# Landslide definition and classification

Cox's Bazar | August 2019

## Background

Landslides occurring in camps are reported on a daily basis through the Site Management Sector Daily Incident Assessment and Reporting System. The development of a detailed classification scheme, however, has proven challenging for the reporting staff. Landslides are therefore defined in broad terms as:
*"The usually rapid downward movement of a mass of rock, earth, or artificial fill on a slope"*.

As a result, the records include a range of both natural and man-made phenomena, which can lead to potential misinterpretations.

This note does not intend to change the current reporting system, but rather seeks to provide a classification framework for actors working on the improvement of landslide documentation and, simultaneously, to illustrate the variety of phenomena that are included in the Site Management daily incident reports.

## Landslide Classification

The proposed classification follows Cruden and Varnes's (1996) revised version of the widely used Varnes classification system (Varnes, 1978). More recently, Hungr et al. (2014) proposed further modifications to Varnes's system, in particular, to improve compatibility with geotechnical and geological terminology of rocks and soils. However, the recommended changes lead to a degree of detail that is beyond the scope of this note.

Landslides are classified according to their **forming materials** and their **type of movement** (see Appendix 2).

The forming materials in camps consist of sediments, which are predominantly loosely consolidated sandstones alternating with silt and minor interbedded claystone. Technically, these are considered rock formations, but due to the fact that they are loosely consolidated and generally heavily weathered at the surface, they are referred to as *"earth"* in Varnes's terminology. Movements are mainly related to falls, topples, slides and flows.

As a result, four main types of landslides (see Table 1) can be described as follows:

- *Earth fall*. Occurs in steep or overhanging slopes from the detachment of soil along a surface on which little shear displacement takes place. This typically occurs where artificial cuts have been made and along eroded or undercut riverbanks.
- *Earth topple*. Occurs in vertical slopes with cohesive materials. Vertical joints or cracks develop behind the edge of the slope, resulting in a forward rotation of a compartment or column of soil. Field observations typically reveal mixed features associated to both fall and topple, making it difficult to clearly distinguish between the two types.
- *Earth slide*. Occurs in moderate to steep slopes and often consists of shallow weathered soil sliding onto a stronger or impermeable substrate (e.g. interbedded clay layers). Rotational slides (also referred to as slumps) involve sliding of the materials along a curved surface. Their occurrence is usually limited to an initial movement that evolves into compound slides or flows.
- *Earth flow (or mudflow)*. Occurs in moderate slopes during or after heavy rain events and involves excess pore-pressure or liquefaction of the sliding materials. It forms characteristic bowl- or balloon-shaped scars on the hill flanks, with the mobilized material spreading out onto the valley floor and being subsequently rapidly washed

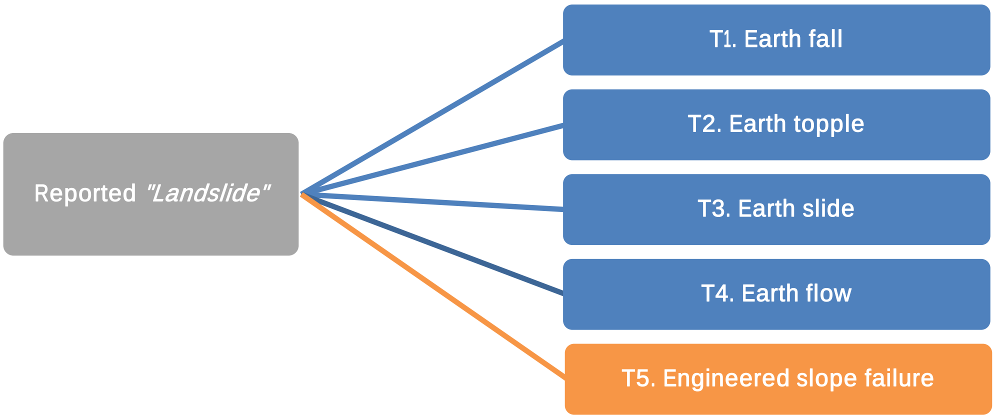
away, only leaving the main scar visible over time. Earth flows often initiate as compound slides. Small-scale surface erosion may also be reported as landslides, though they occur mostly in artificial fills.

A fifth type "*engineered slope failure*" is introduced here. Though not referenced in the existing literature, it is important in the context being discussed as it is also typically reported as a landslide. It refers to the failure of any kind of stabilization structure, typically sand bags or bamboo retaining walls.

Finally, landslides can be understood as a combination of several typologies (i.e. complex styles). In the camps, this mostly relates to slides that evolve into flow-like movements depending on the degree of saturation of the sliding materials.

Appendix 1 presents some examples of these landslide typologies.

Table 1: Main landslide typologies occurring in camps




## Velocity

Landslides, as observed in camps, are characterized by rapid (m/h) to extremely rapid (m/s) velocities, but slower pre-failure movements such as opening of cracks or bulging may precede the failure phase.

## Size

The size range for landslides, as described in the literature, is substantial (ranging from a few $m^3$ to several $km^3$). In this regard, the landslides occurring in the camps are relatively small (up to a few hundred $m^3$). It is therefore appropriate to use specific categorizations for assessing camp settings:

- Small: up to a few $m^3$;
- Medium: 5 to 50 $m^3$;
- Large: > 50 $m^3$.

Falls and topples generally fall within the 'small' or 'medium' category, while slides and flows are medium to large. Failure of engineered slopes are generally small to medium.

## Causes

Table 2 lists the most important factors contributing to the triggering of a landslide. Among these, rainfall represents the critical trigger, in particular, rain intensity. 'Dry' landslides have only been reported in relation to sand mining activities. Ground and morphological causes are important aspects to take account of, however human interventions must be crucially considered, due to their significant role in triggering of landslides:

- The uncontrolled discharge of runoff water from roofs and drains is a major issue since it concentrates a large amount of water in one area of the slope, while leakage from latrine pits induces a continuous moistening of the soil at depth;

- Cuts and excavations made for plots reduce the stability of slopes by removing part of the slope's natural support, while also directly exposing households to the impact of a potential landslide;
- Uncontrolled sand mining activities are extremely dangerous, particularly for children who are unaware of the hazards that they represent;
- Insufficiently compacted and unvegetated fills are easily erodible and are prone to slumps and liquefaction effects during heavy rainfall. Fills can also represent a weight surcharge in the natural underlying terrain;
- Shelters situated at the edges of vertical slopes can provoke localized failures due to excessive loading;
- Finally, deforestation contributes to landslide instability by increasing water runoff, infiltration and soil erosion.

Table 2. Most common causes of landslides in camps (key factors in **bold**)

| | |
|---|---|
| Ground and morphological causes | • **Weathered materials**<br>• **Jointed or fissured materials**<br>• **Contrasts in permeability and stiffness**<br>• Adversly orientated bedding<br>• Weak materials<br>• **River erosion of the slope toe** |
| Physical causes | • **Intense or prolonged rainfall**<br>• Earthquakes |
| Artificial / man-made causes | • **Uncontrolled surface water discharge and water leakage through the soil**<br>• **Cuts** (removal of support)<br>• **Sand mining**<br>• **Uncompacted, unvegetated and over-steepened fills**<br>• **Loading of the slope crest**<br>• **Deforestation** |

## References


- Cruden, D.M., Varnes, D.J. (1996). Landslide types and processes. In Landslides: Investigation and Mitigation, Turner, A.K. and Schuster, R.L. (eds). Transportation Research Board Special Report 247, US National Research Council, Washington, DC, Chapter 3, pp. 36–75.
- Hungr, O., Leroueil, S. and Picarelli, L. (2014). The Varnes classification of landslide types, an update. Landslides, Volume 11, Issue 2, pp 167–194.
- IOM Needs and Population Monitoring (2019). Site Management Category 1 Incident Assessment And Reporting. Survey Analysis: May-November 2018.
- Varnes, D.J. (1978). Slope movement types and processes. In Landslides: Analysis and control, Schuster R.L. and Krizek, R.J. (eds). Transportation Research Board Special Report 176, National Academy of Sciences, Washington, DC, pp. 11–33.

## Appendix 1: Examples of landslides

**Earth fall - small**

Failure of a small volume of weathered soil above an artificial cut. Water was directly discharged onto the slope from the roof above.

**Earth fall - small**

Small failure of a vertical cut, likely due to water infiltration and overloading of the crest (previously a shelter plot).

**Earth topple - medium**

Collapse of a 2-3m high natural cliff (old riverbank) in cohesive soil detached along a near-vertical crack. Right: close-up of the collapsed blocks (up to 0.5m$^3$).

**Earth slide - medium**

Related to a cut made at the base of the slope. The main scarp developed in the upper ledge, and the sliding mass must have been fairly liquid.

**Earth slide - large**

A weathered soil horizon has been sliding onto stiffer clay beds. The sliding mass transformed into a flow-like movement after reaching a steeper step at the bottom of the hill.

**Earth flow - large**

Remaining scar from an older earth flow. Thick sand bed in the middle of the scar. The deposits have been washed away.

**Earth flow – middle**

Front: typical soil erosion (gullies) in artificial fills. Medium-sized earth flow in the back, eventually initiated as a slump**.**

**Engineered slope failure – small**

Bulging of a bamboo retaining wall that is about to collapse.

**Engineered slope failure – medium**

Repair work being carried out at a failed section of a composite ring and bamboo terassing.

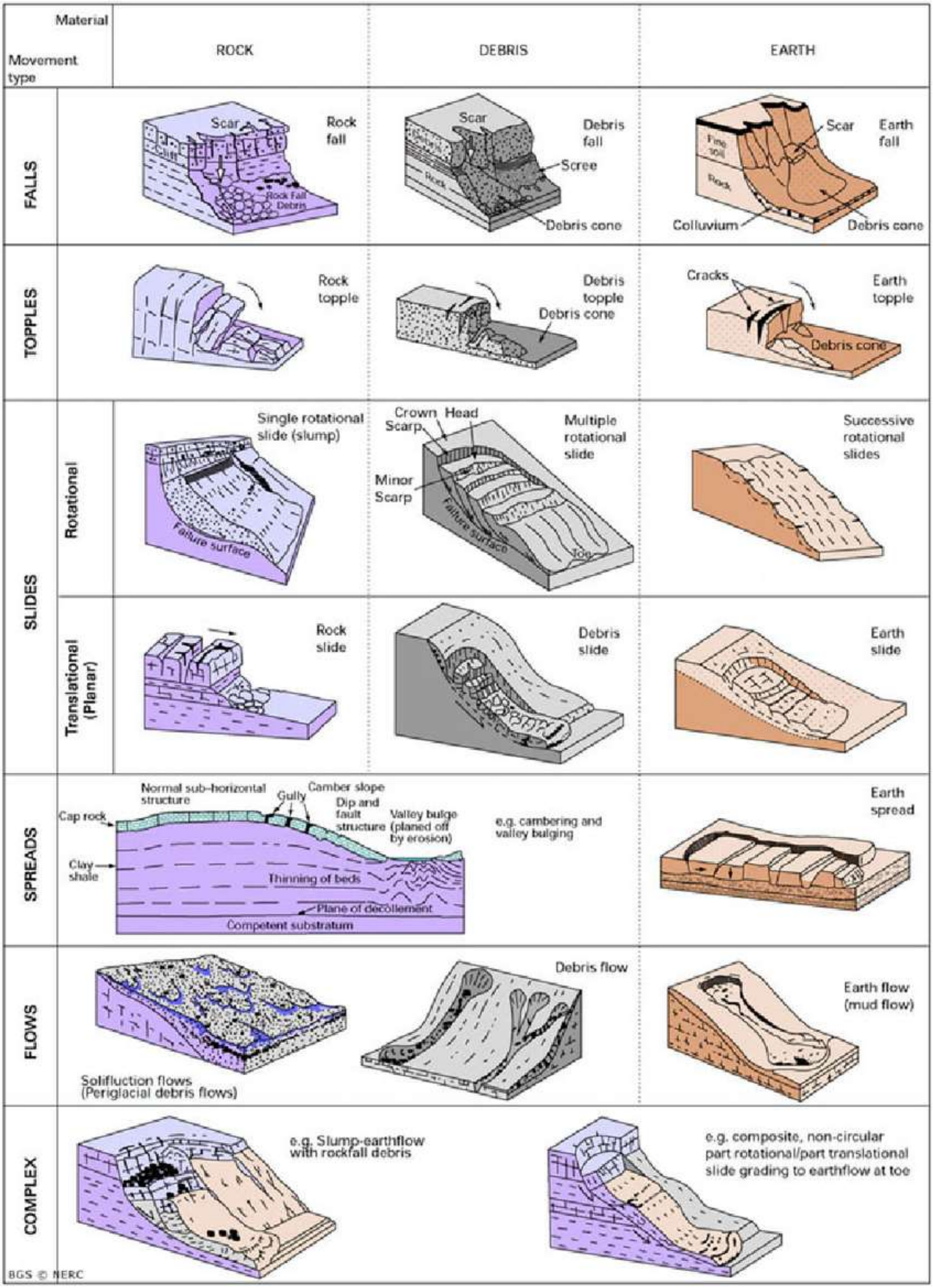
**Earth fall – small**

An overhanging soil compartment showing development of vertical cracks is about to fall / topple.

**Composite failure of engineered slope and slide - medium**

Continuous leakage from pit latrines may be the main causal factor for failure of this slope.

## Appendix 2: Landslide classification after Varnes (1978)




Source: British Geological Survey