A multi-scale regional landslide susceptibility assessment approach: the SUFRA_SICILIA (SUscettibilità da FRAna in Sicilia) project

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INTRODUCTION

The PAI ("Piano Assetto Idrgeologico") program has been applied to the whole Sicilian territory with the aim of producing a landslide risk map (ARTA_SICILIA, 2004). Due to time and data limitations, national governmental authorities drove the PAI to characterize hazard and risk conditions connected to the re-activation of the past landslides rather than to hazard or susceptibility modeling.

Landslide susceptibility assessment poses specific methodological issues when performed for regional mapping (Guzzetti et al., 2005). In fact, in regional application the overall predicting performance is greatly lowered by the lack or roughness of the required data: landslide inventories and thematic maps of the controlling factors. At the same time, no matter the resolution of the processed data, some basic issues of the model building procedures, such as modeling approach, mapping units, landslides classification and representation, and validation strategies (Guzzetti et al., 1999), need to be optimized for regional multi-scale assessment procedures.

To the aim of defining European commonly shared approaches for landslide susceptibility mapping, a European landslide experts group has recently proposed criteria for a multi-level method (TIER: Hervás, 2007). Three susceptibility TIER levels are proposed and reference data and model building procedures are recommended for each. The TIER approach is strictly dependent on the quality of the available landslide inventories and thematic maps, which are needed for the whole European territory.

The SUFRA (SUscettibilità da FRANA) project moves from the same methodological analysis of TIER but, in light of the availability for the Sicilian territory of highly detailed geological l.s. and landslide data, it diverges both in the worked data and in the model building methods which are exploited for the three level landslide susceptibility assessment in Sicily.

LANDSLIDES IN SICILY

Landslides in Sicily are mainly connected to its geologic setting (Fig. 1), which can be resumed as made by three main sectors: the chain sector (running along the northern side); the fore-deep sector occupying the southern inner areas southward to the Sicilian Channel; the fore-land, in the extreme south-eastern side.

Large areas, where continental or torbiditic clayey sequences outcrop on hilly denudation slopes or steep structurally controlled slopes, are affected by slides and flows; the rigid carbonate and metamorphic units which typically mark the head of the slopes, are affected by falls, topples and lateral spreads. Carbonatic rocks, outcropping in the fore-land sector, are almost exclusively affected by falls. Both the ductile clayey formations and the weathered top coverage of the metamorphic units can be interested by rapid debris avalanche/debris flows phenomena.
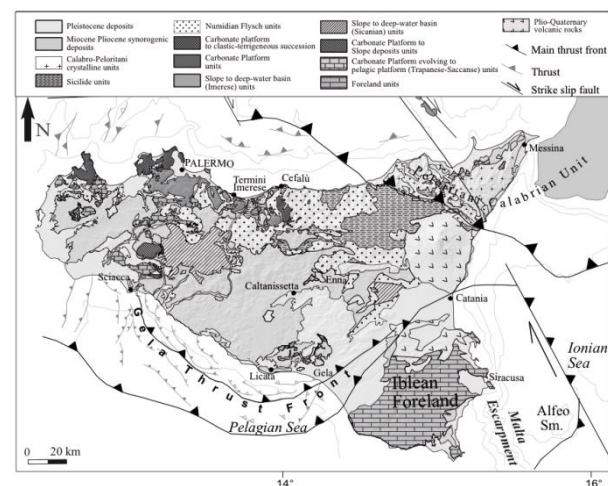

Figure 1 – A geological scheme of Sicily (Valenti et al., in print).

Rainfall, man, volcanic eruptions, and earthquakes are, in the order, the main triggering factors.

The more complete landslide archive for Sicily is the one which was prepared in the framework of

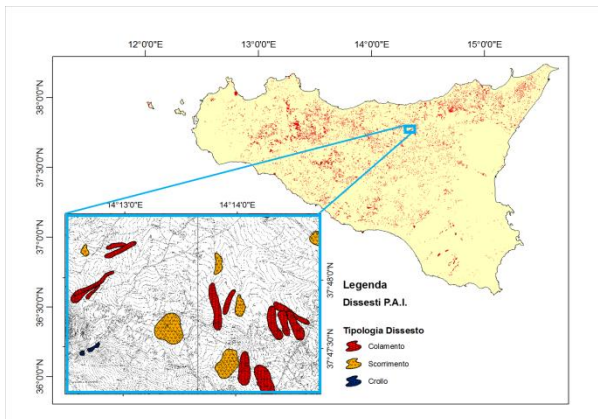the PAI program, consisting of about 30,000 events (Fig. 2).

Figure 2 – The PAI landslide inventory (ARTA_SICILIA, 2004).

THE SUFRA_SICILIA PROJECT

The SUFRA project is based on a three level susceptibility mapping. According to the availability of more detailed data, the three scale for susceptibility mapping are increased respect to the ones suggested by the TIER group to 1:100,000, 1:50,000 and 1:25,000/1:10,000.

The mapping levels exploit climatic, soil use (CORINE2009) and seismic informative layers, differentiating in the details of the core data (geology and topography), in the quality and resolution of the landslide inventory and in the modelling approach (Tab. 1).

SUFRA_100 is based on a heuristic approach which is applied by processing a geologic layer (produced by ARTA integrating pre-CARG 1:100,000 geologic maps); the DEM exploited are IGMI 250m and the mapping units are 1km side square cells. Models are validated with respect to the PAI LIPs (Landslide Identification Points) which are reclassified adopting a simplified scheme. Output cuts of SUFRA100 will be referred to administrative boundaries (provinces).

SUFRA50 is based on statistical analysis of new CARG geologic maps and 20m (ITA2000) - 2m (ATA2007) DEM. The mapping units are 500m and 50m cells, hydrographic and hydro-morphometric units. The landslide inventory is the IFFI2012_LIPs (first level) which is the result of the conversion in IFFI format of the PAI archive, which will be supported by remote landslide mapping (exploiting the ATA2007 aerial photos), according to the IFFI first level approach. Validation of the models will be performed exploiting both random spatial partition and temporal partition methods. Output cuts of SUFRA50 will be based on physiographic (basin) and administrative (municipalities) boundaries.

SUFRA10/25 is based on statistical analysis of new CARG geologic maps (remotely and field adapted) and 2m (ATA2007) DEM. The mapping units are the slope units (SLUs) which are derived by further partitioning the hydro-morphometric units so to obtain closed morphodynamic units. The landslide inventories is the IFFI2012 which is the results of a field supported (on focus) landslide remote systematic mapping, according to the IFFI full level approach.

Examples of SUFRA_100, SUFRA_50 and SUFRA_10 are presented for some representative key sector of Sicily. First results attest for the feasibility and goodness of the proposed protocol.

The SUFRA program aims at enabling the regional governmental administration to cope with landslide prevision, which is the required operational concept in land management and planning. PAI has been a great advance with respect to the "pre-SARNO" conditions, but it is very exposed to fail: it is a blind approach for new activations; it is critically dependent on the quality of the landslide inventories; it cannot project the susceptibility outside the landslide areas.

MAP	SUFRA100	SUFRA50	SUFRA25/10
SCALE	1:100,000	1:50,000	1:25,000 / 1:10,000
METHODOLOGY	HEURISTIC	STOCHASTIC	STOCHASTIC/DETERMINISTIC
MAPPING UNIT	1 km CELLS	500/50 m CELLS - HYDROGRAPHIC UNITS	HYDROMORPHOMETRIC UNITS / SLUs
LANDSLIDE INVENTORY	PAI semplified	IFFI2012 remotely checked	IFFI2012 field checked
GEOLOGY	PRE-CARG MOSAIC	CARG	CARG
DEM	IGMI 250m/NASA SRTM 90m	ITA2000 20m - ATA2007 2m	ITA2000 20m - ATA2007 2m
CLIMATE	MARS/ARTA	ARTA	ARTA
LAND USE	CORINE	CORINE remotely checked	CORINE remotely checked
SEISMICITY	ESPON's GSHP project	INGV	INGV
VALIDATION	GOODNESS OF FIT	RANDOM SPATIAL PARTITION	RANDOM SPATIAL PARTITION/TIME PARTITION

Table 1 – Scheme of the SUFRA aproach.

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