



IMPORTANT DISCLAIMER, GUIDANCE NOTES AND CONDITIONS OF USE FOR LANDSLIDE SUSCEPTIBILITY MAPS

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PURPOSE OF THE MAP

The map contained within this volume was prepared under the following project:

Project: National Landslide Susceptibility Mapping

Duration: 2007 – 2016

The map was prepared with the purpose of assessing landslide susceptibility to assist in the identification of areas that are likely to experience land sliding and develop a model for susceptibility mapping on a national level.

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GUIDANCE NOTES

The following notes explain how this map has been derived and what it does and does not present.

Derivation of Maps

The map included in this volume is a national “susceptibility” landslide map as it provides information on areas which are predisposed to this type of geohazard. The data presented in this map indicates, based on susceptibility banding or slope stability classification, areas ranging from a high susceptibility to landslide events to areas generally devoid of landslide events. The susceptibility classification is based on a Unique Condition Unit (UCU) approach. A UCU is a parcel of terrain where a set of attributes are combined in a unique way. Taken alone they do not provide any indication of the susceptibility of landslides. However, if the number of landslides falling into a particular UCU can be determined and then divided by the area of the relevant UCU this gives a landslide density value (landslides / km²) which is taken as a measure of susceptibility. If a landslide has been observed in an area with a particular combination of attributes then, the rationale is that, if this combination occurs elsewhere that location is also susceptible to landslides.

In the context of landslide susceptibility mapping the parameters being considered for the UCU model are slope, soil type and a Topographic Flow Index (TFI). These are explained in detail below.

Slope - The slope is derived from 20m Digital Elevation Model (DEM) and values can range from 0 degrees (horizontal) to 90 degrees (vertical). The range of slopes is divided into smaller intervals at lower slope values in order to improve the sensitivity of the method applied.

Table 1: Slope bands with band intervals and associated land areas

Slope (Deg)	0-3	3-6	6-10	10-15	15-20	20-30	30-45	45-65	65-90
Interval	3	3	4	5	5	10	15	20	25

Generalised Soils – The generalised soils is derived from the Geological Survey’s National Quaternary Geology dataset and grouped into 7 categories (including water/made ground). The 5 soil groupings are based on their grain size distribution and/or particular characteristic.



Table 2: Generalised soil descriptors and definitions

The GSI's national quaternary geology mapping has been grouped into 5 categories based either on the typical grain size of the material or a particular characteristic. In addition two special categories, Water and Made Ground also exist. These categories and associated abbreviations are described below.			
FMR	These are Fine to Medium Range grain size soils. Typically the 'fine' end of this range is characterised by silts and at the 'medium' end by fine sand.	MCR	These are Medium to Coarse Range grain size soils. Typically the 'medium' end of this range is characterised by sands and gravels and at the 'coarse' end by cobbles and boulders.
FCR	These are Fine to Coarse Range grain size soils and due to their wide variation in size distribution it is not possible to assign these to one or other of the above categories. The predominant material is glacial till which can range from fine clays to large cobbles in a matrix of finer material.	RNS	This abbreviation is for Rock Near Surface and means that the soil is thin with rock less than a metre below the surface or in fact exposed.
Peat	Peat has unique properties and as such has been categorised separately. This category largely consist of peat (or turf) as would normally be recognised and occurs as blanket peat in upland areas but also to a much lesser extent may comprise other highly organic soils in low lying marshlands.	Made	Made ground refers to areas where engineered construction has been undertaken and mainly encompasses urban areas but also includes large embankments at reservoirs and similar structures.
Water	Loughs and Lakes and includes natural and man-made impoundments.		

Topographic Flow Index (TFI) – TFI is derived from 20m DEM and is calculated incorporating factors of slope, flow direction and flow accumulation. It is a measure of how overland flow is concentrated or dispersed by the terrain and also takes account of flow velocity and is classified into three categories – low, medium and high.

Table 3: Topographic Flow Index values and associated descriptions

TFI Value	TFI Description
1	Low TFI – Low concentration of overland flow weighted by the rate at which this occurs.
2	Medium TFI – Medium concentration of overland flow weighted by the rate at which this occurs.
3	High TFI – High concentration of overland flow weighted by the rate at which this occurs.



The parameters are combined and the resultant UCU groupings produce a possible 189 potential UCU combinations (8 slope x 7 soil x 3 TFI).

The UCU model is then weighted by applying a known inventory of landslide events to the combined parameters and values for the number of landslides per UCU is calculated. This basic count is then normalised by dividing the area of the relevant UCU to give values of incidence per area of a UCU i.e. number of landslides/km². These incidence values are then multiplied by 100 which give the number of landslides/100 km².

The incidence values are then banded in order to express landslide susceptibility. The approach taken to categorisation of landslide susceptibility is through a four band scale ranging from 'Low' to 'High'. This uses the relatively simple concept of doubling the number of landslides within each band i.e. break points between each band are doubled. A set of descriptors is then applied to each of the four bands which include the following:

Column	Description
Description	This is the 'susceptibility tag', defining a level of susceptibility and is elaborated upon in other columns which provide information on the physical geography, landslide incidence etc.
Physical Geography	This provides a description of the soil types and slopes which are the most dominant characteristics of a particular band. This has been done by abstracting information on the areas of soil types and slope bands.
Landslide Incidence	The banding itself expresses landslide susceptibility, but this provides some additional details of the conditions (in terms of slope and soil) particular to that band in which most of these slides have occurred.
Indicative Extent (by Number)	This indicates the expected percentage of landslides falling within each band although actual numbers will fluctuate slightly as the inventory develops and is updated.
Indicative Extent (by Area)	This is the land area encompassed within each band expressed as a percentage. It is a feature of the study area, but if the physical characteristics are generally typically of Ireland as a whole then the figures will be relatively stable.

An example of the descriptor for the Moderately Low category is listed below:

Cat	Description	Physical Geography	Landslide incidence	Number	Area
C	Moderately Low	The predominant soil type is Rock Near the Surface and to a much lesser extent Fine to Coarse Range material or Peat which occur in almost equal proportions. Slopes are mainly in the 6-10° band with a significant proportion in the 3-6° range.	The highest number of landslides occurs in the 3-6° Peat class, which also has a high density of slides. However the highest density is in the 20-30° Fine to Medium Range class, but these conditions are extremely limited in extent.	11%	7%



Susceptibility Maps

The national susceptibility map produced is published at a scale of 1:50,000. The base data of the secondary data produced in the map is a 20m DEM. All data input into the model is therefore brought to a resolution of 20m. In order to remove spurious data and to assign average cell values to the DEM for the creation of slope and TFI layers, some additional processing was carried out to the bare 20m DEM. For this reason the national map should only be used at a local level or the scale at which the map is published and not for an individual site or property assessment of landslide susceptibility.

The map was produced partially based on field study data which was captured prior to and during the early - mid stages of the project. They therefore do not account for changes in development, infrastructure or topography that occurred after the date of the final field study data used (2014).

The national DEM was prepared on the basis of 37 Hydrometric Areas within the Republic of Ireland, and their neighbouring coastal islands. The dataset was developed within the Environmental Protection Agency (EPA) Environmental RTDI project (2000-LS-2-M2) "Eutrophication from Agricultural Sources". The DEMs were interpolated from a variety of sources including 1:50,000 digital data from the Ordnance Survey Ireland (OSI) and are currently available as hydrologically corrected grid surfaces with 20m grid cell resolution, and based on the Irish National Grid Coordinate system.

Detailed explanations of the methods of derivation, survey data used and model applied are provided in the relevant reports produced for the project under which the maps were prepared. Users of the maps should familiarise themselves fully with the content of these reports in advance of the use of these maps.

Landslide Susceptibility

The map refers to areas where landslides may occur and these areas are ranked, in accordance to slope stability and associated topographic factors, into categories that range from low to high. It should be noted that the term "susceptibility" refers to the identification of areas which are predisposed to landslides and this is measured by the number of incidences per square km or density of landslides per UCU. This map should not be treated as "*Hazard*" map which show the potential to cause damage by frequency/probability or intensity or "*Risk*" map which shows loss potential.



Uncertainty

The methodology used in this study, the UCU approach, will in some instances produce null observations as a result of no landslide either having occurred/recorded or likely to occur within a particular UCU due to the nature of the conditioning factors. In order to create a comprehensive landslide susceptibility map, all possible UCU's require a density value or susceptibility category. In addition some inconsistencies can occur from the application of this model. These inconsistencies are artefacts arising largely from the fact that some UCU's have very few observations so a single additional landslide may double the apparent incidence weighting.

For those cases where there are no landslide incidences the resultant null categories need to be populated with estimated values. This extrapolation can be thought of as in-filling in three different circumstances:

1. Lower slope ranges - generally less than 10 degrees
2. Upper slope ranges - generally greater than 45 degrees
3. Isolated gaps between populated ranges

This extrapolation is carried out through inspection and judgement when landslide density values have been assigned to susceptibility bands thus allowing values to be logically assigned to null UCU categories. The results of this approach define categories where the distinction between data derived and interpolated is clearly shown. Subsequently, this distinction is maintained in the susceptibility mapping and it will be transparent as to which zones are based on inventory data and which are inferred.

Validation

A number of sense checks have been undertaken on the susceptibility mapping output. In part these are visual checks on the spatial distribution of 'Low' / 'High' susceptibility areas to ensure that they conform to expert judgement. This includes, for example particular attention to peat on steeper slopes where it is recognised historically that these areas have a high susceptibility to peat slides.

Upon completion of the national map validation was carried out using 15% of all landslides in the National Landslide Database, using geostatistical analysis for the division between the remaining 85% and the 15% being used for validation. The results showed that 92% of the validation landslides were located within areas categorised as High, Moderately High or Moderately Low susceptibility.



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PROJECT REPORT REFERENCE LISTING

Landslide Susceptibility Mapping: Literature Review and Findings, April 2011
Landslide Susceptibility Mapping: Developing a Surface Flow Hydrology Index, December 2012
Landslide Susceptibility Mapping: Sensitivity and Consistency Checks, December 2012
Landslide Susceptibility Mapping: Project Summary, December 2012
Landslide Susceptibility Mapping: Classifying Landslide Susceptibility, December 2012
Landslide Susceptibility Mapping: Unique Condition Units: Theory and Practice, February 2013
Landslide Susceptibility Mapping: GIS Data Processing Steps Guide, March 2013

CONTACTS REGARDING MAP INFORMATION

Any user who has reason to believe that these maps contain an error, or who wishes to contribute additional information, is requested to contact the Geological Survey.