

**V<sup>th</sup> Framework Programme**  
*Energy, Environment and Sustainable Development*

**Impact of Large Landslides  
in the Mountain Environment:  
Identification and Mitigation of Risk**

*IMIRILAND*

Research and Technological Development Activities of a Generic Nature:  
The Fight against Major Natural and Technological Hazards

**WP1**

***Description of landslide database***



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## A. DATA ORGANIZATION

### Introduction

Data collection involves both office and field studies. Office studies include the assembly of all existing pertinent information. These data are commonly found in diverse government sources and may include maps, reports, aerial photographs, historical documents, etc.

Field data collection involves a variety of activities ranging from relatively simple, low-cost reconnaissance studies to sophisticated, specialised instrumentation installations.

Data interpretation usually begins with reduction and re-organisation of the initial raw data and this activity results in the production of tables, graphs, maps, profiles.

As spatial and temporal comparisons of the data are of great interest for landslide investigation and comprehension, it has been thought to use a database structured in many sections to manage alphanumeric data, coupled with a GIS software, to manage geographical data.

Data organisation here proposed has the aim of collecting all the information related to each landslide, in order to allow an easy and fast comparison among:

- The geological frame (at regional and local scale) in which selected landslides have formed, where high risk conditions have been created, due to either the large dimension of phenomena and their particular location
- Type and rate of movement, landslide causes
- The different approaches carried out to study each movement
- Monitoring activities and instrumentation planning
- Modelling approaches to understand landslide kinematics and its possible evolution, either to forecast failure (if and when) or run-out (where) after failure
- Stability analyses carried out to define site "hazard"
- Vulnerability degree of goods and activities involved
- Assessment of Risk Scenarios
- Landslide hazard and risk reduction approaches

This logical organisation of data can appear quite "rigid" but in each section, structured both for argument and for geographical/morphological context, there is the possibility to insert and describe a great amount of data, according to their reliability or detail degree, using either look-up table or textual fields.

As regard the compilation we should remember that data analysis should refer only to available data and, as a consequence, not all the fields could be filled.

In the next chapter, database structure is described, according to the arguments dealing with and the scale of analysis.

### Database description

This document represents a report from an Access '97 database that would be used to organise all available information.

Compilers must be careful in the values choice in the different fields, because controls among data are not provided (for example a *fall* as a movement could be wrongly coupled with a movement rate *extremely slow*). Insertion and query operations will be carried on through suitable masks.

It is possible to add values and descriptions in the fields of the sections according to the observations and needs of partners, possibly without changing the general structure of the database.

### Part 1: Regional framework

This first part will contain all the general information which allow a regional framework for each selected site, from a multiple point of view: it will be drawn up a geological, structural, geomorphologic, climatic context at a regional/basin area scale.

The reference will be the catchment area/river basin (or a part of it).

This part is formed by the following sections:

- **1-Regional/River Basin Geology**
- **2-Regional/River Basin Structural Setting**
- **3-Regional/River Basin Morphology**

### Part 2: Local scale

In this section the geological, structural, climatic morphologic, hydrologic/hydrogeologic context in which the landslide occurred is described and analysed at a local scale.

This part is formed by the following sections:

- **4-Local Geology**
- **5-Local Structural Setting**
- **6-Water Conditions**
- **7-Climate**

### Part 3: Landslide

This part, strictly connected to the previous one, is specifically referred to the landslide and contains data of different detail, referring both to present and past situations, in order to compare different characteristics of the landslide and its surroundings in space and time and, as a consequence, to understand and explain phenomena evolution.

The first three sections:

- **8-Landslide Identification**

- **9-Landslide Detail** are related to present
- **10-Landslide Morphometry** situation

While the following:

- **11-Landslide History** are related to different
- **12-Landslide Damages** episodes and describe the
- **13-Landslide Morphology** morphological evolution of

#### **Part 4: Land Use and Risk Assessment/Management**

In this part landslide area and surroundings are characterised in terms of "land use", both as type of vegetation and as type of infrastructures, urban extensions, population present on/near the landslide, with an estimate of their value.

This part is formed by the following sections:

- **14-Land Use**
- **15-Landslide Elements at Risk**

This last section is important for the risk assessment phase, because it gives a first quantification of population, goods and activities that could be involved in case of failure.

#### **Part 5: Landslide investigation, Monitoring instrumentation and Stabilisation/protection Works**

In this part all information concerning field instrumentation used to characterise landslide process (in terms of magnitude, rate and distribution of movements), materials involved, surface waters and ground water levels or pore-pressures within the landslide), climatic factors (precipitation, temperature conditions), stabilisation or protection works (with effectiveness evaluation) are gathered.

This part is formed by the following sections:

- **16-Survey: Boreholes**
- **16\_a Survey Tunnels**
- **17-Survey: Geophysics**
- **18-Survey: Geotechnical Testing**
- **19-Monitoring: Piezometers**
- **20-Monitoring: Deformation Gauges**
- **21-Monitoring: Meteorological conditions**
- **22-Stabilization & Protection Works**
- **22\_a Regulations**

#### **Part 6: Modelling**

This part consists only in one specific section, in which modelling activities carried on for each landslide are described.

- **23-Modelling**

#### **Part 7: First Scenarios**

In this part scenarios deriving from this state of knowledge about each landslide are described, both as a consequence of total failure of the landslide and

as a consequence of local reactivation or secondary processes.

- **24-Scenarios first hypotheses**

#### **Part 8: References**

This part contains all the references from which all available data (both as collection and analysis) derive, as a sort of "metadata".

Besides it will be used (partially or completely) to draw up bibliographic chapters in the reports that will be produced along the project.

It is formed by a specific section.

- **25-References**

#### **List of maps**

To easily locate selected sites from a geographical/administrative point of view the following types of map should be available:

- A. Site location represented by a point at national scale
- B. Site location represented by a point inside the main river basin
- C. Landslide location at local scale, delimiting:
  - the landslide area to which sections *Landslide identification* and some morphometric data of *landslide morphometry* are related,
  - different areas within the landslide to which section *Landslide detail* and some morphometric data of *landslide morphometry* are related.

Besides in the Reference mask has been introduced the possibility to list files of pictures, graphs and tables already in a digital format (for each Reference the compiler can list one or more files related, stored in proper directories, using their paths).

#### **Use of G.I.S.**

This database structure represents a sort of compromise between the typical alphanumeric database and attribute tables of geo-referred geometrical features used with GIS software like ArcView.

Using this last software it would be possible to export from Access database (.mdb) each data set (corresponding to each section) as file .dbf and join it with a vector file (shapefile coverage).

Presumably other more sophisticated software present better compatibility with Access database.

Textual fields (containing more than 255 characters) will be treated in another way.

## **B. Database Section detailed description**

In this chapter a detailed list of fields forming each section is presented, with short description of their contents.

### **1 Regional/River basin Geology**

It furnishes a short description of lithotypes present in the landslide area, at regional scale. Each lithology is described through the following fields.

#### **Lithostratigraphic\_unit**

Name of the lithostratigraphic unit.

#### **Lithotype**

Lithotype and short description of its main characteristics.

#### **Age**

Lithotype age.

#### **Chr\_order**

Number to ordinate lithotype descriptions according to a chronological criterion.

### **2 Regional/River basin structural setting**

In this section the structural assessment of the studied area is described. This section should also contain the main structural features related to glacio-tectonics.

#### **Analysis**

Short description of type of mapping, if derived from field survey or remote sensing or both.

#### **Structural\_features**

Denominations and short description of the main structural features and their characteristics (textual field).

#### **Structural associations**

Denomination and description of the main structural associations into which the above described features have been grouped. The structural associations maybe (or not) strictly related to tectonic phases (textual field).

### **3 Regional/River basin Morphology**

#### **River basin**

River Basin name, for example (Po, Toce)

#### **Area**

Specification of the portion of the basin described (in case of big dimensions).

#### **Morphology**

Short description of the morphogenetic and morphological characteristics of the basin area.

#### **References\_list**

Author, year (see reference section).

## **4 Local Geology**

This section furnishes a more detailed description of lithotypes (superficial deposits and bedrock exposures) present in the landslide area). Each lithotype is described through the following fields:

#### **Lithostratigraphic\_unit**

Name of the lithostratigraphic unit.

#### **Lithotype**

Classification of Lithotype and short description of the main characteristics.

#### **Weathering**

The degree of weathering is determined by examined rock exposures with the unaided eye and by simple strength tests.

The choice is among 4 values:

Fresh; Slightly\_moderately; Severely; Completely Weathered.

#### **Strength\_q<sub>u</sub>**

Strength estimated with the aid of a ball-pen or geological hammer.

The choice is among the 5 values indicated by Unified Rock Classification System and the measured valued:

>100MPa; 50-100MPa; 20-50MPa; 5-20MPa; <5Mpa.

#### **Density**

The estimated rock density utilised by the URCS can be determined rapidly for rock samples.

The choice is among:

>25kN/m<sup>3</sup>; 23.5-25kN/m<sup>3</sup>; 22-23.5kN/m<sup>3</sup>; 20.5-22kN/m<sup>3</sup>; <20.5 kN/m<sup>3</sup>.

#### **Description**

Short description of the main characteristics or other remarks.

#### **Chr\_order**

Number to ordinate lithotype descriptions according to a chronological criterion.

## **5 Local structural setting**

This section furnishes a more detailed description of the major discontinuities observed in the landslide area and surroundings, which had/have an important role in the landslide evolution.

Each discontinuity family is described through the following fields:

#### **Survey**

Type of studies (Field; Remote sensing)

#### **Survey\_description**

Short description of investigation methodologies.

#### **Family**

Name of discontinuity (K1, K2, etc). This denomination should be (if possible) the same reported in "structural features" in section 2 (Regional/River basin structural setting).

### **Discontinuity**

Type of discontinuity (Fault; Bedding; Fracture; Schistosity\_foliation).

### **Discontinuity\_description**

Short description of the feature.

### **Dip, Dip\_direction**

Orientation of observed discontinuity (degree).

### **Length**

Length/continuity of observed discontinuity (as average value). (max 255 characters)

### **Aperture**

Average value of observed discontinuity. (max 255 characters)

### **Roughness**

Average value of observed discontinuity. (max 255 characters)

### **Infilling**

Representative value for type and thickness of infilling material. (max 255 characters)

### **Water**

Short description to evidence water presence. (max 255 characters).

### **Discontinuity\_assessment**

Short description of discontinuity assessment respect to slope orientation. (max 255 characters).

### **Description**

Other specifications or Comments (textual field).

### **Date\_measurement**

Date of structural analysis.

### **References\_list**

Author and year of the study (see References section).

## **6 Water conditions**

In this section Hydrography (principal and secondary) that interests landslide area and surroundings is described in terms of drainage density and shape.

Considerations about groundwater conditions are also contained in this section.

### **Surface\_water\_features**

Short description of the main characteristics of drainage network on studied slope.

### **Aquifer**

Short description of the main characteristics of aquifer/aquifers.

### **Groundwater\_circulation**

Description of groundwater circulation, in a qualitative/quantitative terms if possible (for example, underlying meaningful changes due to hydrometric levels in the main floor, pluviometric events, snow melting, etc.)

### **Permeability/infiltration**

Short description of the permeability characteristics in the landslide area, influencing groundwater circulation and infiltration processes, in a qualitative way.

### **Permeability\_measurement**

permeability measures availability.  
Yes/no

### **Permeability\_value**

Short description of the used methodologies, location in which it has been applied and measured values.

### **Springs**

Presence of springs  
Yes/no

### **Springs\_Flow\_measurement**

Yes/no

### **Springs\_min\_flow**

Min flow value

### **Springs\_max\_flow**

Max flow value

### **Springs\_description**

Flow measurements short description (indicative or measured values), interesting remarks about spring location and flow regimes.

### **Marshes**

Presence of marshes  
Yes/no

### **Marshes\_description**

Short description about location, shape and other characteristics). (Max 255 characters).

## **7 Climate**

Section devoted to climatological/meteorological characterisation of landslide area and surroundings.

### **Pluviometric regime**

Description of pluviometric regime.

### **Thermometric regime**

Description of thermometric regime.

### **Snow regime**

Description of snow regime.

### **Measurement\_description**

Short description of available instruments, number, ecc.

### **Reference\_list**

Author, year (see reference section).

## **8 Landslide identification**

In this section information about landslide are collected, useful to locate and classify landslide process, from a qualitative point of view, referring to its present conditions (see also map C for a geographical location).

Morphometric data are gathered in an other section.

<b>Country</b> Country name (e.g. Italy)	<b>Description1</b> Short description of movement and displaced material. (kinematics of the process) (max 255 char.)
<b>Region</b> Region Name (e.g. Piedmont, Rhone - Alpe)	<b>Movement2</b> Specify the second type of movement (in order of importance) choosing among: (Fall; Topple; Slide; Spread; Flow; Complex; DSGSD; not determined)
<b>County</b> County/Department name (Turin, Isère,)	<b>Rate_movement2</b> Second movement rate: (as above) Extremely slow; Very slow; Slow; Moderate; Rapid; Very Rapid; Extremely rapid
<b>River Basin</b> River name (Po, Toce)	<b>Material2</b> Displaced material by the second movement. Superficial deposit -earth if >80% of the particles are smaller than 2mm, upper limit of sand size; Superficial deposit -debris if 20 to 80% of the particles are larger than 2mm; Sedimentary bedrock; Igneous bedrock; Metamorphic bedrock.
<b>Town</b> Administrative unit/Municipality (ex. Salbertrand)	<b>Description2</b> Short description of movement and displaced material. (kinematics of the process).
<b>Local name</b> Name of the area in which landslide is located (ex. Cassas, Rosone)	<b>Movement3</b> Specify type of movement choosing as above.
<b>Description_morpho</b> Short description of the studied area from a geographic/geomorphologic point of view.	<b>Rate_movement3</b> Specify movement rate as above.
<b>Coordinates_what</b> Coordinates point are referred to: Centroid of landslide area; Highest point of crown	<b>Material3</b> Displaced material.
<b>CoordinateX-UTM CoordinateY-UTM</b> Related to centroid (or to the highest point of crown) of landslide area.	<b>Description3</b> Short description of movement and displaced material. (kinematics of the process) (max 255 char.)
<b>Latitude Longitude</b> Geographical coordinates related to the centroid (or to the highest point of crown) of landslide area.	<b>Movement4</b> Type of movement as above
<b>Slope_characteristics</b> Short description in terms of: Slope elevation (from ridge to floor valley) Slope gradient Slope exposure/orientation	<b>Rate_movement4</b> Movement rate Extremely slow; Very slow; Slow; Moderate; Rapid; Very Rapid; Extremely rapid
<b>Slope_profile</b> Short description of longitudinal and transversal profiles of the slope containing landslide.	<b>Material4</b> Displaced material.
<b>Rupture surface</b> Short description of rupture surface.	<b>Description4</b> Short description of movement and displaced material. (kinematics of the process) (max 255 car.)
<b>Movement1</b> Specify the first type of movement choosing among: (Fall; Topple; Slide; Spread; Flow; Complex; DSGSD; not determined)	<b>Water content</b> Describe the water content of landslide materials. (Max 255 char.)
<b>Rate_movement1</b> Specify first movement rate (see Varnes, 1996 in Landslide-Investigation and mitigation- Spec. Rep. 247-TRB, pp. 50-51) among: Extremely slow; Very slow; Slow; Moderate; Rapid; Very Rapid; Extremely rapid.	<b>Displacement dates</b> List of the main events (max 255 characters)
<b>Material1</b> Displaced material by the first movement: Superficial deposit -earth if >80% of the particles are smaller than 2mm, upper limit of sand size; Superficial deposit -debris if 20 to 80% of the particles are larger than 2mm; Sedimentary bedrock; Igneous bedrock; Metamorphic bedrock)	<b>Date_comments</b> Optional remarks about the date list of movement. (max 255 characters)

In the following fields are listed and described first landslide causes or aggravating factors, subdivided in main categories.

**Causes\_human**

Y/n

**Causes\_human\_description**

List the main human activities which have caused or aggravate the landslide (max 255 characters)

**Causes\_geological**

Y/n

**Causes\_geological\_description**

List the main geological factors which have caused or aggravate the landslide (max 255 characters)

**Causes\_morphological**

Y/n

**Causes\_morphological\_description**

List the main morphological factors which have caused or aggravate the landslide (max 255 characters).

**Causes\_meteo**

Y/n

**Causes\_meteo\_description**

Meteorological condition responsible for paroxysmal events (max 255 characters).

**Causes\_seismic**

Y/n.

**Causes\_seismic\_description**

Earthquake magnitude (max 255 characters).

**Others processes interferences**

Y/n

**Others processes\_description**

Short description of other processes associated with the landslide (debris flows, stream occlusion, etc.).

**Details**

Specify if a more detailed section (9 landslide detail) has been compiled.

Y/n

**History**

Specify if a more detailed section has been compiled for each single event of landslide history (11 landslide history) has been compiled.

Y/n

**Damages**

Specify if a more detailed section has been compiled for damages due to landslide (12 landslide damages) has been compiled.

Y/n

**Boreholes**

Specify if a more detailed section (16 Survey Boreholes) has been compiled.

Y/n

**Geophysics**

Specify if a more detailed section (17 Survey Geophysics) has been compiled.

Y/n

**Geotechnical testing**

Specify if a more detailed section (18 Survey Geotechnical testing) has been compiled.

Y/n

**Piezometers**

Specify if a more detailed section (19 Monitoring piezometers) has been compiled.

Y/n

**Deformation gauges**

Specify if a more detailed section (20 Monitoring deformation gauges) has been compiled.

Y/n

**Meteo**

Specify if a more detailed section (21 Monitoring meteorological conditions) has been compiled.

Y/n

**Stabilisation**

Specify if a more detailed section (22 Stabilisation & protection works) has been compiled.

Y/n

**Modelling**

Specify if a detailed section (23 Modelling) has been compiled.

Y/n

**Map\_description**

Author, year, title, scale (max 255 characters).

**Numerical map**

Numerical map availability

Y/n

**References\_list**

Author, year (See reference section)

**9 Landslide detail**

This section should be filled if different areas (for stability conditions, type, age, rate of movement) can be recognised inside the studied landslide, due to its particular complexity (see map C for geographical location).

**Landslide**

"Official" Name with which the landslide is well known. It represents the necessary link among the sections in each database (one for each landslide).

**Area**

Short description related to the location of the described area inside the landslide.

**Identification/name**

Name/abbreviation of the sector or zone to which this section is addressed (ex. Bertodasco inside Rosone landslide).

### **Movement1**

Specify the most important type of movement choosing among:  
(Fall; Topple; Slide; Spread; Flow; Complex; DSGSD; not determined)

### **Rate\_movement1**

Specify first movement rate (see Varnes, 1996 in Landslide-Investigation and mitigation- Spec. Rep. 247-TRB, pp. 50-51) among:  
Extremely slow; Very slow; Slow; Moderate; Rapid; Very Rapid; Extremely rapid.

### **Material1**

Displaced material by the first movement:  
Superficial deposit-earth if >80% of the particles are smaller than 2mm, upper limit of sand size;  
Superficial deposit -debris if 20 to 80% of the particles are larger than 2mm; Sedimentary bedrock; Igneous bedrock; Metamorphic bedrock)

### **Description1**

Short description of movement and displaced material. (kinematics of the process).  
(max 255 char.)

### **Movement2**

Specify the second type of movement (in order of importance) choosing among:  
(Fall; Topple; Slide; Spread; Flow; Complex; DSGSD; not determined).

### **Rate\_movement2**

Second movement rate: (as above)  
Extremely slow; Very slow; Slow; Moderate; Rapid; Very Rapid; Extremely rapid

### **Material2**

Displaced material by the second movement.

### **Description2**

Short description of movement and displaced material. (kinematics of the process).

### **Water content**

Describe the water content of landslide materials.

### **Displacement dates**

List of the main events (years)  
(max 255 characters)

### **Date\_comments**

Optional remarks about the date list of movement.  
(max 255 characters)

*In the following fields are listed and described first landslide causes or aggravating factors, subdivided in main categories.*

### **Causes\_human**

Y/n

### **Causes\_human\_description**

List the main human activities which have caused or aggravate the landslide  
(max 255 characters)

### **Causes\_geological**

Y/n

### **Causes\_geological\_description**

List the main geological factors which have caused or aggravate the landslide (max 255 characters)

### **Causes\_morphological**

Y/n

### **Causes\_morphological\_description**

List the main Morphological factors which have caused or aggravate the landslide (max 255 characters).

### **Causes\_meteo**

Y/n.

### **Causes\_meteo\_description**

Meteorological condition responsible for paroxysmal events (max 255 characters).

### **Causes\_seismic**

Y/n.

### **Causes\_seismic\_description**

Earthquake magnitude (max 255 characters).

### **Others processes interference**

Y/n

### **Others processes\_description**

Short description of other processes associated with the landslide (debris flows, stream occlusion, etc.).

### **Map\_description**

Author, year, title, scale of available map (max 255 char.).

### **Numerical map**

Numerical map availability  
Y/n

### **References\_list**

Author, year (See reference section)

## **10 Landslide morphometry**

This section contains the main morphometric parameters, meaningful for landslide characterisation and for the comprehension of its evolution.

Quantitative parameters should be obtained through a large scale mapping (at least 1:10.000).

Sometimes it could be necessary to make more than one set of measurements: in this case in the field "Referred" will be inserted *Landslide detail* and field "Identification/name" will be related to the specific sector analysed.

### **Referred**

Specify if the measured value are related to the entire landslide or to a part of it. (ref. Landslide detail).

### **Identification/name**

Short description of the considered area. (to be filled only if related to landslide).

### **Area\_total**

Total surface of landslide (calculated on horizontal plane).

**Crown\_altitude**

Elevation of the highest point of main scarp.

**Crown\_height**

Height of main scarp from top of displaced mass to the highest point of the main scarp.

**Top\_altitude**

Elevation of the highest point of displaced mass.

**Toe\_altitude**

Elevation of the lowest point of displaced mass.

**Length\_min\_total**

Minimum distance from tip to crown (Lr).

**Length\_centre\_line**

Total length from tip to crown measured along centre line.

**Length\_tip\_top**

Minimum distance from tip to top (Ld).

**Length\_center\_line\_horizontal**

Total length from tip to crown on centre line (horizontal extent).

**Difference\_level**

Total height of landslide.

**Travel\_angle\_alpha**

Travel angle from tip to crown.

**Width\_Mass**

Width of displaced mass (Wd).

**Width\_Rupture**

Width between flanks (Wr).

**Depth\_Mass**

Max depth of displaced mass (Dd).

**Depth\_rupture**

Max depth of rupture surface below original ground surface.

**Volume**

Approximate value or estimated according to the formula  $V = \pi/6 Ld Dd$ .

**Date**

Date of measurements.

**Author\_description**

Author or Reference of measurements, specifying used methodologies.

**11 Landslide history**

This is an articulated and complex section in which reactivation of the landslide or of parts of it as different episodes are described. Information result from historical analysis or from specific studies or reports. In this section collected data are characterised by different degree of detail and precision, according to the source.

A specific section (**11-a History description**) has been introduced to synthesise in a textual field (memo) the landslide evolution in terms of movements and morphological changes derived from

historical analysis, and from the interpretation and summarisation of all the records compiled in the section 11. If it isn't possible to described each single event ad asked in the section 11, at least section 11\_a should be compiled.

**Town**

Name of town or Municipality (in case of large landslide which can involve more municipalities).

**Local name**

Name of the area in which landslide is located (Cassas, Rosone).

**Date\_beginning**

Initial date of the meteorological event or of the period in which the reactivation occurred.

**Date\_end**

End date of the meteorological event or of the period in which the reactivation occurred.

**Date\_comments**

Other remarks about date occurrence.

**Movement1**

Specify first type of movement choosing among: (Fall; Topple; Slide; Spread; Flow; Complex; DSGSD; not determined)

**Rate\_movement1**

Specify first movement rate choosing among: Extremely slow; Very slow; Slow; Moderate; Rapid; Very Rapid; Extremely rapid.

**Material1**

Displaced material by the first movement: Superficial deposit -earth if >80% of the particles are smaller than 2mm, upper limit of sand size; Superficial deposit -debris if 20 to 80% of the particles are larger than 2mm; Sedimentary bedrock; Igneous bedrock; Metamorphic bedrock).

**Description1**

Short description of kinematic characteristics of the process. (max 255 char.)

**Movement2**

Second type of movement (in chronological order). (Fall; Topple; Slide; Spread; Flow; Complex; n.d.)

**Rate\_movement2**

Second movement rate choosing among: Extremely slow; Very slow; Slow; Moderate; Rapid; Very Rapid; Extremely rapid

**Material2**

Displaced material by the second movement. Superficial deposit -earth if >80% of the particles are smaller than 2mm, upper limit of sand size; Superficial deposit -debris if 20 to 80% of the particles are larger than 2mm; Sedimentary bedrock; Igneous bedrock; Metamorphic bedrock)

**Description2**

Short description of kinematic characteristics of the process. (max 255 char.)

**Water content**

Describe the water content of landslide materials

Very Wet; Wet; Moist; Dry

### **Movement representative**

Indicate the most significant/main movement, useful for a cartographic representation. (Fall; Topple; Slide; Spread; Flow; Complex; DSGSD; not determined).

### **Description representative**

Short description of cinematic characteristics of the process. (max 255 char.)

### **Causes\_human**

Y/n

### **Causes\_human\_description**

List the main human activities which have caused or aggravate the landslide (max 255 characters).

### **Causes\_geological**

Y/n

### **Causes\_geological\_description**

List the main geological factors which have caused or aggravate the landslide (max 255 characters)

### **Causes\_morphological**

Y/n

### **Causes\_morphological\_description**

List the main morphological factors which have caused or aggravate the landslide (max 255 characters).

### **Causes\_meteo**

Y/n

### **Causes\_meteo\_description**

Meteorological condition responsible for paroxysmal events (max 255 characters).

### **Causes\_seismic**

Y/n.

### **Causes\_seismic\_description**

Earthquake magnitude (max 255 characters).

### **Others processes interferences**

Y/n

### **Others processes\_description**

Short description of other processes associated with the landslide (debris flows, stream occlusion, etc.).

### **Rupture surface**

Short description of the rupture surface (shape, depth, etc..)

### **Area\_total**

Total surface of landslide (calculated on horizontal plane).

### **Crown\_altitude**

Elevation of the highest point of main scarp.

### **Crown\_height**

Height of main scarp from top of displaced mass to the highest point of the main scarp.

### **Top\_altitude**

Elevation of the highest point of displaced mass.

### **Toe\_altitude**

Elevation of the lowest point of displaced mass.

### **Length\_min\_total**

Minimum distance from tip to crown (Lr).

### **Length\_centre\_line**

Total length from tip to crown measured along centre line.

### **Length\_tip\_top**

Minimum distance from tip to top (Ld).

### **Length\_center\_line\_horizontal**

Total length from tip to crown on centre line (horizontal extent).

### **Difference\_level**

Total height of landslide.

### **Travel\_angle\_alpha**

Travel angle from tip to crown.

### **Width\_Mass**

Width of displaced mass (Wd).

### **Width\_Rupture**

Width between flanks (Wr).

### **Depth\_Mass**

Max depth of displaced mass (Dd).

### **Depth\_rupture**

Max depth of rupture surface below original ground surface.

### **Volume**

$V = \pi/6 Ld Dd$ .

### **Date**

Date of measurements

### **Volume\_max particles**

Max volume of particles forming displaced mass.

### **Volume medium**

Average volume of particles forming displaced mass.

### **Studies**

Field surveys; Technical reports; Others

### **Date observation**

To be filled in case of specific or direct surveys.

### **Map\_description**

Short description of available maps.

### **Numerical\_map**

Y/n

### **References**

Field related to data source.

## **11-a History description**

### **History\_description**

Description of landslide evolution.

## **12 Landslide damages**

This section contain information about damages related to reactivation of landslide, derived either from historical analysis and from specific technical reports and studies.

### **Town**

Name of Town or Municipality.

### **Local name**

Name of the area in which the damage occurred.

### **Date\_beginning**

Date of the damage (beginning and end if it occurred in a period of time).

### **Date\_end**

Date of the damage.

### **Date\_comments**

Other remarks about damage occurrence.

### **Victims**

If phenomenon produced victims  
Y/n

### **Victims\_number**

Number (if known) or size order (historical datum: few, some, many, etc.).

### **Victim\_precision**

Y- precise value; direct information  
n- interpreted datum

### **Injured\_people**

Y/n

### **Injured\_number**

Number (if known) or size order (historical datum: few, some, many, etc.).

### **Injured\_precision**

Y- precise value; direct information  
n- interpreted datum

### **Evacuated**

Y/n

### **Evacuated\_number**

Number (if known) or size order (historical datum: few, some, many, etc.).

### **Evacuated\_precision**

Y- precise value; direct information  
n- interpreted datum

### **People\_damage**

Short description of damages to people.

### **Residences\_damage**

Damages to residential buildings.  
Y/n

### **Residences\_description**

Short description of damages occurred to private or public buildings (residences, school, hospital, church).  
(max 255 characters).

### **Degree\_residences**

Damage degree (high, medium, low)

### **Historical Buildings**

Church, museum, ...

Y/n

### **Historical Buildings\_descr**

Short description of damages occurred to historical/artistic buildings (max 255 characters)

### **Degree\_historical**

Damage degree (high, medium, low)

### **Industrial**

Damages to industrial activities

Y/n

### **Industrial\_description**

Short description of damages occurred to industrial activities (factories, tertiary settlements, electric plants, etc..), (max 255 characters)

### **Degree\_industrial**

Damage degree (high, medium, low)

### **Transport\_network\_damage**

Y/n

### **Transport\_network\_descr**

Short description of damages occurred to transport networks (main roads, highways, railways, secondary roads, etc..) (max 255 characters)

### **Level\_transport**

Damage degree (high, medium, low)

### **Infrastructure\_damage**

Y/n

### **Infrastructure\_description**

Short description of damages occurred to infrastructures (lifelines, stabilisation works, water network, etc.)

### **Degree\_Infrastructure**

Damage degree (high, medium, low)

### **Process-description**

Short description of the process responsible for the damages.

### **Geo-referred**

If the damage is geo-referred.

Y/n

### **Precision**

Specify if it is available a precise location or a symbolic one.

### **References\_type**

Field survey; Technical report; Other report.

### **Reference**

Author, Year, etc..

## **13 Landslide morphology**

This section is fundamental because describes all the main features characterising the landslide, useful to understand the process in terms of type of movement, rate, triggering mechanism, possible evolution, etc..

In this section are collected all the data obtained through aerial photointerpretation in different period, field mapping and surveying, in order to draw the landslide history, with particular reference to the last 50-70 years. From this information some early consideration about landslide evolution can be done. Each record should contain information about each single feature or group of similar features. There is also the possibility to describe synthetically the landslide area as a whole from a morphologic point of view, in order to make comparisons from landslide situations observed in different period, the term “landslide area” is dedicated to a short morphology description of the whole area.

#### **Date\_record**

Date of this section compilation (present).

#### **Features**

Choose from this list:

Crown; Crown cracks; Main scarp; Minor scarp; Transverse cracks; Radial cracks; Transverse ridges; Cracks; Trenches; Surface of rupture; Flank; Displaced material; Zone of depletion; Zone of accumulation; Unstable zone; Landslide area; Others

#### **Feature\_location**

Where the described feature is located respect to the landslide.

#### **Features\_description**

Short description of the analysed feature, referring to field survey date or aerial photos date.

#### **Date\_forming\_feature**

Date/period of feature formation (if it is possible to relate it to a known meteorological event).

#### **Meteorological event**

If the feature (or group of features) is related to a well known event (see above).

Y/n

#### **Date\_feature**

Date of field observation or of Aerial photos (as Year and month) or of field survey.

#### **Features\_comparison**

Short description of the feature through the comparison among previous observations.

#### **Map\_description**

Author, Year, scale of available maps (255 char.)

#### **Numerical\_map**

If the feature is reported in a numerical map.

Y/n

### **14 Land Use**

This section is formed by a check list of the major land uses in the area where the landslide is located, using for the main categories boolean field (Y/n) and short descriptions about their distribution (in what part of landslide it occurs).

#### **Artificial surface**

Evidence the presence of Urban areas, with infrastructures, in a general sense.

In the following section (15) human good and activities are better described.

Y/n

#### **Artificial surface where**

Short descriptions about the location (in which part of landslide they are recognised: near the main scarp, near depletion zone, in accumulation zone, near/on the landslide toe...).

#### **Pasture**

Y/n.

#### **Pasture where**

Short descriptions about the location (in which part of landslide they are recognised: near the main scarp, near depletion zone, accumulation zone, near/on the landslide toe...).

#### **Meadow**

Y/n.

#### **Meadow\_where**

Short descriptions about the location (in which part of landslide they are recognised: near the main scarp, near depletion zone, accumulation zone, near/on the landslide toe...).

#### **Agriculture**

Y/n.

#### **Agriculture\_where**

Short descriptions about the location (in which part of landslide they are recognised: near the main scarp, near depletion zone, accumulation zone, near/on the landslide toe...).

#### **Shrub**

Y/n.

#### **Shrub\_where**

Short descriptions about the location (in which part of landslide they are recognised: near the main scarp, near depletion zone, accumulation zone, near/on the landslide toe...).

#### **Forest**

Y/n.

#### **Forest\_where**

Short descriptions about the location (in which part of landslide they are recognised: near the main scarp, near depletion zone, accumulation zone, near/on the landslide toe...).

#### **Forest\_deciduous**

Y/n

#### **Forest\_deciduous\_where**

Short descriptions about the location (in which part of landslide they are recognised: near the main scarp, near depletion zone, accumulation zone, near/on the landslide toe...).

#### **Forest\_conifer**

Y/n.

### **Forest\_Conifer\_where**

Short descriptions about the location (in which part of landslide they are recognised: near the main scarp, near depletion zone, accumulation zone, near/on the landslide toe...).

### **Coppice**

Y/n.

### **Coppice\_where**

Short descriptions about the location (in which part of landslide they are recognised: near the main scarp, near depletion zone, accumulation zone, near/on the landslide toe...).

### **Trees\_twisted**

This is a further specification within forest areas, because tree shape is important to evaluate stability condition of the landslide affected area and surroundings.

Y/n.

### **Trees\_twisted\_where**

Short descriptions about the location (in which part of landslide they are recognised: near the main scarp, near depletion zone, accumulation zone, near/on the landslide toe...).

### **Trees Bending**

Tree shape is important to evaluate stability condition of the landslide affected area and surroundings.

Y/n

### **Trees Bending where**

Short descriptions about the location (in which part of landslide they are recognised: near the main scarp, near depletion zone, accumulation zone, near/on the landslide toe...).

### **Map\_description**

Short description of available map.

### **Numerical map**

Existence of numerical map.

Y/n

### **References\_list**

Author, year (see reference section)

## **15 Landslide elements at risk**

Detailed description (also as a list) of people, goods, buildings, infrastructures present in landslide influencing area.

### **Town**

Name of Town or Municipality

### **Local name**

Name of the area in which landslide is located (Cassas, Rosone).

### **Inhabitants\_permanents**

Number of permanent inhabitants.

### **Inhabitants\_permanents\_description**

Remarks about population.

### **Inhabitants\_temporary**

Number of temporary inhabitants

### **Inhabitants\_temporary\_description**

Remarks about, period of increasing population, presence of camping, ecc.

### **Building**

Surface assigned to residences or populated buildings, such as hospital and school (Extent in m<sup>2</sup>). (max 255 characters).

### **Building\_value**

Estimates in Euro of residence buildings total value, using following intervals:

$\leq 10^6$ ;  $10^6-10^7$ ;  $10^7-10^8$ ;  $>10^8$  Euro

### **Buildings\_description**

Description of historical/artistic buildings present in the studied area.

(max 255 characters).

### **Historical Buildings**

Description of historical/artistic buildings present in the studied area.

(max 255 characters).

### **Historical Buildings\_value**

Very high; High; Local.

### **Industrial Buildings description**

Description of industrial settlements present in the studied area (max 255 characters).

### **Industrial activities polluting**

Indicate if there are industrial activities at risk of pollution in case of damage.

Y/n

### **Industrial Buildings\_value**

Estimates in Euro of industrial buildings total value, using following intervals:

$\leq 10^6$ ;  $10^6-10^7$ ;  $10^7-10^8$ ;  $>10^8$  Euro

### **Transport network**

List of the transport infrastructures present in the studied area and potentially involved.

(max 255 characters).

### **Transport network\_primary**

Y/n

### **Transport network\_value**

Estimates in Euro of transport network total value, using following intervals:

$\leq 10^6$ ;  $10^6-10^7$ ;  $10^7-10^8$ ;  $>10^8$  Euro;

### **Water network**

Short description of water network (max 255 characters).

### **Water network\_primary**

Is Water network of primary importance in the studied area?

Y/n

### **Water network\_value**

Estimates in Euro of transport network total value, using following intervals:

$\leq 10^6$ ;  $10^6-10^7$ ;  $10^7-10^8$ ;  $>10^8$  Euro

### **Dams**

Short description of dams existing in the studied area, with an estimate of retained water volume. (max 255 characters).

### **Dam\_value**

Estimates in Euro of dam total value, using following intervals:

$\leq 10^6$ ;  $10^6-10^7$ ;  $10^7-10^8$ ;  $>10^8$  Euro

### **Agricultural goods**

Short description of agricultural goods present (max 255 characters).

### **Agricultural goods\_value**

Estimates in Euro of agricultural goods total value, using following intervals:

$\leq 10^6$ ;  $10^6-10^7$ ;  $10^7-10^8$ ;  $>10^8$  Euro

### **Map**

Description of available map (255 char.)

### **Numerical map**

Y/n

## **16 Survey Boreholes**

In this section data obtained from boreholes, such as identification of the materials with distinctive properties are organised and described. Determination of characteristics data are obtained by retrieving representative samples for tests.

### **Sampling\_type**

Short description about drilling and sampling methods and samples quality (undisturbed, disaggregate, ecc). Max 255 characters.

### **Description**

Borehole number, depth, position with respect to the landslide, etc.

### **Borehole\_logging**

Borehole logging description (yes/no)

### **Date\_boring**

Date of drilling

### **Management**

Name of organisation responsible for drilling, sampling testing and/or data processing.

### **Georeferred**

Is the borehole geo-referred ?

Y/n

### **Date\_compilation**

Compilation record date

### **Meaningful Values**

Short description and remarks on the most significant values.

### **Reference\_list**

Eventual reference to an external database

## **16-1 Survey Tunnels**

In this section data obtained from survey tunnels are organised and described. Determination of characteristic data are obtained by retrieving representative samples for tests.

### **Drilling**

Identification of drilling method choosing among: Drilling Blast; TBM; Shielded TBM; Others

### **Other drilling**

Specify other drilling method used

### **Description\_drilling**

Short description of drilling as textual field (max 255 char.)

### **Date\_drilling**

Date of drilling

### **Management**

Name of organisation responsible for drilling, sampling testing and/or data processing.

### **Meaningful Values**

Short description and remarks on the most significant values.

### **Reference\_list**

Eventual reference to an external database

### **Altitude (m)**

Numerical value

### **Depth (m)**

Numerical value

### **Diameter (m)**

Numerical value

### **Structural data**

Specify if structural data have been collected and stored (y/n)

### **Georeferred**

Is the tunnel geo-referred ?

Y/n

### **Date\_compilation**

Compilation date.

## **17 Survey geophysics**

Section devoted to geophysical survey.

### **Type**

Surface; Subsurface.

### **Testing**

Electrical resistivity; Electromagnetic conductivity profiling; Seismic Refraction profiling; Direct seismic; Microgravity; Ground-penetrating radar; SASW; other.

### **Other\_type**

Short description of other measurements type.

### **Management**

Name of organisation responsible for measurements, data collection and/or data processing.

### **Description\_test**

Short description of available instruments, number, depth, ecc.

### **Date\_test**

Date of test execution

### **Date\_compilation**

Compilation record date.

### **Meaningful Parameters**

Short description and remarks on the most significant parameters and their range of values.

## **18 Survey Geotechnical Testing**

In this section information about geotechnical testing on materials directly or indirectly involved by landslide processes are collected.

### **Management**

Name of laboratory or organisation that made the test

### **Type**

Choose between:

Laboratory test; *In situ* test.

### **Testing**

Rock: Monoaxial test; triaxial test; direct shear test; plate load test; flat jack test; pressiometer test (PMT); hydraulic fracture test; point load test; Schmidt hammer.

Soil: classification test; Triaxial UU test; Triaxial CU test; Triaxial CD test; Simple Shear test; oedometer test; plate load test; SPT; CPT; CPTU; SCPT; PMT; Dilatometer (DMT); field vane test; other.

### **Other\_type**

Short description of other measurements type.

### **Description\_test**

Short description of the test  
(Max 255 characters).

### **Date\_test**

Date of test execution

### **Date\_compilation**

Compilation record date.

### **Meaningful Parameters**

Short description and remarks on the most significant parameters and their range of values.

## **19 Survey Piezometers**

This section is devoted to field instrumentation used to monitoring groundwater level and circulation.

### **Measurement\_type**

Specify piezometer type:

Open standpipe; Twin-tube hydraulic; Pneumatic; Vibrating-wire; Electrical resistance strain gauge; 4- to 20 mA pressure transmitter; other.

### **Other\_type**

Short description of other measurements type

### **Measurement\_description**

Short description of available instruments, number, depth, etc.

### **Measurement frequency**

Frequency of measurement.

### **Date\_first\_measure**

Date of the first measure.

### **Date\_last\_measure**

Date of the last measure.

### **Management**

Name of organisation responsible for measurements, data collection and/or data processing.

### **Geo-reference**

Is the instrument geo-referred?

Y/n

### **Meaningful Values**

Short description and remarks on the most significant values.

### **Date\_compilation**

Compilation record date

## **20 Monitoring: field instrumentation**

Section devoted to landslide movement control instrumentation.

### **Measurement\_type**

List of instruments (deformation gauges)

Conventional Topographic Survey; DPGS; Tiltmeter; Probe extensometer; Embankment and borehole extensometer; Inclinometer-probe type; TDR (Time Domain Reflectometry); Plumb line and inverted pendulum; Liquid level gauge; Acoustic monitoring system, other.

### **Other\_type**

Short description of other measurements type

### **Measurement\_description**

Short description of measurements  
(max 255 characters)

### **Measurement frequency**

Frequency of measurements.

### **Date\_first\_measure**

Date of the first measure.

### **Date\_last\_measure**

Date of the last measure

### **Management**

Name of organisation responsible for measurements, data collection and/or data processing.

### **Geo-referred**

Is the instrument geo-referred ?

Y/n

### **Meaningful Parameters**

Short description and remarks on the most significant parameters and their range of values.

#### **Date\_compilation**

Compilation record date.

### **21 Monitoring: Meteorological conditions**

Section devoted to climatological/meteorological parameters gathering in the landslide area.

#### **Measurement\_type**

Thermistore; Thermocouple; Rain gauge; Snow gauge; Weir for measuring water flow; other.

#### **Other\_type**

Short description of other measurements type

#### **Measurement\_description**

Short description of available instruments, number, etc.

#### **Measurement\_frequency**

Frequency of measurement.

#### **Date\_first\_measure**

Date of the first measure.

#### **Date\_last\_measure**

Date of the last measure

#### **Management**

Name of organisation responsible for measurements, data collection and/or data processing.

#### **Georeferred**

Is the instrument geo-referred ?

Y/n

### **Meaningful Parameters**

Short description and remarks on the most significant parameters and their range of values.

#### **Date\_compilation**

Compilation record date

### **22 Stabilisation/protection Works**

In this Section stabilization works present in landslide area are described.

#### **Stabilization\_type**

Choice from a list.

#### **Date\_construction**

Date of construction

#### **Efficiency**

Estimate of Efficiency/effectiveness degree.  
Low; medium; high.

#### **Description**

Short description of the remedial work described.

#### **Geo-referred**

Y/n

### **22-1 Regulations**

In this Section regulations or rules or other preventive measures applied are described in a “memo” field.

#### **Landslide**

Choice from the list.

#### **Regulations**

descriptions of adopted actions or measures.

### **23 Modelling**

#### **Landslide**

Name of landslide to which the model has been applied.

#### **Modelling\_type**

This field identifies one or more kind of models used. Most common models are reported: numerical, deterministic and statistic ones. For “others” we intend, for example, a coupled model like deterministic with a stochastic distribution of variables (e.g. Monte Carlo method).

The choice is among:

numerical; deterministic; statistic; others.

#### **Modelling\_Others\_t**

Brief description of the models not listed above.

(max 255 characters)

#### **Modelling\_description**

Description of the adopted model. The main characteristics of the model should be emphasised, with some notes on hypothesis that have been adopted (boundary and water conditions, constitutive laws and so on).

#### **Management**

Name of organisation responsible for modelling.

#### **Triggering**

Is the model able to describe the triggering of the movement?

Y/N

#### **Triggering\_description**

Description of triggering conditions (max 255 characters).

#### **Runout**

Is the model able to describe the evolution and the run-out of the movement?

Yes/No

#### **Runout\_description**

Description of run-out conditions (max 255 characters).

#### **Output**

Description of the results coming from the model (safety factor, displacements, absence or presence of movement and so on) (max 255 characters).

#### **Date\_compilation**

When the model has been made or applied.

## **24 Scenarios first hypotheses**

### **Description\_involved\_area**

Short description of areas directly or indirectly involved by landslide evolution in a catastrophic or not catastrophic way.

Each scenario is presented and described in probability occurrence decreasing order.

### **Scenarios: Occurrence\_probability**

Indication of the occurrence probability of the supposed scenario indicating :

High Probability / Medium / low probability;

### **Triggering\_causes**

Description of triggering factors for the supposed scenario (for example, intense rainfall, rapid snowmelting coupled with spring rainfall, earthquake, etc.).

### **Process\_description**

Description of processes, according to the supposed scenario determined by landslide evolution.

### **Effects\_damages**

Short description of morphological effects and damages, according to the supposed scenario.

### **Remedial\_works**

Short description of first actions to reduce landslide hazard, either as remedial works, development restrictions and civil protection planning during and post event.

## **25 References**

### **Report Type**

Choose from this list to classify the data source document/study.

Geological study; Geomorphologic study; Engineering geologic study; Model study; Climate study; Aerial photo; Satellite image; Topographic map (raster); Topographic map (vector); Topographic map (traditional); Hazard and Risk assessment; Land use regulations; Other

### **On\_purpose**

Specify if the described document is strictly related to the studied landslide or not.

Y/n

### **Author**

Example:

- 1) Turner, A.K.; Schuster, R. L. (editors)
- 2) Hutchinson, J.N.
- 3) Genio Civile di Torino

### **Title**

Example

- 1) Landslide investigation and mitigation
- 2) Methods of locating slip surface in landslide
- 3) Field analysis

### **Publisher**

Example

- 1) National Academy Press, Washington, D.C.

- 2) Not published

### **Date**

- 1) 1996
- 2) 1983
- 3) 1957

### **Series**

- 1) Special Report 247, Transportation Research Board, National Research Council, 673 p.
- 2) Bulletin of the association Engineering Geologist, Vol. 20, n°3, pp. 235-252.

### **Abstract**

Textual field (255 characters).

### **Other remarks**

Textual field (255 characters).

### **Maps**

Evidence the presence of thematic maps/or if the documents itself is a map.

Y/n

### **Map\_title\_contents**

Title of map and brief description (255 characters).

### **Scale**

Scale map

### **Numerical Map**

Evidence if it is in a digital/numerical format or on paper.

Y/n

### **Gis\_software**

Specify used software

### **Area**

Define spatial collection of the document. (255 characters).

### **Keywords**

List of keywords

### **Comments and notes**

Textual field (255 characters).

### **Use\_reference - section**

Specify the section which is addressed to (1 regional geology, 14 land use, 23 modelling, etc.), choosing from a look-up table.

### **Files - section**

In this mask you can insert the name of useful and available in digital format files, specifying directory in which they are contained.

The button "path" present in this mask but also in the opening one, corresponds to a macro which builds the field "path", combining landslide code (for example 3 for Rosone, that you choose in the first mask of references and that is not visible), directory denomination (ex: **dir\_2**) in which there is the file considered; file **name** (max 8 characters), file extension (choosing from an implementable table).

Et the end, a brief **description** of the file itself (as an explanation of the figure or table or graph) is foreseen (max 255 characters).