32,000 landslides in the Emilia-Romagna Apennines: knowledge and management

di Giovanni Bertolini \(^1\), Maria Teresa De Nardo \(^2\) & Marco Pizziolo\(^2\)

\(^1\)Regione Emilia-Romagna, Servizio Provinciale Difesa del Suolo di Reggio Emilia, Via Emilia S.Stefano 25, Reggio Emilia. E-mail: nds2@regione.emilia-romagna.it; \(^2\)Regione Emilia-Romagna, Ufficio Geologico, Viale Silvani 413, 40122 Bologna, E-mail: mtdenardo@regione.emilia-romagna.it, mpizziolo@regione.emilia-romagna.it

Few Italian Regional Councils have the same deep knowledge of landslide distribution in its territory as the Emilia-Romagna one. This is the result of intensive work, which started with the Geological Map of the Emilia-Romagna Apennines (scale 1:10,000) surveyed in the last fifteen years and which has recently been given a synthesis by means of the Landslide Inventory Map (Carta Inventario del Dissesto, CID) issued in 1996 and of the Map of Slope Instability Hazard Assessment for regional Rescue Services' purposes (Carta della pericolosità da frana, CPF) issued in 1998, both drawn at the scale 1:25,000.

If thematic mapping is due to the regional Ufficio Geologico, intensive research, monitoring, consolidation works and control, directly carried out by the Servizi Provinciali di Difesa del Suolo (formerly known as "Geni Civili"), add further relevant information on the processes involved in phenomena of instability, as well as on the historical record of major landslide activations.

This updated knowledge enables us to state that 17% of the hill and mountain areas of our regional territory is subject to landslides. Most landslide accumulations are quite large in size and are the result of the climatic changes through the Holocene. 4647 landslides have a surface that exceeds 100,000m\(^2\) and 534 are over 1/2 Km\(^2\). The most ancient landslide bodies are about 1 1,000 yBP and were therefore originated during the deglaciation phase following the last glacial peak, dating from about 20,000 years ago.

There are about 32,000 such landslides in the Emilia-Romagna Apennines; one third of them were active when the survey, that led to the compilation of the inventory maps, was carded out. The remaining ones are dormant, and just for this reason the danger has been often underestimated by the populations (sometimes even by public bodies); the result is, paradoxically, a source of risk that may be even greater than that induced by active landslides. As a matter of fact, these large dormant landslides often feature a flat morphology of their lower side (foot), which may wrongly look 'suitable' for the settlement of human activities and buildings. In most cases they are ancient earth flows, the result of subsequent events over thousands of years. A good example is provided by the large landslide of Cavola (Reggio Emilia), which is the result of 1300 years of alternating phases of activity and dormancy, according to carbon-14 dating was made at different depths. In most cases the mobilization of such large landslides is the result of deep-seated creeping (which can be measured only instrumentally), followed by sliding which, occasionally, evolves into earth-flow phenomena. In the evolution process of major landslides, these three phases are transitory in time and space and mainly depend on the amount of water available (pore, joint-water pressure) at the time given. In most cases, the reactivation of the landslide is only due to deep-seated creeping and is followed by sliding, which occurs when the shear-strength of the material is overcome. Earth-flows rarely occur, since they requires a large amount of water to reach a visco-fluid physical state. This last phase may be sometimes reached in spring, due to snow-melting, so that
displacement rates of a few tens of metres per day can be reached. The average thickness of landslide accumulations ranges normally around 15 metres, but there are frequently landslides which are 40-60 metres thick.

The landslides in the Apennines generally alternate long periods of dormancy (from a year to a century) to short periods of activity (days or few months). For this reason, in the past few centuries, 1889 human settlements have been built directly on, or just adjacent to landslides and are therefore under constant threat. This is also due to the short historical memory of natural hazards on the part of the populations, but also of public bodies committed with land use planning and management.

Luckily, the low rate of displacement of our landslides has rarely constituted a real danger for human lives, even though at least 53 people have been the direct victims of landslides in the past fifty years.

Social and economic damages have been, however, inestimable; slope instably might have been one of the causes of the migration of the new generations towards the plain. The recent case of the large landslide at Corniglio (a town in the province of Parma), which resulted in the destruction of dozens of houses and the complete interruption of many productive activities in the period 1994-1996, is still a heavy burden on the conscience of previous town council authorities and administrators.

The response of public authorities has frequently been the issuing of stricter, administratively more effective rules, but real hazard has not been assessed, actually. Harsh restrictions concerning the areas subject to landslides often result in the worsening of the situation, since possible development may be under constraint without proper motivation. Coexistence with dormant landslides is sometimes possible and even necessary, even though hazard, i.e. the probability of occurrence of an event within a set period of time and a given area, must be carefully analysed and estimated. Within the Emilia-Romagna region, qualitative and relative landslide hazard has been assessed over its territory. New instruments, such as historical archive research, absolute dating and, above all, constant monitoring, require prompt application. Research has already started in a few areas (for instance in the province of Reggio-Emilia), thanks to the commitment of the regional technical services. As a consequence, a "deterministic" approach (which has proved inadequate especially in the case of large landslides, which represent complex phenomena only partially reproducible by means of mathematical models) has to be abandoned in favour of a more "probabilistic" kind of approach, to be acknowledged by land-use regulations and restrictions alike.