



CAPRA

CENTRAL AMERICA PROBABILISTIC RISK ASSESSMENT
EVALUACIÓN PROBABILISTA DE RIESGOS EN CENTRO AMÉRICA

BELIZE

TASK I
HAZARD IDENTIFICATION, HISTORICAL REVIEW
AND PROBABILISTIC ANALYSIS

TECHNICAL REPORT TASK 1.1 A
REVIEW: HISTORICAL EVENTS





Evaluación de Riesgos Naturales
- América Latina -
Consultores en Riesgos y Desastres

Consortium formed by:

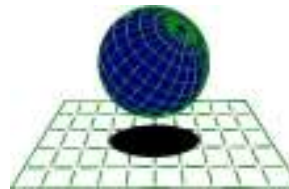
Colombia

Carrera 19A # 84-14 Of 504
Edificio Torrenova
Tel. 57-1-691-6113
Fax 57-1-691-6102
Bogotá, D.C.



España

Centro Internacional de Métodos Numéricos
en Ingeniería - CIMNE
Campus Nord UPC
Tel. 34-93-401-64-96
Fax 34-93-401-10-48
Barcelona



C I M N E

México

Vito Alessio Robles No. 179
Col. Hacienda de Guadalupe Chimalistac
C.P.01050 Delegación Álvaro Obregón
Tel. 55-5-616-8161
Fax 55-5-616-8162
México, D.F.



ERN Ingenieros Consultores, S. C.

ERN Evaluación de Riesgos Naturales - América Latina
www.ern-la.com

Direction and Coordination of Technical Working Groups – Consortium ERN America Latina

Omar Darío Cardona A.
Project General Direction

Luis Eduardo Yamín L.
Technical Direction ERN (COL)

Gabriel Andrés Bernal G.
General Coordination ERN (COL)

Mario Gustavo Ordaz S.
Technical Direction ERN (MEX)

Eduardo Reinoso A.
General Coordination ERN (MEX)

Alex Horia Barbat B.
Technical Direction CIMNE (ESP)

Martha Liliana Carreño T.
General Coordination I CIMNE (ESP)

Specialists and Advisors – Working Groups

Julián Tristancho
Specialist ERN (COL)

Miguel Genaro Mora C.
Specialist ERN (COL)

César Augusto Velásquez V.
Specialist ERN (COL)

Karina Santamaría D.
Specialist ERN (COL)

Mauricio Cardona O.
Specialist ERN (COL)

Sergio Enrique Forero A.
Specialist ERN (COL)

Mario Andrés Salgado G.
Technical Assistant ERN (COL)

Juan Pablo Forero A.
Technical Assistant ERN (COL)

Andrés Mauricio Torres C.
Technical Assistant ERN (COL)

Diana Marcela González C.
Technical Assistant ERN (COL)

Carlos Eduardo Avelar F.
Specialist ERN (MEX)

Benjamín Huerta G.
Specialist ERN (MEX)

Mauro Pompeyo Niño L.
Specialist ERN (MEX)

Isaías Martínez A.
Technical Assistant ERN (MEX)

Edgar Osuna H.
Technical Assistant ERN (MEX)

José Juan Hernández G.
Technical Assistant ERN (MEX)

Marco Torres
Associated Advisor (MEX)

Johner Venicio Correa C.
Technical Assistant ERN (COL)

Juan Miguel Galindo P.
Technical Assistant ERN (COL)

Yinsury Sodel Peña V.
Technical Assistant ERN (COL)

Mabel Cristina Marulanda F.
Specialist CIMNE (SPN)

Jairo Andrés Valcárcel T.
Specialist CIMNE (SPN)

Juan Pablo Londoño L.
Specialist CIMNE (SPN)

René Salgueiro
Specialist CIMNE (SPN)

Nieves Lantada
Specialist CIMNE (SPN)

Álvaro Martín Moreno R.
Associated Advisor (COL)

Mario Díaz-Granados O.
Associated Advisor (COL)

Liliana Narvaez M.
Associated Advisor (COL)

Juan Camilo Olaya
Technical Assistant ERN (COL)

Steven White
Technical Assistant ERN (COL)

Local Advisors

SNET Francisco Ernesto Durán
& **Giovanni Molina** El Salvador

Osmar E. Velasco
Guatemala

Oscar Elvir Honduras
Romaldo Isaac Lewis Belize

Interamerican Development Bank

Flavio Bazán
Sectorial Specialist

Tsuneki Hori
Internal Consultant

Cassandra T. Rogers
Sectorial Specialist

Oscar Anil Ishizawa
Internal Consultant

Sergio Lacambra
Sectorial Specialist

World Bank

Francis Ghesquiere
Coordinador Regional

Edward C. Anderson
Specialist

Joaquín Toro
Specialist

Stuart Gill
Specialist

Fernando Ramírez C.
Specialist

Contents

1	General.....	1-1
1.1	Structure of the entities database	1-2
1.2	Structure of the Related Information database.....	1-3
2	Entities, centres and institute of interest.....	2-1
2.1	World entities.....	2-1
2.2	Belice entities	2-7
3	Projects, studies, research e initiatives	3-1
4	Computer systems of interest.....	4-1
4.1	Earthquake.....	4-1
4.2	Tsunami.....	4-2
4.3	Hurricane.....	4-2
4.4	Flood	4-4
4.5	Landslide.....	4-6
4.6	Multihazard evaluation systems.....	4-7
4.7	Risk	4-7
5	Specific documents.....	5-9
6	General catalogue of information required.....	6-1

Table index

TABLE 1-1 FIELDS OF THE ENTITIES DATABASE	1-2
TABLE 1-2 FIELDS OF THE ENTITIES DATABASE	1-2
TABLE 1-3 FIELDS FOR THE RELATED INFORMATION DATABASE.....	1-3
TABLE 1-4 LIST OF POSSIBLE OPTIONS IN THE FIELD "SUBJECT" IN THE RELATED INFORMATION DATABASE....	1-4
TABLE 1-5 LIST OF POSSIBLE OPTIONS FOR THE FIELD "INFORMATION QUALITY" IN THE RELATED INFORMATION DATABASE	1-4
TABLE 5-1 DOCUMENTS CLASSIFIED BY SUBJECT	5-9
TABLE 6-1 FIELDS FOR THE INFORMATION REQUIRED DATABASE.....	6-1
TABLE 6-2 LIST OF POSSIBLE OPTIONS FOR THE FIELD "SUBJECT" IN THE INFORMATION REQUIRED DATABASE	6-2
TABLE 6-3 LIST OF POSSIBLE OPTIONS FOR THE FIELD "TYPE" IN THE INFORMATION REQUIRED DATABASE .	6-2

1 General

This report summarises available sources of information in Central America, to develop the variations of hazard, exposure, vulnerability and risk in the context of the CAPRA project.

The organisation of information consists of two main databases:

- Entities, centres and institutes
- Related information

The entities centres and institutions of interest database refers to entities, said research centres and institutes, not necessarily located in Central America, which in one way or another can provide information for the project. In particular, it is of interest to know of the projects which those entities are pursuing in Central America

Further, the related information database includes data of the following types:

1. *Projects, studies, research and initiatives*: this principally refers to products which have been developed or are related to several applications in Central America, and have generated or may generate relevant information in the medium term.
2. *Computer systems of interest*: this refers to systems developed by government or private entities, related to the topic. They need not have been designed for application in Central America
3. *Specific publications or documents*: this includes any type of document, publication, archive, database, and in general any component of information which may be of interest to the project. It includes special publications such as maps, catalogues, atlases, etc. Reference is also made to articles in local or international journals, and books or parts of books which may be of interest.

In the sections below we present the structure of each of the databases formed, and the list of information available. The Reports provide the databases for direct consultation. For the purposes of distribution, ease of use and possibility of updates, these databases are delivered in Excel format.

1.1 Structure of the entities database

The following is the description of the fields included in the Entities database (Table 1-1). The complete database appears in the Annex ERN-CAPRA-T1.1A-1.

*Table 1-1
Fields of the Entities database*

Field	Data type	Description
N°	Integer	ID
Country	Text	Country name
Entity	Text	Entity name
Description	Text	Entity description and kind of work done
Associated entities	Text	Associated entities name
Home	Text	Main web site
Important links description	Text	Important links description
Important links URL	Text	Important links URL
Contact	Text	Contact information

In turn, the field "Contact" contains information given in Table 1-2, for certain entities.

*Table 1-2
Fields of the Entities database*

Field	Data type	Description
Contact	Text	Contact name
Phone	Text	Phone number (with country and are acode)
Fax	Text	Fax number
Zip code	Text	Zip code
Email	Text	Contact e-mail
Address	Text	Contact address
Division	Text	Entity division

1.2 Structure of the Related Information database

We now describe the fields included in the Related Information database (Table 1-3), which as explained, can be classified into systems, projects, computer systems and publications or documents. Annex ERN-CAPRA-T1.1A-2 includes the related database.

*Table 1-3
Fields for the Related Information database*

Field	Data type	Description
N°	Integer	ID
Country	Text	Country name
Region/Zone	Text	Zone or región covered by data file
Theme	Text	File classification theme
File type	Text	File type (document, map, database, etc.)
Name/Project	Text	File name or title
Description	Text	Contents summary
Extension	Text	File extension
Entity/Owner	Text	File owner
Date	Text	File creation date
Quality	Text	File quality assessment, referred to CAPRA needs
Access restriction	Text	Access restriction
Use restriction	Text	Use restriction
Path	Text	File path on local machine
Web link	Text	File associated web link
Contact	Text	Contact information
Reference	Text	Bibliographic reference
Comments	Text	General comments

The list of possible options in which each file is classified is presented in Table 1-4. Table 1-5 then presents a list of possible options to evaluate the quality of each file in the database.

Table 1-4
List of possible options in the field "Subject" in the Related Information database

N°	Information category
1	General country information
2	Main cities information
3	Special zones information
4	Earthquake
5	Hurricane
6	Hydrometeorological
7	Flooding
8	Landslide
9	Volcano
10	National infrastructure
11	Cities infrastructure
12	Spetial zones infrastructure
13	Multi-hazard
14	Tsunami
15	Risk
16	Rainfall
17	Risk management plans and policies
18	Risk, hazard and vulnerability
19	Software
20	Other

Table 1-5
List of possible options for the field "Information Quality" in the Related Information database

N°	Information quality
1	High
2	Medium
3	Low

2 Entities, centres and institute of interest

The information related to Entities is summarised below. This information also appears in the Annex ERN-CAPRA-T1.1A-1. The presentation is subdivided into the world entities, and entities in Belize.

2.1 World entities

- The World Bank

Available at: <http://www.worldbank.org>

Description: a vital source for financial and technical assistance for developing countries around the world. Among its main research, there are world development indicators, prospects for the economy and development report. The World Bank engages in a number of projects, and provides a wide variety of services for analysis and consultancy to assist countries and the international community to respond to the needs in development matters.

It contains more than 27,000 free downloadable documents, including documents for operations (projects, consultancy work, analysis and evaluations), formal and informal research, and most of the Bank's publications.

- United States Geological Survey – USGS

Available at: <http://www.usgs.gov>

Description: USGS helps the United States to provide reliable scientific information to minimise the loss of life and property due to natural disaster. It manages resources and improves and protects the quality of life. Among its most important links there is that for threats for "Hazards", in which there is information on projects, studies and research on natural hazards to the United States. The Earthquake Centre, which contains a number of publications, analyses and statistics on earthquakes; there is a software link related to earthquakes, in which some of the most important programmes can be downloaded, to apply to seismic analysis and links to the study of volcanoes, in which publications, reports and maps may be downloaded

- Centro De Coordinación Para La Prevención De Desastres Naturales En América Central – CEPREDENAC

Available at: <http://www.cepredenac.org>

Description: Responsible for helping to reduce vulnerability and impact of disasters, as an integral part of the process of transformation and sustainable development in the region, in the context of the in Central American Integration System (SICA), through the promotion, support and development of policies and measure measures for prevention, mitigation, preparation and disaster management.

The most important downloadable documents include manuals and studies on disaster prevention.

- **National Oceanic And Atmospheric Administration – NOAA**

Available at: <http://www.noaa.gov>

Description: The National Oceanic and Atmospheric Administration (NOAA) is a scientific agency of the US Department of Commerce, and it focuses on conditions of the oceans and atmosphere. It advises on meteorology, makes maps of the oceans and skies, has a guide on the use and protection of ocean and coastal resources, and leads studies to improve the understanding of management of the environment.

Some of the entities affiliated to NOAA are:

- ✓ Atlantic Oceanographic And Meteorological Laboratory -AOML
Available at: <http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html>
Description: Links for hurricanes and databases.
- ✓ Pacific Marine Environmental Laboratory – PMEL
Available at: NOAA <http://www.pmel.noaa.gov/>
Description: Oceanic Observatory.
- ✓ National Hurricane Center NHC
Available at: <http://www.nhc.noaa.gov/>
Description: Real-time data on hurricanes.
- ✓ HURDAT
Available at: <http://www.aoml.noaa.gov/hrd/hurdat/>
Description: database for hurricanes in the Pacific and Atlantic. Trajectories and historical details.

- **Columbia University**

Available at: <http://www.columbia.edu/>

Description: The Columbia University page contains several items of research and publications associated with a range of projects and research groups.

Centres affiliated to this entity:

- ✓ Center for Hazards and Risk Research – CHRR
Available at: <http://www.ldeo.columbia.edu/chrr/research/hotspots/>
Description: Information on the World Bank study “Natural Disaster Hotspots”
- ✓ Center for International Earth Science Information Network CIESIN
Available at: <http://www.ciesin.org/>
Description: This is a centre within the Earth Institute of the University of Columbia; it specialises in online data, information management, spatial integration of data and training, and interdisciplinary research related to human rear interaction in the environment. It contains the text of more than 140 environmental treaties, numbers of inhabitants, access to Geographical Information Systems, interactive consultation

with the World Bank databank which contains 125 social economic variables for more than 170 economies for 1965-1993, and interactive consultation the World Resources Institute (WRI).

- ✓ International Research Institute for Climate And Society IRI
Available at: <http://portal.iri.columbia.edu>
Description: The International Institute for Applied Systems Analysis is a private research organisation which conducts interdisciplinary scientific studies on the environment, the economy, and technological and social matters in the context of the human dimension in global change.
- ✓ Lamont Doherty earth observatory LDEO
Available at: <http://www.ldeo.columbia.edu>
Description: Reserarch in Herat sciences, geology, geophysics, tectonics, seismology
- ✓ National Center for Disaster Preparedness NCDP
Available at: <http://www.ncdp.mailman.columbia.edu/>
Description: Research centre for study and analysis of US capacity to prepare for and respond to a disaster.
- ✓ Earth Institute
Available at: <http://www.earthinstitute.columbia.edu>
Descripción: Centro de investigación en ciencias de la tierra. Se pueden descargar publicaciones.
- ✓ Socioeconomic data and Application Center SEDAC
Available at: <http://sedac.ciesin.columbia.edu/>
Description: Socioeconomic information associated with CIESIN research.
- ✓ Center for Research on Environmental Decision CRED - Columbia University
Available at: <http://www.cred.columbia.edu>
Description: Information on climate and weather.

- **International Institute For Applied Systems Analysis – IIASA**

Available at: <http://www.iiasa.ac.at/>

Description: International Institute for Applied System Analysis is a private research entity which conducts inter-disciplinary scientific studies on the environment, the economy and technological s and solcial matters in the context of the human dimension and global change.

- ✓ Risk And Vulnerability RAV
Available at: <http://www.iiasa.ac.at/Research/RAV/>
Description: Information on vulnerability and risk; informatioin on Hotspots.

- **Economic Commission for Latin American and the Caribbean - ECLAC**
Available at: <http://www.eclac.org/>
Description: ECLAC is one of the five regional commissions of the United Nations. It was founded to contribute to economic development in Latin America, and to coordinate actions designed to promote and strengthen economic relations between countries and with other nations in the world. Later, its work was widened to the Caribbean, and it was and the objective of promoting social development was incorporated.
- **World Meteorological Organization – WMO**
Available at: http://www.wmo.ch/pages/index_en.html
Description: World weather research programme. Information on hurricanes and cyclones
- **Bureau of Meteorology – BOM**
Available at: <http://www.bom.gov.au/>
Description: Meteorological, climatic and hydrological data in real time, for Australia. Publications and research. Numerical predictions.
- **United Nations Organisation for Education, Science and Culture – UNESCO**
Available at: www.unesco.org
Description: UNESCO promotes international, cooperation in education, cup science, culture and Communications among its 193 member states and six associate members. The documents, statistics and regulatory instruments of member countries can be downloaded from the webpage, including those for Latin America and the Caribbean
- **World Weather Information Service**
Available at: www.worldweather.org
Description: A real-time meteorological information service for the world. Information for major cities is available for Costa Rica and Nicaragua.
- **International Tsunami Information Center – ITIC**
Available at: <http://ioc3.unesco.org/itic/>
Description: Availability of tsunami catalogues.
- **U.S. Environmental Protection Agency – EPA**
Available at: http://www.epa.gov/athens/wqatsc/html/watershed_models.html
Description: Availability of several models of water flows in rivers and river basins.
- **Federal Emergency Management Agency – FEMA**
Available at: <http://www.fema.gov/>
Description: Information and publications mainly on floods, storms and fires
- **Spa Risk LLC**
Available at: <http://scauthorporter.com/index.htm>

Description: Risk of natural catastrophe and disasters caused by man. Publications on risk can be downloaded.

- **Southern California Earthquake Center – SCEC**

Available at: <http://www.scec.org>

Description: Publications research and catalogues on earthquakes. Information of the OPENSHA.

- **Estrategia Internacional Para La Reducción De Desastres De Las Naciones Unidas EIRD/ONU**

Available at: <http://www.eird.org/esp/cdcapra/DocsIndex.htm>

Description: Documents and information on the CAPRA workshop/meeting Managua, February 12-13, 2007

- **National Institute of Building Science – NIBS**

Available at: <http://www.nibs.org/>

Description: knowledge and advisory services on the development and regulation of science and technology in construction. Information on HAZUS (multihazard loss estimation methodology)

- **Applied Technology Council – ATC**

Available at: <http://www.atcouncil.org/>

Description: ATC's mission is to develop and promote the study of the art and presentation of use of resources and applications of engineering to help contribute to the mitigation of the effects of natural disasters and other hazards in the context of construction

- **National Aeronautics and Space Administration – NASA**

Available at: <http://www.nasa.gov/>

Description: This entity has a database on hazards and matters related to Earth sciences. In general terms, is responsible for the activities retreat to space exploration, scientific discoveries and aeronautical research.

- **Earthquake Engineering Research Institute – EERI**

Available at: <http://www.eeri.org/>

Description: Reduction of seismic risk

- **Norwegian Seismic Array – NORSAR**

Available at: <http://www.norsar.no>

Description: Bulletins and publications on seismic hazards and risks. Databases, seismic catalogues.

- **International Center of Geohazards – ICG**

Available at: <http://www.geohazards.no>

Description: ICG conducts research regarding the evaluation, prevention and mitigation

of natural hazards, including risks of landslides and rockfalls, due to rain, flood, earthquake and human intervention

- **Emergency Events Database EM-DAT**

Available at: <http://www.emdat.be/>

Description: A database for natural disasters on a world scale

- **Estrategia Internacional Para La Reducción De Desastres - EIRD**

Available at: <http://www.eird.org/index-esp.html>

Description: Recognizing that natural hazards may affect anyone, UNISRD sets up alliances and applies a global approach to reduce disasters. World Campaign in 2008-2009 for disaster reduction

- **Provention Consortium**

Available at: <http://www.proventionconsortium.org/>

Description: Analysis of risk

- **Munich Re**

Available at: <http://www.munichre.com>

Description: Risk studies worldwide.

- **Swiss Re**

Available at: <http://www.swissre.com>

Description: Risk studies worldwide.

- **The Smithsonian National Museum of Natural History**

Available at: <http://www.volcano.si.edu/>

Description: Information on volcanoes worldwide. Database and historical records.

- **Organization of American States - OAS – Office for Sustainable Development and Environment – OEA**

Available at: <http://www.oas.org>

Description: Publications on management and natural hazards associated with sustainable development

- **Centro Regional De Información Sobre Desastres Para América Latina y Caribe – CRID**

Available at: <http://www.crid.or.cr>

Description: Compilation and dissemination of available information on disasters in Latin America and the Caribbean

- **International Association of Volcanology And Chemistry of The Earth's Interior – IAVCEI**

Available at: <http://www.iaovcei.org/>

Description: International Association of Volcanology. Volcanology bulletins and

publications.

- **The Collapse Caldera Database – CCDB**

Available at: <http://www.gob-csic.es/CCDB/CCDBframe.htm>

Description: A GIS application for volcanoes. Statistics, catalogues, database

- **Comisión Centro Americana De Ambiente y Desarrollo – CCAD**

Available at: <http://www.ccad.ws/documentos/mapas.html>

Description: Maps, downloading of shapes for Central America (topography, infrastructure, meteorology, hydrology, reserved zones).

- **Center For Research On Epidemiology Of Disasters – CRED – Université Catholique De Louvain**

Available at: <http://www.cred.be/>

Description: Information for the mitigation of disasters, focused on public health, epidemiology and structural, social and economic actors

2.2 Belize entities

The Table related to information of the Belize Entities may be seen in Annex ERN-CAPRA-T1.1A-1

3 Projects, studies, research e initiatives

The following are the titles of the principal studies included in the related information database. The full database is presented in Annex ERN-CAPRA-T1.1A-2.

- **Global Seismic Hazard Assessment Project – GSHAP**

Available at: <http://www.seismo.ethz.ch/GSHAP/>

Description: Downloadable global data related to seismic hazard maps and reports

- **World Housing Encyclopedia**

Available at: <http://www.world-housing.net/>

Description: An encyclopaedia for housing construction in active seismic areas

- **RESIS II**

Description: Project for the evaluation of seismic hazard in Central America, Guatemala, Enrique Molina; El Salvador, Griselda Marroquin; Honduras, José Jorge Escobar; Nicaragua, Emilio Talavera; Costa Rica, Wilfredo Rojas and Alvaro Climent, Panamá: Eduardo Camacho-Astigarrabia, Spain: Belén Benito, Norway: Conrad Lindholmp

- **The Smithsonian's Global Volcanism Program**

Available at: <http://www.volcano.si.edu/>

Description: A project of the Smithsonian National Museum of Natural History. Worldwide information of volcanoes. Basic databases and historical records

- **Atlas de Centroamérica**

Available at: <http://atlas.snet.gob.sv/atlas/>

Description: Information on natural disasters. The Central America atlas for natural hazards is principally designed to share information, experiences, results, etc with local actors and analysts in the management and prevention of the risks of disasters

- **Nathan**

Available at: <http://mrnathan.munichre.com/>

Description: A project of Munich Re, which is formed by a network for appraising natural hazards. It is focused on the natural hazard maps

- **SERVIR**

Available at: <http://www.servir.net/>

Description: SERVIR is a regional system for visualisation and monitoring for Mesoamerica, formed by satellites and other geospatial data for use by scientists, and decision-taking by administrators, researchers, students and the public in general. It covers the nine areas of social benefit, following the global observation systems (GEOSS): disasters, ecosystems, biodiversity, time, weather, water, health, agriculture and energy.

- **Caribbean Catastrophe Risk Insurance Facility - CCRIF**

Available at: <http://www.ccrif.org/index.php?main=1>

Description: CCRIF offers parametric insurance for damage caused by natural events. It is designed to limit the financial impact of hurricanes and earthquakes for governments in the Caribbean, providing rapid liquidity for the short term.

- **Central American Network for Disasters and Health Information – CANDHI**

Available at: <http://www.candhi.org>

Description: The CANDHI network is an initiative of the Central America region, and is an attempt to reduce the occurrence or impact of disasters. It contains bibliographical data on publications related to disaster management, software tools for information centres to facilitate the digitalisation and exchange of documents with complete texts in the area of disasters, and a contact network operating locally and internationally in disaster management.

- **Global Risk Identification Program - GRIP**

Available at: <http://www.gri-p.net/index.php>

Description: Risk research. Access to information requires a password.

- **United Nations Development Programme – UNDP**

Available at: <http://www.undp.org/> <http://www.pnud.org.ni>

Description: UNDP's main contribution is the development of capacity-the "how" of development. In the context of national appropriation, UNDP effort supports countries' in which programmes are being implemented to develop national and local capacity to achieve human development. Documents, indicators and statistics on development may be downloaded for UN Member Countries.

- **Global Change Master Directory - GCMD**

Available at: <http://gcmd.nasa.gov/>

Description: NASA directory. Contains a database on hazards, and aspects of earth sciences

- **Red de Información Humanitaria para América Latina y el Caribe - REHUM**

Available at: <http://redhum.org/>

Description: REHUM is a network based on the creation of bridges between principal humanitarian actors or organisations which produce relevant information for humanitarian agents, as well as those who play a role in the preparation for and response to emergencies occurring in Latin America and the Caribbean, and facilitating public access.

4 Computer systems of interest

The following computer systems of interest to the project are included, as a function of the type of hazard. For information on the software, see Annex ERN-CAPRA-T1.1A-2.

4.1 Earthquake

- **CRISIS2007**

A system for the integration of seismic hazard in a given zone. Allows definition of sources, seismicity, attenuation, and analysis and sites for analysis.

- **EZ-FRISK**

<http://www.ez-frisk.com/index.html>

Software to calculate seismic hazard, local response, manipulation of seismic signals, the obtaining of signals consistent with a defined response spectra. There are pre-determined files of seismic sources, seismicity and attenuation

- **Open Seismic Hazard Analysis – OpenSHA**

<http://www.opensha.org/>

Analysis of seismic hazard in Open Source Code.

- **Open System for Earthquake Engineering Simulation– OpenSEES.**

<http://opensees.berkeley.edu/index.php>

Non-linear analyses of structures and soils under seismic action, in Open Source Code.

- **SEISMOCARE**

A GIS system to calculate seismic hazard due to scenarios on the scale of cities or populated areas. Allows risk estimates to be calculated, with facilities in the definition of infrastructure exposed.

- **Prompt Assessment of Global Earthquake for Response PAGER**

<http://earthquake.usgs.gov/eqcenter/pager/>

The PAGER system provides estimates of which populations may be affected by the occurrence of a given earthquake, the location of those places, and the number of inhabitants in each. The program uses a central location data and earthquake magnitudes from USGS, population data from the LANDSCAN, and it makes an approach to local effects based on the topographical slope. The program calculates modified Mercalli intensities, and generates a Shake Map for the zone of greatest influence of the event.

4.2 Tsunami

- GEOWAVE

Tsunami modelling. The program can simulate a number of sources of tsunamis, with various mechanisms of generation, occurring at different times.

- DART (Deep-ocean Assessment and Reporting of Tsunamis)

<http://nctr.pmel.noaa.gov/Dart/>

A system designed to detect a tsunami in real-time with the BPR tool, which records the signal in the sea. BPR measures pressure fluctuations indirectly, by evaluating vibration variations which these fluctuations cause.

- TELEMAC 2D

<http://www.telemacsystem.com/gb/info/comm/telemac2d/telemac2d.html>

The program is used as to simulate free flow surfaces in two connections of horizontal space. At each point of the grid, the program calculates the depth of the water and the two components of velocity. It is used to model scenarios for tsunamis, arising from submarine mass faults, amongst other applications

- TREMORS (Tsunami Risk Evaluation Through Seismic Moment of a Real time System)

The system is based on a seismic station compatible with an IBM computer and specific software. The system detects the earthquake, locates it, calculates seismic momentum, and gives the related alert. These alerts are based on estimates of seismic momentum and all processes are conducted automatically.

4.3 Hurricane

- ADCIRC

<http://adcirc.org/>

A hydrodynamic model of the finite elements for coasts, rivers and floods. This is a programme to solve time-dependent equations, free circulation over certain surfaces and volumes of transport in 2D and 3Ds. Typical applications include (1) modelling of tides and wind direction (2) analysis of hurricanes and floods, (3) degradation and studies of deposited materials, (4) transport, (5) operations close to coasts.

- CANDIE

<http://www.phys.ocean.dal.ca/programs/CANDIE>

A 3-dimensional model for ocean movement. It has been applied to a range of problems in modelling, most recently in the western region of the Caribbean, by Shen Tang (2003, 2004) and in the Lunenburg Bay of Nova Scotia, by Sheng Wang (2004).

- Delft3D

http://delftsoftware.wldelft.nl/index.php?option=com_content&task=view&id=18&Itemid=34

Delft3-D is a 2-D/3-D system, a world leader in models for researching hydrodynamics, the transport of sediment, morphology and quality of water for river and coastal environments.

- **HURISK**

This is essentially a statistical program with a graphic interface, which aims to determine the periods of return of wind and routes, movements and intensities of the phenomenon, developed for coastal zones or areas close to the Atlantic coast region.

- **SBEACH (Storm-induced Beach Change Model)**

<http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=Software!31>

Simulates the erosion of coasts, shores and dunes, produced by waves, storms, and high levels of water.

- **STWAVE - Steady State spectral WAVE**

<http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=Software;9>

A flexible, easy-to-use model, for the growth and propagation of waves. STWAVE simulates depth induced by the refraction of the wave, depth and slope induced by breaking waves, diffraction, and parametric growth of the wave due to the influence of wind, and the interaction between the waves and limitation in redistribution and dissipation of energy in a growing wave field.

- **UnTRIM2004**

http://www.baw.de/vip/en/departments/departament_k/publications/pkb/untrim/untrim-en.html

A model to simulate flow and the process of transport in problems of various free surfaces. It is used to simulate storms

- **WAVEWATCH III**

http://polar.ncep.noaa.gov/waves/main_int.html

This software models wind waves generated by tropical cyclones far offshore. The main advantage of this approach is that cyclones can be modelled with spatial grids which cover much smaller areas than conventional ones, meaning that the model can be run with a higher spatial resolution. The basic appraisal of the model is executed by using ideal wind fields, forming a vortex.

- **WISWAVE**

<http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=SOFTWARE!7>

WISWAVE is the second generation of a wave model developed in the context of WIS. This model predicts directional spectra, and the properties of waves: the average height of the wave, its peak period, the average direction vector, and components related to the atmosphere of incoming winds.

4.4 Flood

- 2D diffusive overland-flow

A diffusion model of surface flow and the operation of pumping stations. Developed to simulate flooding in urban areas caused by an overload of drainage systems, sewers and pumping stations. The model's parameters are calibrated and verified for discrete storms.

The results can be useful to prevent flood damage, by redesigning and expanding the capacity of storm sewers.

The model may also be used to obtain potential flood maps, which will allow measures to be taken for the mitigation and control of floods.

- DAMBRK A DAM-BREAK FLOOD FORECASTING MODEL

<http://www.dodson-hydro.com/software/hydro-cd/programs/dambrk.htm>

This calculates the hydrography of the output of a dam which is failing, taking account of the geometry of the fault, storage in the dam, and intake. Output hydrography is dynamically channelled through the valley downstream.

Results of the model include depths downstream as a function of time and the travel time of the wave.

- FLOWSIMU-1

Hydrodynamic model of non-permanent flow in 1-D. Calculates the hydrodynamic data of flooding in real-time

- HEC - HMS HYDROLOGIC ENGINEERING CENTER- HIDROLOGICAL MODELING SYSTEM

<http://www.hec.usace.army.mil/software/hec-hms/>

Modelling of rain and floods

- HEC-RAS

<http://www.hec.usace.army.mil/software/hec-ras/hecras-download.html>

Model in the public domain. Allows the exchange of data with the ArcGIS system through HEC-GeoRAS.

The numerical model included in this programme allows an analysis to be made of permanent 1-D flow gradually varied on a free surface. Geometric and topographic data are required for the basin under study.

It allows hydraulic modelling of a permanent and non-permanent regime for open basins and rivers.

Based on this tool, data can be obtained for importation into flood prediction models, such as, for example, the elevations of water surface during a given event.

- HY-7 WSPRO: WATER-SURFACE PROFILE COMPUTATIONAL MODEL

<http://www.ftwa.dot.gov/engineering/hydraulics/software/softwaredetail.cfm>

Calculates flow profiles for subcritical, critical or supercritical conditions, acting in 1D and, with gradual variations in a permanent state.

The model is able to analyse flow in open channels, flow under bridges, flow in sewer systems, the flooding of causeways and road crossings with hydraulic structures.

- **LIS FLOOD-FP**

The generation of flood models is in 2-D. This is a rainfall-runoff model, with a partially physical base. It can be combined with a high-resolution climate model such as HIRHAM. It produces values for water depth and data for the preparation of hazard maps for floods.

- **MIKE21C**

A hydrodynamic calculation model to determine the level of the water at different points, and flow at average depth in an analysis groups.

- **SOBEK**

A 2-D hydrodynamic model to represent floods. It calculates depths and flow velocity. These data can be exported to a GIS, to enable shear stress, current levels, and Froude Number to be obtained.

- **SWAT**

The model examines the effect of weather, the use and coverage of soil, on hydrology and heads of water in a given basin. It calculates data for heads of water in a basin for each year.

- **SWMM**

Developed by US EPA (Huber and Dickinson, 1988)

It will simulate water flow in sewer systems. Further, it is useful in analysing runoff flows which exceed the design capacity in sewer systems, and overflows in collectors, soakaways, and pumping stations, which leads to flooding in cities.

Calculates hydrograms and analyses flows which exceed the capacity of sewer systems. Combined with flood models in 2-D, it provides very useful results for managing urban flooding.

- **TEMPO TOOL**

Simulates water levels, using the determination of transfer functions which describe a number of processes: runoff, filtering and groundwater flow. Involves an iterative procedure.

It needs evapo-transpiration and rain series obtained from local meteorological stations. The results are the level of water in time, and determination of a threshold for rainfall which will generate overflows.

- **TREX**

TREX (two-dimensional Runoff Erosion and Export) is a model to simulate extreme flooding in major river basins in semiarid regions of the western United States. The distributed model captures the effects of spatial and temporal variability of extreme storms, for safety purposes in dams in major basins. At the same time, it is an alternative to the unit hydrogram models and models for rain-runoff.

The model gives accurate simulations of peak flows and flood times.

- **FLO-2D**

This model analyse the calculation of depth, velocity and pressures at any time and in any cell analysed. It focuses on the obtaining of sediments by flooding, and the deposit of materials. It simulates flows and avalanches.

It allows floods with paper-concentrated close to be channelled, and simulate the rupture of dykes. This makes it a very useful tool to evaluate the risk of flood in river plains and steep gradients.

4.5 Landslide

- **3-DSlopeGIS**

This is a computer programme which uses a GIS (ArcObjects of ISRD), to make a spatial analysis of the DIS, and to manage data effectively in a 3-D slope problem.

The system has been used in urban planning, in the prediction of possible landslides based on a previous disaster, and to generate landslide maps.

- **ArcSDM**

This is an extension of ArcView GIS software. Its purpose is to develop special prediction models using regional databases. The maximum evidence of geological and geomorphological databases is used to generate maps which show the likelihood of instability on slopes.

- **GEO5 Slope Stability**

<http://www.finesoftware.eu/geotechnical-software/slope-stability/>

The program analyses the stability of slope strata.

- **LISA**

<http://forest.moscowfsl.wsu.edu/engr/lisa0.html>

Level 1 stability analysis (LISA), allows an analysis of slope stability. It reduces the likelihood of failure in natural slopes.

- **SLOPE 2009**

<http://www.geostru.com/Espanol/Software/Slope.htm>

Program for the analysis of slope stability in soils with and without cohesion. The software allows the discovery of soil movements, the evaluation of progressive breakup, and the application of several models of stress/deformation ratios.

- **SLOPE/W**

<http://www.geo-slope.com/products/slopew2007.aspx>

This is software for slope stability, which calculates the safety factor in soil and rock slopes. With SLOPE/W., simple and complex problems can be analysed for a wide variety of slippage surfaces, conditions of pore pressure, soil properties, methods of analysis and load conditions. Result Safety factor in earth and rock slopes.

- **STABL**

<http://www.ecn.purdue.edu/STABL/>

This is a program designed in FORTRAN to solve problems of slope stability in two dimensions.

- **STABLE**

[http://www.geotechnicaldirectory.com/page/Software/Slope_stability_\(soil\)_html](http://www.geotechnicaldirectory.com/page/Software/Slope_stability_(soil)_html)

This is a program designed in FORTRAN to solve problems of slope stability in two dimensions.

- **STONE**

This is a programme for 3-D simulation of rockfalls. It uses the GIS technology to manipulate thematic information available in digital format.

It generates simple maps used to evaluate hazards from rockfalls. The output raster includes a count of the trajectory of rock fall, maximum velocity, and maximum height calculated for each cell. The output of vectors include flat and 3-D trajectories for rockfalls.

4.6 Multihazard evaluation systems

- **SERVIR Viz**

http://www.iagt.org/servir_viz/espanol/

A GIS, used to consult in recent information related to events of natural hazards in Central America. Mounted on the NASA Worldwind platform.

- **Hazards US – HAZUS**

<http://nibs.org/hazusweb/> o <http://www.fema.gov/plan/prevent/hazus/>

HAZUS is a computer tool which allows the evaluation of risks of earthquake, flood and hurricane in United States. The program evaluates physical damage to buildings and infrastructure, and economic loss including the cost of repair and replacement, loss of profits and unemployment, and social impact including estimates of needs for shelter by the pigeons, and the population exposed to natural disaster.

4.7 Risk

- **CATSIM**

<http://www.iiasa.ac.at/Research/RAV/Projects/catsim.html>

Developed by the International Institute for Applied Systems Analysis, this is a tool to manage the financial risk related to extreme events. It is part of the risk and vulnerability project (RAV).

- **Mitigation Information and Risk Identification System – MIRISK Software (Open Source).**

MIRISK is a GIS mounted on the Internet, whose main objective is to provide information on the existence of natural hazards anywhere in the world, for entities and users interested in development projects. It allows preliminary evaluations to be made of the risk to which the project is subject, and the cost-benefit ratio of mitigation measures. It is basically founded on information in the World Bank study "Natural Disaster Hotspots". It allows the intensities of any type of hazard to be seen anywhere in the world, with a grid resolution of up to 0.5 minutes (depending on the hazard). It includes a module for estimated loss, and a module for cost-benefit analysis.

- **Open Source Risk Software – OpenRisk**

<http://www.risk-agera.org/>

Analysis of risks in Open Source Code.

5 Specific documents

Table 5-1 shows the statistics of documents, articles and books available up to the present, classified in the "Subject" field. The statistics do not include information on maps or cartography. Table 5-1 shows statistics of documents, articles and books in "general" level, because there is no information on documents for release. The complete Table, with all documents, can be seen in Annex ERN-CAPRA-T1.1A-2.

Table 5-1
Documents classified by subject

	Theme	Available Documents
1	Risk, hazard and vulnerability	17
2	Software	12
3	Earthquake	22
4	Tsunami	20
5	Hurricane	24
6	Rainfall	20
7	Flooding	44
8	Landslide	61
9	Volcano	26
10	Other	8

Total	254
--------------	------------

6 General catalogue of information required

There follows a summary of information of prime importance required to obtain an acceptable database in terms of risk profile for the country, at least to have demonstrative examples of different applications for risk analysis. Most of the information contained in this catalogue refers to files in SHAPE format and country maps, databases for historical events and infrastructure, and a study is of vital importance to the region analysed. Annex ERN-CAPRA-T1.1A-3 presents the full catalogue of information required. Table 6-1 presents the fields defined from the Table corresponding to the Information Required.

*Table 6-1
Fields for the information required database*

Field	Data type	Description
Nº	Integer	ID
Country	Text	Country name
Theme	Text	Information theme
Type	Text	Data type (map, image, database, etc.)
Description	Text	Information description
Available	Text	Information availability
Priority	Text	Priority for the CAPRA Project
Entity	Text	Information provider entity
Comments	Text	Additional relevant comments
Quality	Integer	Quality index
Land coverage	Integer	Land coverage index

The list of possible options for the “Subject” of information required is classified in Table 6-2. Table 6-3 presents a list of possible options for the field "Type".

Table 6-2
List of possible options for the field "Subject" in the Information required database

N°	Information category
1	General country information
2	Main cities information
3	Special zones information
4	Earthquake
5	Tsunami
6	Hurricane
7	Hydrometeorological
8	Flooding
9	Landslide
10	Volcano
11	National infrastructure
12	Cities infrastructure
13	Spetial zones infrastructure

Table 6-3
List of possible options for the field "type" in the information required database

N°	Information type	Symbol
1	Map	M
2	Photograph	F
3	Database	B
4	Document	D

For the information required, priorities have been classified simply as P-Principal and S.-Secondary. It should be noted that the information presented in this section is different from the related information database described earlier, since the information required database only contains the groups of information requested for the country when starting the project, and forming an inventory which controls what information required is held at the beginning, and what is not. The detailed inventory of maps, photographs and images available at present is included in the related information database (see Annex ERN-CAPRA-T1.1A-2).

ANNEX LIST

- Annex ERN-CAPRA-T1.1A -1 Entities BEL.xls – Digital file
- Annex ERN-CAPRA-T1.1A-2 Information database BEL.xlsx – Digital file
- Annex ERN-CAPRA-T1.1A-3 Required information catalog BEL.xlsx – Digital file