Research article

# LAND-deFeND — An innovative database structure for landslides and floods and their consequences

Elisabetta Napolitano, Ivan Marchesini[*], Paola Salvati, Marco Donnini, Cinzia Bianchi, Fausto Guzzetti

*CNR IRPI, Via Madonna Alta 126, I-06128, Perugia, Italy*

ABSTRACT

Information on historical landslides and floods — collectively called "geo-hydrological hazards — is key to understand the complex dynamics of the events, to estimate the temporal and spatial frequency of damaging events, and to quantify their impact. A number of databases on geo-hydrological hazards and their consequences have been developed worldwide at different geographical and temporal scales. Of the few available database structures that can handle information on both landslides and floods some are outdated and others were not designed to store, organize, and manage information on single phenomena or on the type and monetary value of the damages and the remediation actions. Here, we present the LANDslides and Floods National Database (LAND-deFeND), a new database structure able to store, organize, and manage in a single digital structure spatial information collected from various sources with different accuracy. In designing LAND-deFeND, we defined four groups of entities, namely: nature-related, human-related, geospatial-related, and information-source-related entities that collectively can describe fully the geo-hydrological hazards and their consequences. In LAND-deFeND, the main entities are the nature-related entities, encompassing: (i) the "phenomenon", a single landslide or local inundation, (ii) the "event", which represent the ensemble of the inundations and/or landslides occurred in a conventional geographical area in a limited period, and (iii) the "trigger", which is the meteo-climatic or seismic cause (trigger) of the geo-hydrological hazards. LAND-deFeND maintains the relations between the nature-related entities and the human-related entities even where the information is missing partially. The physical model of the LAND-deFeND contains 32 tables, including nine input tables, 21 dictionary tables, and two association tables, and ten views, including specific views that make the database structure compliant with the EC INSPIRE and the Floods Directives. The LAND-deFeND database structure is open, and freely available from http://geomorphology.irpi.cnr.it/tools.

## 1. Introduction

Information on historical landslides and floods — hereafter collectively referred to as "geo-hydrological hazards" — is important to understand the complexities and dynamics of past events, and proves useful to construct and validate landslide and flood prediction models and to design appropriate mitigation measures. Databases and digital catalogues on geo-hydrological hazards store, organize, and manage information on the physical characteristics, the geographical location, and the temporal occurrence of past landslide and flood events (Hervás, 2013). A number of databases

and digital catalogues with information on natural hazards — including geo-hydrological hazards — were compiled and used for research, insurance and economic purposes (e.g., Guzzetti and Tonelli, 2004; Munich Re, 2011; Menoni et al., 2016; Swiss Re, 2017). Modern databases on natural hazards and their consequences exploit geographical information system (GIS) technology to locate geographically the historical events, and to store geographic information on the events. The information stored in the databases is then made available through dedicated Web-GIS, or using Web Services and Spatial Data Infrastructures (SDI).

Only a few databases exist at the global scale (Table 1), including the U.S. Geological Survey Advanced National Seismic System (ANSS) Composite Catalog of earthquakes (https://earthquake.usgs.gov/data/comcat/), the Global Active Archive of Large Flood Events, compiled by the Dartmouth Flood Observatory of the University of

**Table 1**

Catalogues available at different scales and for different natural hazards. CF, capable faults. EQ, earthquakes. FL, floods. LS, landslides. MS, mass disasters. NC, natural catastrophes. NH, natural hazards. References: [1] Munich Re, 2011; [2] Swiss Re, 2017; [3] Boschi et al., 1997; [4] Guidoboni et al., 2007; [5] Locati et al., 2014; [6] Llasat et al., 2013; [7] Michetti et al., 2000; [8] Basili et al., 2008; [9] Rovida et al., 2016; [10] Martino et al., 2014; [11] APAT & Trigila, 2007; [12] Guzzetti et al., 1994; [13] Guzzetti and Tonelli, 2004; [14] Petrucci and Versace, 2004.

| | Hazard | Name | Coverage | Institution | Web page | Ref | ID |
|---|---|---|---|---|---|---|---|
| Global | EQ | COMprehensive earthquake CATalog [ComCat] | since 1898 | USGS - ANSS | earthquake.usgs.gov/data/comcat/ | – | 1 |
| | FL | Global active archive of large flood events | since 1985 | University of Colorado - DFO | floodobservatory.colorado.edu/Archives/index.html | – | 2 |
| | MS | Emergency events Database [EM-Dat] | since 1900 | CRED | www.emdat.be/ | – | 3 |
| | NC | NatCat SERVICE | since 1980 | Munich Re | natcatservice.munichre.com/ | [1] | 4 |
| | NC | Sigma data | since 1970 | Swiss Re | www.sigma-explorer.com/ | [2] | 5 |
| Europe | EQ | Catalogue of strong earthquakes in Italy and Mediterranean area [CFTI4Med] | 461 BC-1997 760 BC-1500 | INGV & SGA | storing.ingv.it/cfti4med/ | [3, 4] | 6 |
| | EQ | European Archive of Historical EArthquake Data [AHEAD] | 1000−1899 | INGV & AHEAD partners | www.emidius.eu/AHEAD/main/ | [5] | 7 |
| | FO | FLOODHYMEX | 1981−2010 | HyMeX | mistrals.sedoo.fr/HyMeX/ | [6] | 8 |
| Italy | CF | ITalyHAzard from CApable faults [ITHACA] | – | ISPRA | sgi.isprambiente.it/GMV2/index.html | [7] | 9 |
| | EQ | Database of Individual Seismogenic Sources [DISS] | – | INGV | diss.rm.ingv.it/diss/index.php/54-database-access | [8] | 10 |
| | EQ | Parametric catalogue of Italian earthquakes [CPTI15] | 1000−2015 | INGV | emidius.mi.ingv.it/CPTI15-DBMI15/index_en.htm | [9] | 11 |
| | EQ | Italian catalogue of earthquake-induced ground failures [CEDIT] | 1000−2016 | Università La Sapienza, CERI | www.ceri.uniroma1.it/index_cedit.html | [10] | 12 |
| | LS | Inventario dei Fenomeni Franosi in Italia [IFFI] | 1918−2014 | ISPRA | www.progettoiffi.isprambiente.it/cartanetiffi/cartografia.asp | [11] | 13 |
| | LS-FL | Aree Vulnerate Italiane [AVI] | 1918−2001 | CNR GNDCI | sici.irpi.cnr.it/avi.htm | [12] | 14 |
| | LS-FL | Sistema Informativo sulle Catastrofi Idrogeologiche [SICI] | 18th-20thC. | CNR GNDCI | sici.irpi.cnr.it/ | [13] | 15 |
| Region in Italy | LS-FL | Catasto dissesti Regionale | 20th-21st C. | Regione Valle d'Aosta | http://catastodissesti.partout.it/# | – | 16 |
| | LS-FL | Aree storicamente inondate e fenomeni di dissesto idrogeologico [ASICal] | 119−2004 | Università della Calabria, Camilab | www.camilab.unical.it/web/camilab/prodotti-products | [14] | 17 |
| | LS-FL | Geologia e dissesto | 1918−2005 | ARPA Piemonte | www.arpa.piemonte.gov.it/approfondimenti/temi-ambientali/geologia-e-dissesto | – | 18 |
| | LS | Cartografia del dissesto della Regione Emilia-Romagna | Middle age - 2013 | Regione Emilia-Romagna | applicazioni.regione.emilia-romagna.it/cartografia_sgss/user/viewer.jsp?service=dissesto | – | 19 |
| | NH | Archivio storico online degli eventi calamitosi della Provincia Autonoma di Trento [ARCA] | 339−2005 | Provincia Autonoma di Trento | www.protezionecivile.tn.it/territorio/Banchedati/ | – | 20 |