Pan-European and nation-wide landslide susceptibility assessment

DURATION : 2012 – 2013

TARGET COUNTRIES : Europe continental level with focus regional sites in Portugal, Romania and the Caucasus

PARTNERS INVOLVED :
Coordinating centre: CERG Strasbourg, France
Other centres: GHHD Tbilisi, Georgia , ECBR Bucharest, Romania , ISPU Florival, Belgium ,
Other partners: University of Strasbourg (UdS, J.-P. Malet, A. Puissant), University of Lisbon (ULISBOA, J.-L. Zêzere), University of Caen (O. Maquaire), IGRA (M. Micu), Technical University of Catalonia (UPC, J. Corominas), Joint Research Centre (JRC, J. Hervàs, M. Van Den Eeckhaut), German Geological Survey (BGR, A. Günther), National Research Council, Research Institute for Hydrogeological Protection (CNR-IRPI, P. Reichenbach)

OBJECTIVES OF THE PROJECT

Global objective for 2012-2013 :

In the framework of the European Soil Thematic Strategy, a project to map landslide susceptibility at the scale of Europe (i.e.1:1 Million) was suggested in 2007 by the Soil Information Working Group (SIWG) of the European Soil Bureau Network (ESBN). The methodology consists of identifying the potential areas subject to generic landslide types by expert knowledge using available thematic and environmental data. The choice of the 1:1 M scale allows the use of harmonized data sets for all Member States as input to the susceptibility model.
Within this context and with support of the International Programme on Landslides (IPL), the German Geological Survey (BGR), the National Research Council, Research Institute for Hydrogeological Protection (CNR-IRPI) and the EUR-OPA Major Hazards Agreement, the Landslide Expert Group of JRC, among which 3 CERG members, proposed a preliminary heuristic assessment exploiting a reduced set of landslide conditioning factors derived from common pan-European data sources for the whole of the European Union and adjacent countries (Hervàs et al., 2007). Evaluation of the susceptibility estimates with national-level landslide inventory data from France, Great Britain and Italy suggests that zoning of Europe according to e.g. morphology and climate and preparation of individual models for each of these zones could give more reliable results (Günther et al., 2011; Malet et al., submitted).

The objectives of the project are:
1) To refine the preliminary assessment at the Pan-European scale by estimating three independent maps per landslide type (e.g. slides, falls and flows) and propose a methodology to combine the three independent maps in one unique compound landslide susceptibility map; the susceptibility modelling will be carried out by comparing a spatial multi-criteria approach (SMCE) and a fully data oriented statistical approach (logistic regression). This objective is being carried out as part of the Landslide Expert Group of JRC;
2) To propose nation-wide assessments of landslide susceptibility for three countries (Portugal, Georgia and Romania) by compiling national landslide inventories and using a statistical modelling approach (logistic regression) on a series of environmental factors on data with higher resolution than for the Pan European map. A method to integrate information on landslide triggers (rain, earthquake) in the analysis will be proposed and tested in Georgia, Portugal and Romania (possibly the use of meteorological information derived from remote-sensing imagery will be used);
3) To analyse (through a dedicated online questionnaire) the different methods of assessment (Landslide Risk Assessment Model; LRAM) and the categories of maps used in practice by the European Countries in their regulation for landslide susceptibility, hazard and risk mapping, and identify the pro & cons of each methodology.

The Project has a European dimension and a significant impact within the activities of the "European and Mediterranean Major Hazards Agreement" since it involves four specialised centres (CERG, GHHD, ECBR, ISPU). The expertise of the academic partners (see above) guarantees the success of the research activities, as some of them (JRC-BGR-UdS-CNR) are already working closely together within the 'Landslide Expert Group'. Co-funding to the research will be made available by each of the partners.

Specific yearly objectives :

2012:
1a) Update of the actual landslide European inventory (focus on location and landslide type) with data from Portugal, Georgia and Romania in order to complement a database in construction within the Landslide Expert Group (CERG, GHHD, ECBR, BGR, JRC, IGRA).
1b) Test of the methodologies for susceptibility mapping per main landslide type (slide, flow and fall) at 1:1 M scale using SMCE and logistic regression models at the Pan-European scale, and evaluation of the performance of the modeling (CERG, BGR, UdS, CNR, JRC, UPC).
1c) Collection and organisation of relevant data for the national and regional assessments in Portugal, Georgia and Romania (CERG, GGHD, ECBR, IGRA)
1d) Set up of the "Landslide Risk Assessment Model, LRAM" survey and launch of the questionnaire on the internet (ISPU, CERG).

2013:
2a) Production of the national and regional susceptibility maps for Portugal, Romania and Georgia, and comparisons with the Pan-European map (CERG, GGHD, BGR, UdS, IGRA, CNR, JRC, UPC).
2b) Analysis of the response to the survey, and production of a synthetic report with the pro/cons of the methods used in each country (ISPU, CERG)

2c) Diffusion of the results through joint publications

EXPECTED RESULTS

2012:
1) Organisation of a 2-days workshop in France (Strasbourg) to define the working methods and present the data already available
2) Organisation of a landslide inventory database (for scientific purpose) with indication on landslide location and landslide type at the European scale, and for Portugal, Georgia and Romania (the database will not be transferred).
3) Oranisation of a database of environmental factors (geology, slope, land cover, rain) for Portugal, Georgia and Romania
4) Test of the performance of the statistical models at the Pan-European scale.
5) Diffusion of the on-line internet questionnaire on LRAMs on the ISPU website, and identification of target people in each country.

2013:
1) Organisation of a 2-days workshop in Portugal (Lisbon) to discuss the progress of the work
2) Production and diffusion of the European susceptibility maps per landslide types.
3) Test of the performance of the statistical models at the national and regional scales for Portugal, Georgia and Romania, and integration of triggering factors (rain, earthquake acceleration map) in the model. Set up of the methodology.
4) Analysis of the survey, and production of a synthetic report on the advantages and limitations of the different methods used in each country.
5) Diffusion of the results through joint publications

RESULTS OBTAINED PREVIOUSLY (if any)

The proposed susceptibility assessment obtained for France in 2011 for three landslide types (falls, flows, slides) and based on slope angle, lithology and land cover will be 1) extended by testing more robust statistical techniques, 2) tested on country-side data sets available for Portugal, Spain and Belgium, 3) and later applied to the European scale using the climate-physiographic regions suggested by Günther et al. (2011).

References:
Günther, A., Van Den Eeckhaut, M., Reichenbach, P., Hervás, J., Malet, J.-P., Foster, C., Guzzetti, F. (2011). New developments in harmonized landslide susceptibility mapping over Europe in the framework of the European Soil Thematic Strategy. In: Margottini, C., Canuti, P. Sassa, K. (Eds): Proceedings of the Second World Landslide Forum, 3-7 October 2011, Rome, Italy, Springer (to be published in 2012).
Hervás, J. (Ed.), 2007. Guidelines for Mapping Areas at Risk of Landslides in Europe. Proc. Experts Meeting, JRC, Ispra, Italy, 23-24 October 2007. JRC Report EUR 23093 EN, Office for Official Publications of the European Communities, Luxembourg, 53 pp.
Landslide Expert Group: http://eusoils.jrc.ec.europa.eu/library/themes/Landslides/
Malet, J.-P., Puissant, A., Mathieu, A., Van Den Eeckhaut, M., Fressard, M. (submitted). Landslide susceptibility assessment at 1:1M scale for France. Landslides, 15p. (submitted in July 2011).
Co-funding 2012:
- UdS: ChangingRISKS Project funded by the European Commission by the Seventh Framework Programme - Instrument ERA-NET CIRCLE - co-funding provided: 3000 €.
- JRC: Landslide Expert Group - co-funding provided: 1000 €
- ULISBOA: DISASTER - GIS Project funded by the Portuguese Foundation for Science and Technology - co-funding provided: 2000€
Co-funding 2013:
- UdS: ChangingRISKS Project funded by the European Commission by the Seventh Framework Programme - Instrument ERA-NET CIRCLE - co-funding provided: 1000 €.
- JRC: Landslide Expert Group - co-funding provided: 1000 €
- ULISBOA: DISASTER - GIS Project funded by the Portuguese Foundation for Science and Technology - co-funding provided: 2000€

RESULTS OBTAINED IN 2012

Work package 1 (prepared by CERG, GHHD, ECBR):

Description:
Refined Pan-European Landslide Susceptibility Map / Leader: CERG
Associated deliverables:
D.1.1 Update of the actual landslide European inventory of the Landslide Expert Group (CERG) - M+6
D.1.2 Spatial multi-criteria model (CERG) -M+9
D.1.3 Statistical (logistic regression) model (CERG) -M+12

Discussion on the methodology to progress in the European Landslide Susceptibility mapping of Europe according to landslide typology

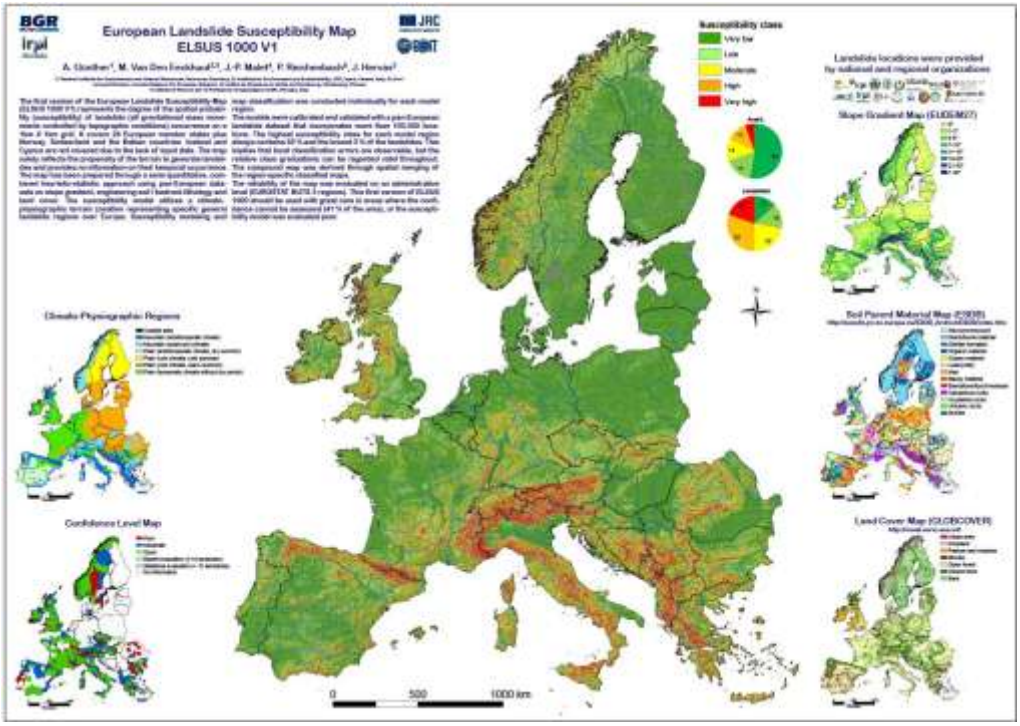
In 2012, the main objective was to discuss on the methodology among a group of experts. A meeting has been organized in October 2012 in Berlin (hosted by BGR) where national landslide susceptibility assessments, different methods for evaluating the performance of the assessments, and access to data were discussed.
The time schedule and all presentations of the meeting can be found on the CERG website at: www.cerg.eu

European Centre on Geomorphological Hazards
Centre Européen sur les Risques Géomorphologiques

Presentations of the meeting #1 (16-18 October 2012, Berlin, Germany)

- **The European Landslide Expert Group** (J.Hervás)
- **The preparation of the European Landslide Susceptibility Map ELSUS 1000 Version 1** (A.Günther et al.)
- **Objectives of the CoE - CERG / GHHD / ECBR / ISPU Project** (J-P Malet)
- **Romania: Status of nation-scale landslide susceptibility mapping and available data** (M.Micu)
- **Landslide Susceptibility Mapping in Georgia** (T. Tsamalashvili & T.Chelidze)
- **Status of nation-scale landslide susceptibility mapping in Portugal** (J-L Zêzere)
- **Landslide susceptibility mapping at 1:1M scale over France** (J-P Malet et al.)
- **Update on nation-scale landslide susceptibility mapping in Italy** (P.Reichenbach)
- **Spatial agreement of predicted patterns in landslide susceptibility maps** (S.Sterlacchini et al.)
- **Risk assessment methodologies for landslides** (J-P Malet & O.Maquaire)

Further to this meeting, several trials to validate the version 1 of the landslide susceptibility map of Europe have been realized, and the work will be presented at the forthcoming EGU 2013 Conference.



Different to previous continental and global scale landslide susceptibility studies, we start with collecting more than

102,000 landslides in 22 European countries. These landslides are heterogeneously distributed over Europe, but are indispensable for the evaluation and classification of Pan-European datasets that can be used as spatial predictors for landslide susceptibility, and the validation of respective assessments. We further attempted a subdivision of the European territory into seven different climato-physiographic zones by combining morphometric and climatic constraints for terrain differentiation, and additionally defining coastal areas as a 1km inland from the coastline. Landslide susceptibility modelling was performed for the individual model zones involving heuristic spatial multicriteria evaluations, and validated with the inventory data using receiver operating characteristics. The reliability of the resulting susceptibility map ELSUS 1000 Version 1 was examined on an administrative terrain unit level in areas with landslide information. The ELSUS 1000 was further evaluated through comparisons with available national and regional landslide susceptibility maps. These evaluations suggest that although the first version of ELSUS 1000 is capable for a correct synoptic prediction of landslide susceptibility in the majority of the area, it needs further improvement in terms of data used. These should also consider differentiated susceptibility evaluations with respect to different landslide types. ELSUS 1000 Version 1 can be downloaded together with auxiliary data from the European Soil Data Centre (ESDAC) hosted at JRC.

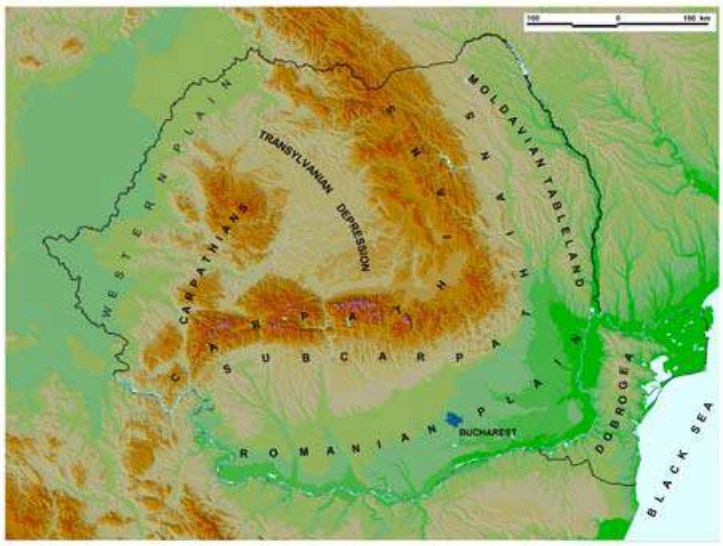
Work package 2 (prepared by GHHD, ECBR, CERG*):*

Description:
National assessments of Landslide Susceptibility for three countries / Leader: GHHD
Associated deliverables:
D.2.1 Collection of inventory data and predisposing factors data for the three countries (Georgia: GHHD; Romania: ECBR Portugal: CERG) - M+6
D.2.2 Organisation of the database for the three countries - M+9
D.2.3. Collection of triggering factors for the three countries - M+12
D.2.4. Statistical model for Portugal (CERG) - M+12

Nation-wide assessment of landslides: focus on Romania

In 2012, the project focused on creating a status of nation-scale landslide susceptibility mapping for Romania, and on preparing the data and maps needed for the analysis.

A brief overview on landslide typology in Romania
Romania represents one of Europe's main landslide hotspots. More than 2/3 of its territory corresponds to mountainous, hilly and tableland units (Fig.1) that are prone to a wide variety of landslides, which are triggered mainly by precipitation but also by earthquakes. Vrancea seismic area represents an intra-continental collision area, generating sub-crustal (90-150 km deep) earthquakes which may affect along a NE-SW direction a large European space extended from Ukraine to Bulgaria.
The complexity of landslide forms and processes is induced by the litho-structural parameters of the main relief units, by the climate characteristics (shifting from the more humid, Atlantic, in the western half to a continental one, marked by temperature and precipitation contrasts and extreme events in the east) and the long-lasting inhabitation.

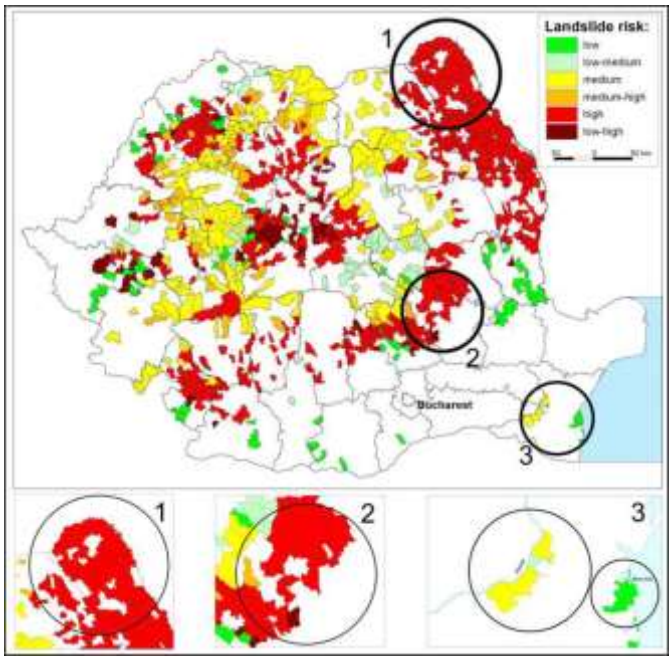


The main relief units of Romania

Throughout Romania's territory, several areas are showing an increased landslide occurrence (from both first time failures and reactivations points of view) potential: the Flysch Carpathians, the Subcarpathians, the Moldavian Tableland and the Transylvanian depression. The Flysch Carpathians represents mainly the outer-facing third of the Eastern and Curvature sector, and especially due to lithology (alternations of thin or thick, unconsolidated to well-cemented sandstone packages with schistose marls and clays) they are characterized by high magnitude/low frequency deep-seated complex (alternation of translational and rotational sectors) debris and rock slides (the majority being considered reactivation of dormant, periglaciar landslide deposits). Their triggering framework involves quite often spring showers overlapping snowmelt. The loose lithology of the Subcarpathians (molasse deposits of clays, marls, sands and gravels in a very heterogeneous disposition of intensely folded and faulted strata) is also the main responsible for the wide variety of low magnitude but high frequency landslides: shallow and medium seated

earth and debris slides, earth flows, rarely debris flows, triggered by heavy summer rainfalls, long-lasting autumn showers or thaw processes in early spring. The homocline relief build up on young (Neogene) sediments that forms the Transylvanian and Moldavian Tablelands is marked mainly by shallow and medium-seated earth slides and by complex (sometimes related to spreads) deep-seated slides called in Transylvania glimee. An update of landslide articles (and available data) in Romania is made by Balteanu et.all (2010) and within Loczy et.all (2012).

Landslide hazard and risk, legislative framework
From commune (local) to county (regional) and national level, the risk-related landslide issues are taken into consideration by several authorities, each one having specific attributions. At commune level, the Local Committee for Emergency Situations (organized by each municipality) issues post-failure documentations on damages-causing landslides to the next level, which is the County Inspectorate for Emergency Situations. Their preparedness/post-failure interventions are integrated within a county plan for landslide risk reduction measurements, which is discussed inside the County Committee for Emergency Situations, an institution that includes also the heads of County Prefecture and County Council. The County Council is responsible for developing the county landslide risk map, mandatory for the County Territorial Arrangement Plan. The main national institution that integrates such studies is the General Inspectorate for Emergency Situations, which works with other ministries in developing national-scale preparedness or intervention documentations.



NUTS 5 (communes) distribution of landslide risk in Romania (LG 575/2001)

The legislative framework is based on several laws (LG 575/2001, LG 124/1995, HGR 382/2003, HGR 447/2003, GT-019-98) which are regulating the procedures meant to develop landslide risk maps and to implement them into territorial planning procedures. The suggested method is a qualitative one, based on an expert judgment of the weights of several criteria: lithology, geomorphic, structural, hydrological and climatic, hydrogeology, seismicity, silviculture, human. Within the legislative framework there are some gaps, dealing with both form and fund issues. Besides an old conceptual and methodological framework (with obvious problems in explaining and applying the differences among susceptibility, hazard and risk), the subjectivity and uncertainty of the proposed method is increased by elusive expressions like "main valleys, reaching maturity stage, with young tributaries" or "slopes with average heights and average-high steepness" which are used as ranking criteria for landslide favorability classes. In the mean time, the legislation does not make any recommendations concerning a scale-methodology dependency.
The law 575/2001 makes a hierarchy of 987 communes and towns showing differenced landslide risk levels. Besides the bizarre distribution of risk classes (Fig.2, medallion 1 and 2), which shows high values all across the Moldavian plain, overestimating the intensity of the phenomenon compared with the Subcarpathians, one may notice also, sometimes, the complete absence of landslide risk inside high risk areas. The list also contains information about potential Danube lateral erosion and sea cliff undermining (Fig.2, medallion 3) Adding to that the fact that a lot of communes in the Subcarpathians showing indeed a high risk (Catina, Chiliile, Chiojdu, Odaile: CHANGES FP7) are curiously excluded from the hierarchy, the representativity of such a map is reduced to a rather general overview, and should be compared with other existing maps (Balteanu et.all, 2010) in order to built a proper confidence map.

Nation-wide assessment of landslides: focus on Georgia

1. Collection and organisation of relevant data for the national and regional assessments in Georgia:
Elevation data - DTM (Digital Terrain Model)
Relief slope's database
Hydrological data
Engineering Geology map of Georgia
The active fault system of Georgia
Land use
Landslide database

2. Test of the methodologies for susceptibility mapping per main landslide type (slide, flow and fall) at 1:1 M scale using SMCE and logistic regression models at the Pan-European scale, and evaluation of the performance of the modelling.
3. Set up of the "Landslide Risk Assessment Model, LRAM" survey and launch of the questionnaire on the internet.
Report structure:
In the Introduction (chapter 1) the overall description of the problem and its significance is discussed.
In the second chapter the main goals, objective and sub objectives are represented
The next chapter shows the short description of the available dataset.
The methodologies and application for the territory of Georgia is shown in the chapter N4.
The full report has been given to coordinating Centre, CERG.

Work package 3 (prepared by ISPU, CERG):

Description:
Analysis of the Landslide Risk Assessment Models used for mapping in the CoE members states
Associated deliverables:
D.3.1. Workshop of 1 day in Brussels to define the scope of the survey (CERG & ISPU) - M+6
D.3.2. On-line (web-based) creation of the survey (ISPU) - M+9
D.3.3.Diffusion of the survey to identified persons - M+10

The workshop was cancelled as it finally appeared as not necessary. Unfortunately, the survey was received only in December and it was technically not possible to transform in a web-based survey in 2012.

ACTIVITIES PLANNED IN 2013 ***(split by partner)***

Working package 1 (prepared by CERG, GHHD, ECBR):
Description:
Refined Pan-European Landslide Susceptibility Map / Leader: CERG
Associated deliverables:
D.1.4 Test of the performance of the model - quality control (CERG) - M+18
D.1.5 Writing of a joint point publication (CERG) -M+24

Work package 2 (prepared by GHHD, ECBR, CERG):
Description:
National assessments of Landslide Susceptibility for three countries / Leader: GHHD
Associated deliverables:
D.2.5 Statistical model for Georgia (GHHD & CERG) - M+14
D.2.6 Statistical model for Romania (ECBR & CERG) - M+14
D.2.7 Methodology to integrate dynamic factors in the analysis (CERG & GHHD) - M+18
D.2.8 Statistical model integrating triggering factors for the three countries (CERG & GHHD) - M+24

Work package 3 (prepared by ISPU, CERG):
Description:
Analysis of the Landslide Risk Assessment Models used for mapping in the CoE members states
Associated deliverables:
D.3.4 Analysis of the questionnaire's response (ISPU) M+14
D.3.5 Synthetic report on the advantages and limitations of each LAMs per country (ISPU & CERG) - M+9
D.3.6.Publication of the results on-line at the ISPU website - M+24

Work package 4 (prepared by CERG):
Description:
Project management
Associated deliverables:
D.4.3 Mid-term project meeting with all participants in Portugal (CERG) - M+14
D.4.4. Project reporting (CERG) - M+24