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Identifying and Mapping Landslides from Google Earth

What are Landslides?

The term landslide denotes "the movement of a mass of rock, debris or earth down a slope". Other terms used to refer to landslide include 'mass movements', 'slope failures', 'slope instability' and 'terrain instability'. Ground subsidence and collapse are not taken as landslide.

Classification of Landslides

Landslide classification is based on Varnes (1978) system which has two terms: the first term describes the material type (Rock, Earth and Debris) and the second term describes the type of movement (Fall, Topple, Slide and Flow).

> There is a conceptual confusion in the term landslide since it is referred both to landslide deposit (displaced and accumulated mass) and the movement of material along a slope.

Rock: a hard or firm rock mass that was intact and in its natural place before the initiation of movement.

Earth: material in which 80% or more of the particles are smaller than 2mm, the upper limit of sand sized particles.

Debris: contains a significant proportion of coarse material; 20% to 80% of the particles are larger than 2mm, and remain less than 2mm.

The types of movement describe how the landslide movement is distributed through the displaced mass.

Falls: take place rapidly by free-fall, bouncing, or rolling, and may develop into either slides or flows (Figure 1.1A).

Topples: consist of the rapid rotation of a unit of rock or soil about some pivot point. Toppling may not lead to falls, slides or flows (Figure 1.1B).

Slides: involve the movement along one or more distinct surfaces. Slides are subdivided into 'rotational slides' and 'translational slides', depending upon the shape of the failure plane (Figure 1.1C).

Rotational slides: also referred to as slumps, involve movement along a curved failure plane. Often the failure plane did not exist before movement occurred.

Translational slides: involve the movement of many rock or soil units along a plane. Often the failure plane existed before movement occurred.

Flows: describe movement that resembles a viscous fluid. Some flows occur slowly, others occur rapidly. In most cases, water is an integral component.

Complex landslides: involve the combination of two or more types of movement. Commonly one type of movement starts the material moving, such as a debris slide, and once underway the material takes on the character of another type of movement, such as a debris flow.
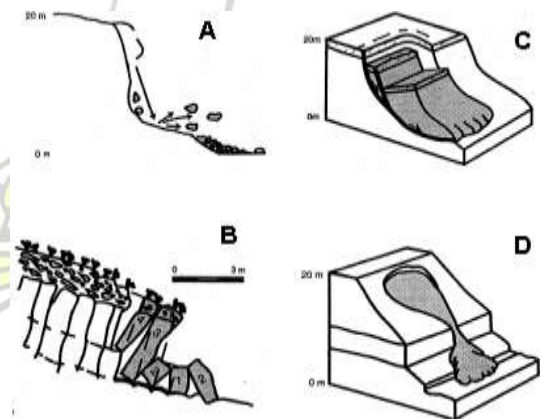
Fig 1.1 Schematic diagram of types of movement: (A) fall, (B) topple, (C) slide, and (D) flow (cross ref. AGS, 2000).

> The term material type used should describe the displaced material in the landslide before it was displaced. Creep is a type of flow that occurs very slowly. Combining the two terms gives classifications such as Rock fall, Rock topple, Debris slide, Debris flow, Earth slide, Earth flow etc.

Parts of Landslides

Some of the terminology that is commonly used in describing landslide parts in inventory are given below (refer Figure 1.2).

Landslide Length-Distance between crown and toe, measured usually in meter

Scar length-Distance between crown and toe of surface of rupture, measured usually in meter

Landslide Width-Distance between right and left flank, measured usually in meter as scar width or width of accumulation zone

Scar depth-Vertical depth of depletion zone, measured usually in meter

> Landslide morphometric details are often not correctly depicted. It is important to have homogeneity in expressing landslide features, including landslide type. Care must be taken to specify length as whether scar length or length of the landslide. Scar length is only the length of depletion zone.
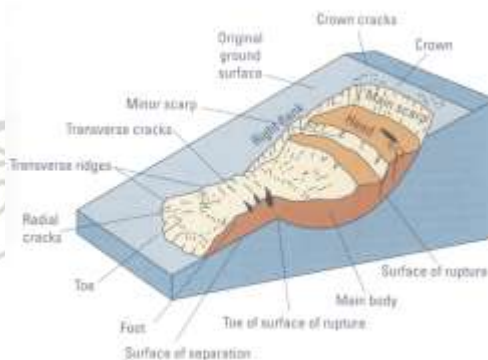

Fig 1.2 Left figure: a simplified illustration of a rotational landslide (earth slide) that evolved into earth flow. Image illustrates commonly used labels for the parts of a landslide (from Varnes, 1978); Right figure: annotated photograph showing important landslide features. Red and blue lines represent landslide initiation and deposition area, respectively.

Landslide Inventory Mapping

Once landslide is located and identified in the field, it has to be mapped on a basemap (toposheets or images) as accurately as possible. A single rainfall event can trigger one landslide or many landslides. Each individual landslide has to be identified, mapped and inventoried one by one.

Mapping scale	Activities
1:50,000/25,000 (covering large area)	• Prepare an inventory of mappable landslides in the area from aerial photographs and /or satellite imagery, and by field mapping and from historic records. • The inventory includes the location, classification, landslide surface area and so far as practicable the date of occurrence of landsliding. • Show landslides as polygon on a toposheet along with topographic information including contours, roads, streams, land use etc. • Show scar of unmappable smaller landslides as point on toposheet.
1:10,000 (covering small area)	• The same activities as 1:50k/25k plus • Distinguish different parts of the landslides importantly initiation (depletion) and deposition area through field mapping • Map landslide features and boundaries • Collect and assess historical information on the activity of landsliding. • Analyse the past evolution of the land use to know whether human activities have had an influence on the incidence of landslides

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Attempt should be made for a mappable landslide that its source area (depletion area) and displaced/accumulated area (including run-out) should be mapped and depicted separately. This will facilitate Landslied Susceptibility Mapping mapping when only landslide depletion part is considered for rating different landslide preparatory factors.

Landslide location reference (lat/long) should only be obtained from toposheet after plotting either using manual method or in GIS by rectifying the toposheet. Centre of landslide scar should be the point for measuring its latitude and longitude

It has been observed that workers have 'casually' putting lat/long reference in inventory using GPS at comfortable location, which at times lie far away from the landslide scar either on road or nearby accessible point. Such practice should be avoided as far as possible

Landslide Mapping from Google Earth

Now high resolution remote sensing data (satellite images and aerial photographs) are commonly used in landslide mapping. Google Earth's new features which include the ability to view old satellite images, and 3D view have made landslide identification possible (**Error! Reference source not found.**).
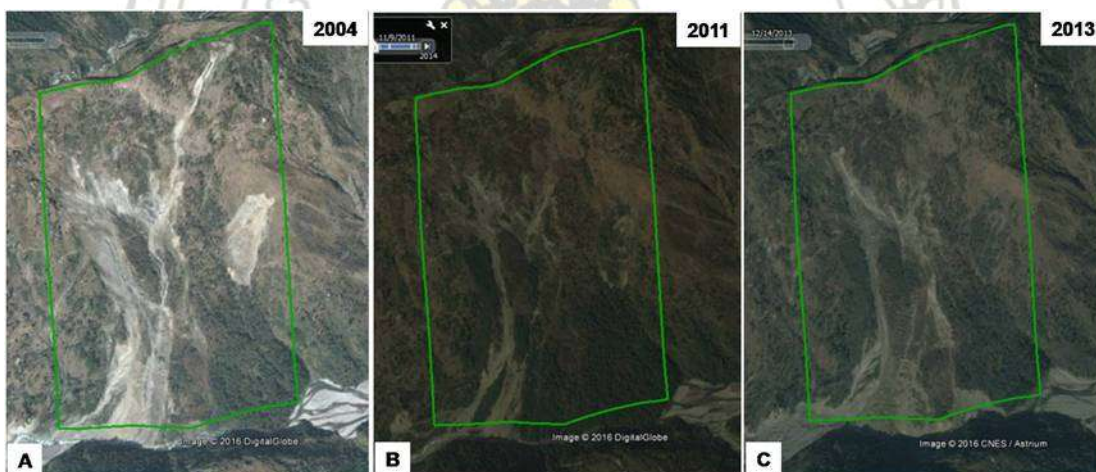

Fig 1.3 Bedula landslide and its morphological changes as viewed in different time frames in Google Earth images

Measuring landslides in Google Earth

In this practical, we will demonstrate how to measure the area of a landslide (and observe its change over time, and its profile) using Google Earth and import it in GIS. We will use as an example a landslide from Ukhimath Landslide, UK. The Ukhimath landslide was triggered by heavy rainfall in August 1998. The landslide buried a part of village and dammed River Madhyamaheshwar.

Start Google Earth: Start Google Earth from your PC by going to Start >Start Google Earth

Search: Enter the name of location (Ukhimath in this case) in the Search panel (top left) and click Search. The Google earth will automatically zoom to Ukhimath, a small town in Rudraprayag district.
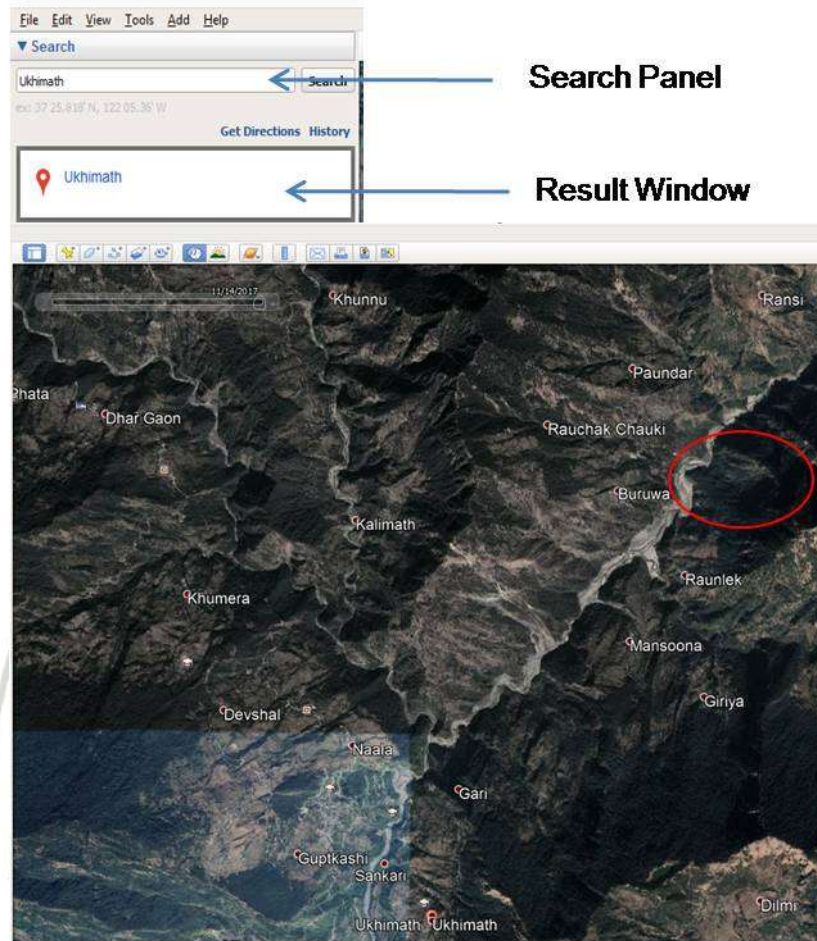
Zoom out a bit and you will see a big landslide to the NE of Ukhimath (more clearly in 2009 image) circled in red in figure above.

Pan Around: You can move around the landslide and see it more closely. You can navigate or move around the landslide in Google earth by holding the left mouse button and dragging it to the desired location.

Zoom in and out: You can Zoom in and out by scrolling the mouse wheel in and out using the mouse. Alternatively, you can hold down the right mouse button and drag the mouse up to zoom out. To zoom in, hold down the right mouse button and drag the mouse down. You can also Zoom in and out using the navigation controls. To view and use the navigation controls, move the cursor over the top right corner of the 3D viewer. The navigation controls automatically appear whenever you do this; they fade from sight when you move the cursor elsewhere. Zoom in by clicking on the zoom in button **(+ sign)** and zoom out by clicking on the zoom out button **(- sign)**.

Tilt the 3D View: Hold the SHIFT key and drag the left mouse button towards you or hold the SHIFT key and press the Down key on the keyboard to tilt the viewer toward the horizon view. You will be able to see the 3D view as if you were looking towards the horizon. You can reset the view to the top-down orientation by pressing the "u" key on the keyboard.

Look Around: To look around from a single vantage point, as if you were turning your head, press CTRL and left mouse button and drag. You can reset the view to the north-upview by pressing the "n" key on the keyboard.

Rotate the view: Press CTRL + scroll UP to rotate clockwise, CTRL + scroll DOWN to rotate counter-clockwise.

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Coordinates (latitude and longitude) & Elevation: Move your cursor to the location and you will see that the latitude and longitude are displayed in the bottom right corner. The elevation shows the approximate elevation of the place at which your cursor is. Eye Altitude: It is the distance (from high up) from which you are viewing the ground.


Previous Imagery: To view the old images click on the "Show Historical imagery" icon, displayed at to left corner of the window.

Zoom Ukhimath landslide to eye alt: 11717 ft and change historical imagery to different times. Observe the changes in the body of the landslide. An image taken in evening might appear darker as compared to images taken during noon. Moreover different times of the day will result in longer or shorter shadow.

> Coordinate type can be changed using Tool Functions: Select *Tools* from main menu bar and go to *Options*

How to map landslide boundary in Google earth?

Landslides are identified from Google Earth if the landslide is fresh and boundaries are distinct. You can observe that Ukhimath landslide looks fresh and distinct in 2004 image then in 2017 when vegetation covers the landslide. Once you have identified the boundary of the landslide visually, you can map it and calculate its area using Google Earth.
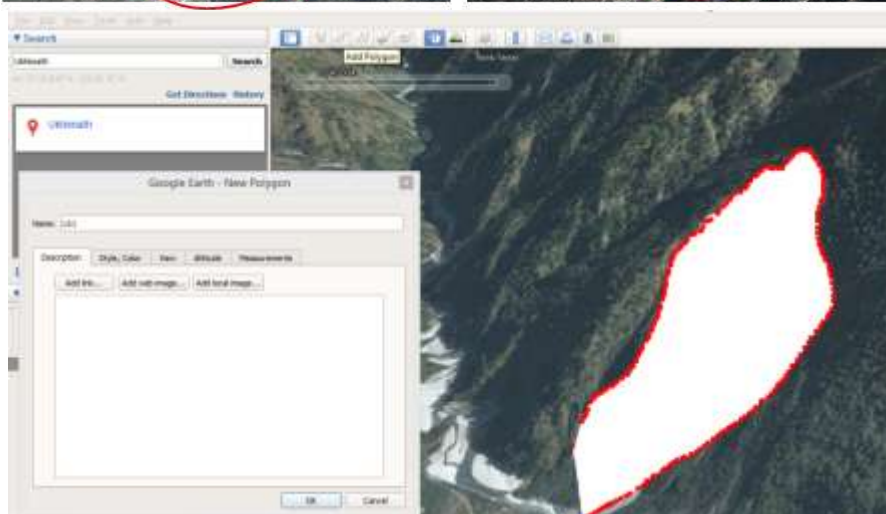
Click on *Add Polygon*. A *Google Earth New polygon* box appears. Give a Name: LS1 or Landslide1. Start digitizing by clicking or dragging the mouse left button to create the boundary of the landslide. Once finished, click OK.

LS1 will be added to temporary places (on the left). To calculate its area, Copy it and

Open
http://earthpoint.us/shapes.aspx

Paste the copied LS1 in blank space. Make sure "Sq. Meters" or "Sq. Kilometres" is selected under area and "Meters" or "Kilometres" is selected under length.

Click on *Export to Excel*. A new window opens. Click OK when asked *Open with Microsoft Excel*.

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How to export mapped landslide in Google Earth to ArcGIS?

Landslides mapped from Google Earth can be exported in ArcGIS using KML or KMZ format.
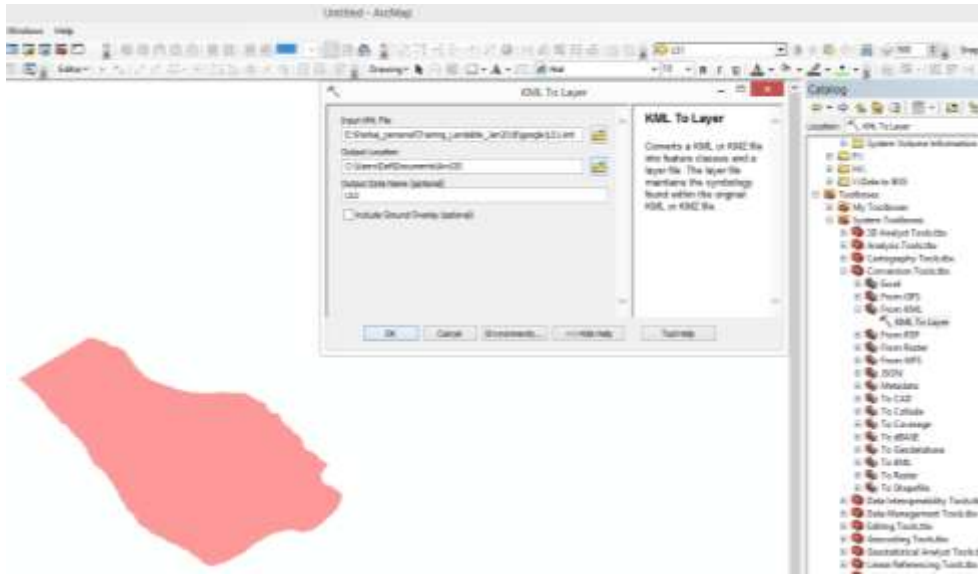
Right Click on LS1 (on temporary places in Google Earth) and select *Save Places As*. In the new box, give File name: *LS1* and Save as Type: *kml*.

Open ArcGIS. Go to *Toolboxes / Conversion Tools / From KML / KML To Layer. A kml to layer box appears.* Give Input *KML File as LSI.kml* using file browser. Give Output Location: select folder and Output Data Name: *LS1*. Leave rest as default and click OK.

In ArcGIS TOC, a polygon layer will be added. Change colour to view it.

Creating shapefile of the KML image?

The KML file imported in ArcGIS is displayed in the Table of Contents (TOC) with 60% transparency. To view it you have to reduce the transparency to zero.

The landslide polygon mapped from Google Earth gets imported in ArcGIS with Geographic coordinates displayed in Decimal Degree. In order to calculate area, length etc, this needs to be converted in shapefile and projected.

The created shapefile will be in Geographic coordinates displayed in Decimal Degree. It can be projected in UTM or any other system using Projection functionalities in Arc GIS (Toolboxes / Data Management Tools / Projection and Transformations / Project / Give Input dataset as LS1 / Output Dataset as LS1_prj / Output Coordinate System as WGS_1984_UTM_Zone_43N / Click OK).

Note: Always Open a New Map Document to view the projected polygons. Alternatively, the unprojected polygons or layers can directly be exported into File Geodatabase of ArcGIS to include Projection parameters.

On the TOC, expand LS1 and *Right Click on Polygons / Properties / Display /* give '0' value to Transparent and click OK.

Creating shapefile:
Right Click on Polygons / Data / Export Data. An *Export Data* box appears. *Click on folder icon on Output feature class /* Give Name: LS1 / *Save as type*: select Shapefile from dropdown and click Save / Click OK.

In ArcGIS TOC, LS1 shapefile will be added.