover changes to landslide activity: a case study from Italy

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Land-use/land-cover changes, whether of natural origin or man-made, can influence the susceptibility of slopes to landsliding. The mechanical properties of slope materials can be altered through agricultural activities involving ploughing or other modifications of the existing cover, as well as through conversion, i.e. changes of the cover from one type class to another (e.g. deforestation for cropland). Different environmental transformations can also affect the soil water balance and thus groundwater pressures and effective strengths of slope materials. Although geotechnical models can indicate the expected general trends of influence of land-use changes (either decreasing or increasing stability), more investigations seem necessary to assess in practice their relative significance with respect to other important factors (hydrogeological, geomorphological, physical) driving the spatial and temporal occurrence of landsliding. We address this issue by documenting and comparing the land-use/land-cover changes and landslide activity variations occurred in over 40 years in an area of central Apennine mountains. Two series of georeferenced and orthorectified airphotos (from 1954 and 1990) as well as one meter pixel resolution orthophoto images from 1997 were used to classify a landslide-prone area of 27 km2. The following major classes were distinguished: developed (artificial) land (urban and rural settlements, roads and other infrastructures); barren land (exposed rocks); barren land (exposed mudstones/clays); cultivated land; arboreous land (forest, dense shrub); grassland. The classification results show that the area has undergone pronounced land-use/land cover changes since 1954. In particular, the spectacular decrease of cultivated land (from 63 % to 15 %, expressed in terms of areal frequency), linked to the abandonment of agricultural activities, coincided with large increases in grass land (from 17.5 % to 38,5 %) and arboreous land (from 8.5 % to 35 %), as well as with the expansion of settlements and infrastructures (from 1 to over 4 %). In comparison, the overall variations in landslide

activity were rather modest. Nevertheless, the incidence of landsliding in rural areas apparently decreased as the abondoned land was overtaken by grass land, dense shrub and forests. At the same time landslide activity expanded towards and upon newly developed peri-urban hillside areas. It is likely that this increased susceptibility to landsliding reflects not only land cover modifications but also the changes in other forms of human impact on the local environment (e.g. greater input from septic systems and leaky pipes to groundwater recharge, greater runoff volumes from urbanised areas and roads, inadequate maintainance of surface drainage works in peri-urban areas). The shift in spatial susceptibility to landsliding has clear socio-economic implications as the value of peri-urban elements (population density, property and infrastructure) at actual or potential landslide risk is higher with respect to those of rural areas. The outcomes of this work may be of more general interest. Indeed, similar shifts in mass movements susceptibility are likely occurring elsewhere in the Apennines, following the progressive abandonment of agricultural activities in rural areas in the last few decades. Furthermore, many Italian hilltop/hillside towns located in geomorphologically active mountainous regions have recently undergone development and their new peri-urban areas appear now prone to landslide hazards