Resilience to and recovery from unstable ground – perspectives from the UK and further afield

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Compared to many other European countries, the occurrence of contemporary landslides in the UK is dominated by relatively infrequent and relatively small (10^2-10^5 m^3) rainfall-triggered events. However, these events, whether occurring in natural terrain or along engineered slopes, appear to have a disproportionate effect on the economy where these impact transport infrastructure or construction. Particularly in wet years (e.g. 2012/13) and during storms (e.g. Desmond 2015) landslide occurrence can have a significant detrimental effect on the functioning of the UK society. For example, in 2015 there were 143 earthworks failures on Network Rail, more than two per week. This results in high costs - emergency repairs cost 10 times that of planned works, which in turn cost 10 times that of maintenance work. However, long dry spells also have significant cost implications. The recent dry summer is forecasted to result in a subsidence insurance bill exceeding £350m and differential shrink of railway embankment materials in the southeast of the country affects allowable line speeds.

Further afield, we are frequently confronted with the extremely serious impacts of unstable ground on vulnerable populations. Earthquakes and heavy rainfall, and the clusters of landslides that these generate, can result in significant fatalities, major destruction of properties and disruption of societal development for long periods of time.

In the context of these presentations we use the word 'resilience' to provide an indication of how much communities can withstand a stress such as landslides, ground subsidence, and earthquakes (referred to as geohazards). We use the word 'recovery' to indicate the effort required to get households/communities back onto the developmental pathway they were on before the stressor occurred.

Achieving greater resilience and improved (self-)recovery needs to be underpinned by an improved knowledge of the geohazards and we will discuss a series of examples:

- **Natural terrain landslides in the UK** - highlighting research into operational national daily landslide hazard assessment (DLHA) by the British Geological Survey (BGS) as part of the UK Natural Hazards Partnership (NHP)
- **Landslides occurring in engineered assets** (cuttings and embankments) – highlighting research of the ACHILLES consortium that examines how long-linear infrastructure assets can be better maintained and monitored to make them more resilient for the future.
- **The cost implications of landslide occurrences** – illustrated using a case study from Scotland of landslides affecting transport networks.
- **Contributing factors and responses to a debris flow disaster** – illustrated by the Zhouqu 2010 (China) event.
- **Self-recovery in rural and urban contexts following a major earthquake** - findings of the Promoting Safer Building consortium following the 2015 Gorkha Earthquake in Nepal.
- **Preparing for the future** – recognising potential problems now to limit negative consequences for the future; an illustration from Lanzhou (China).

The presentations aim to provide ample material for lively discussions.

Susanne Sargeant is a disaster and development geoscientist at the British Geological Survey. She completed her PhD in earthquake seismology in 2002 (University of East Anglia). Her scientific research has been on topics relating to seismic hazard assessment and seismic wave attenuation. She has also worked on many seismic hazard projects for engineering clients and has co-authored the national seismic hazard maps for the UK and the United Arab Emirates. Susanne has a keen interest in humanitarian and development work and has worked on research and capacity building projects in many developing countries including Nepal, Kazakhstan, Bangladesh and Myanmar. Susanne has held two knowledge exchange fellowships, which have focussed on increasing the use of earthquake science in humanitarian and development NGOs and in the resilience building process more generally. Susanne leads BGS involvement in the Promoting Safer Building consortium and is particularly interested in how geoscience and geoscientists can support self-recovery after disasters. She is also an experienced facilitator and works with groups for various purposes such as to identify lessons learned from challenge–led research projects.

Tom Dijkstra is an engineering geologist/geomorphologist and works in the School of Architecture, Building and Civil Engineering at Loughborough University. He studied Physical Geography at Utrecht University (NL) with Geomorphology, Quaternary Geology and Soil Science as specialisations and completed his PhD on Chinese loess landslides. Tom managed the multi-disciplinary UK climate impact forecasting for slopes network (CLIFFS) and contributed to a series of linked research projects that include the EPSRC-funded FUTURENET (establishing a modelling architecture to assess transport infrastructure resilience as it is exposed to multi (geo) hazards in a changing climate), iSMART and ACHILLES projects/programme grant understanding the materials and soil-water-vegetation behaviour of long-linear assets (e.g. transport infrastructure embankments and cut slopes) in a changing climate. In particular in Nepal and China his research focus is on geohazards and community resilience and recovery in dynamic landscapes contributing, among others, to the work of the Promoting Safer Building consortium.