NATURAL DISASTER: MITIGATION AND MANAGEMENT THROUGH GIS – The Italian Experience

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Key words: Land Disaster Management, Earthquake Mitigation, Civil Protection, GIS, Zoning, GIS Mapping

SUMMARY

Over the last decade, Italy has suffered numerous natural calamities that brought extreme damages on its natural landscape, real estate and heritages sites. The magnitude of these calamities, unfortunately also signified casualties.
After the 2012 earthquake in the region of Emilia Romagna, the Italian Civil Protection designed a new way to prevent and mitigate the effects of natural disasters, in order to be able to quickly respond on emergencies, address the primary needs and limit and recover from the damages. The new Condizioni Limiti di Emergenza, or the CLEs are created to be utilized as the principal instrument on designing new emergency preparedness plans and coordinate necessary actions when faced with critical circumstances.
This paper focuses on the foregoing procedure of data collection and the development of new dynamic, standardized and easily updatable emergency plans and thematic maps. Furthermore, some case studies would also be presented in which will show a comprehensive view of the different situations wherein CLEs are used, whether it would be a small Italian borgo, or a bigger city with an imminent emergency situation.

SUMMARY (Italian)

L'ultimo decennio ha visto l'Italia subire numerose calamità naturali che hanno portato ingenti danni al proprio patrimonio paesaggistico, immobiliare e storico-artistico. L'entità di queste calamità, purtroppo significava anche la perdita di vite umane.
Dopo il terremoto 2012 nella regione dell'Emilia Romagna, Il Dipartimento Nazionale della Protezione Civile italiana ha progettato un nuovo modo per prevenire e mitigare gli effetti dei catastrofi naturali, in modo da poter rispondere rapidamente a situazioni di emergenza, rispondere alle necessità primarie, limitare i danni conseguenziali e facilitare il recupero dagli eventi dannosi.
Le nuove Condizioni Limiti di Emergenza, o le CLE sono state progettate create per essere utilizzate come strumento principale nella redazione di nuovi piani di emergenze e coordinare le prime azioni necessarie e mitigare le criticità.
Questo documento mira a spiegare la procedura standard della raccolta dei dati e lo sviluppo di nuovi piani di emergenza e carte tematiche, i quali dovranno essere dinamici, standardizzati e aggiornabile. Inoltre, alcuni case study verranno esposti al fine di mostrare la potenzialità di tale strumento e dare una visione completa delle diverse situazioni in cui si utilizzano CLE, sia in un contesto urbano relativamente piccolo (borgo), sia in un tessuto urbano complesso come una città capitale con un'imminente situazione di pericolo.

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INTRODUCTION:

On the morning of April 6, 2009, a 5.9 (Richter, 6.30 on Magnitude-scale) earthquake hit L'Aquila in the region of Abruzzo. This disaster cost the loss of 308 victims and caused damage on numerous buildings, both of recent constructions and of historical importance. However, it also paved way for the Italian government to new enact measures related or relating to public safety, mitigation, risk assessment, rescue and recovery, on the occurrence of an earthquake.

Particularly, article 11 of Law n. 77 of 24 June 2009 (the converted Decreto Abruzzo), provides possible financial aids or funding for actions directed towards prevention and mitigation of seismic risks throughout the national territory. The implementation of Art. 11 was assigned to the Dipartimento della Protezione Civile / Department of Civil Protection) and is regulated by the Ordinanze dal Presidente del Consiglio dei Ministri (OPCM - Ordinances from the President of the Council of Ministers) and by the Ordinanze del Capo Dipartimento della Protezione Civile (OCDPC – Ordinances from the Head of the Dept. of Civil Protection).

The same law identifies "Seismic Microzoning" (Microzonazione Sismica) as a key-tool for initiating a strategic seismic risk mitigation.

For the first time, a multi-year program is adapted and is in effect in the whole country. It resulted to various deeper studies about seismic events and specific measures to ensure public and private safety.

The first ordinance issued under this implementation was the OPCM n. 3907 of 13 December 2010, which specifies how the funds should be used for the year 2010. The main directives were:

a) to conduct surveys pertaining to Seismic Microzoning (MS) and to be able to define the areas susceptible to seismic amplifications or permanent ground deformation during an earthquake;

b) to create measures to favor localized building strengthening or seismic improvement or, even demolition and reconstruction of buildings and strategic public works;

c) to favor localized structural strengthening or seismic improvement or demolition and reconstruction of privately owned structures;

d) to call to (urgent) actions for seismic risk mitigation regarding main infrastructures such as bridges and viaducts, that are of particular interest in case of a seismic event.

The Dipartimento della Protezione Civile allocates the funds among regions on the basis of each Seismic Risk Index favoring those areas with a higher risk index ($ag \geq 0{,}125g$) therefore creating preventive measure to greatly reduce citizen casualties.

Among the measures funded and supported at the national level, Seismic Microzoning (MS) which resulted to be the most important for the seismic risk prevention and mitigation. These surveys aim to streamline the knowledge of what actually happens in an event of an earthquake, providing the Government with valuable information on designing, planning, managing emergency and post-earthquake reconstruction.

With the issuance of OPCM 4007/12 the analysis of Condizione Limite per l'Emergenza (Emergency Condition Limit - CLE) was introduced. It has the objective of verifying physical elements present on existing emergency plans (coordination centers, emergency areas, infrastructures framework) to ensure a proper operability of the interventions after a particular seismic event.

WHAT IS SEISMIC MICROZONING?

Following a seismic event, primary damage assessment on buildings and infrastructures allows the identification of different types of situations depending on a location's distance from the epicenter, along with the amplification of seismic motion or soil instability. This kind of observation is the main objective of Microzonazione Sismica (Seismic Microzoning), which serves the purpose of recognizing in municipal or sub-municipal scale the geological and geotechnical conditions that can change significantly the characteristics of a seismic motion or may produce permanent soil deformations.

A complete technical report of MS permits the identification of different areas of study, which includes:

- Stable areas, in which the seismic motion doesn't change compared to the expected ideal conditions of plane and rigid rock;
- Stable areas with amplifications, or the areas in which seismic motion is changed with regards to the expected ideal conditions of rigid and plane rock, caused by the geological and geotechnical characteristics and the morphology of the territory;

- Unstable areas, where any earthquake-induced phenomenon may cause permanent soil deformation such as landslides, soil liquefaction, ground level fault lines and ground graduations may create morphological terracing.

Seismic Microzoning (MS) permits seismic prevention and seismic risk evaluation thus, can be considered as an important tool for emergency planning, urban design and local government planning.

Moreover, in territorial management plans, studies on MS could be conducted on areas for which the regulatory conditions include areas for building purposes, areas for infrastructures, areas dedicated for civil protection and potential areas of transformation.

The MS studies are of fundamental importance in the planning in order to:

- Guide the choice of areas for new settlements;
- Define acceptable measures under a given area;
- Plan the investigation and the levels of study;
- Establish guidelines and procedures of intervention in urbanized areas;
- Define action priorities.

In emergency planning, either on municipal or provincial levels, MS allows for better and conscious identification of key elements (strategic building, emergency areas, roads and infrastructures accessibility and connection) of an emergency plan and proper use of available resources. In fact, the sole knowledge of the possible localized effects caused by a seismic event in a territory may contribute to:

- Choose emergency areas and facilities and strategic buildings located on stable environments;
- Identify the critical traits of any infrastructure for which, in the event of collapse of the adjacent buildings, could be a subject to a specific safety assessment or evaluation.

Seismic Microzoning helps to understand the level of vulnerability and exposure of a certain area of study. This may lead to optimization of available resources aimed at mitigating seismic risk.

THE ROLE OF CLE:

"Condizione Limite per l'Emergenza, (CLE)" of an urban settlement is defined by the Ordinances from the President of the Council of Ministers n. 4007/2012, as that condition in which, after an occurrence of the earthquake and despite the concurrent physical and functional damages that may interrupt all urban and residential functions, a settlement can still retain the

operations of most of the strategic capabilities during emergency, its accessibility and connection inside and outside the local urban framework.

The concept of CLE plays an important role in introducing a sense of "structure" in emergency planning and somehow, it renders any emergency plan vital in urban planning. Its introduction demands the need to contextualize the strategic unit within the current urban system, of which it must assess the behavior in terms of its capacity to resist extreme stresses such as earthquake. It also requires a re-evaluation of the different components of an urban system according to one's relevance.

Studying CLE may also mean assessing the entire operation of an urban settlement, because it may represent a vulnerable element or as a useful resource during an event. From this standpoint, risk analysis may not only mean focusing on the identifying strategic elements, but rather, permits the assessment of the urban elements that may be compromised during a seismic event, hence, allowing the identification of which urban functionality may be lost or may able to resist after an earthquake. This leads to determining a new urban subsystem that must ensure the stability of a given functionality (emergency management) in case of earthquake.

CLE represents a different method of urban planning focusing primarily on identifications and valuations of possible interventions to prevent structural risks.

In other words, CLE analysis connects emergency planning and urban planning, with the latter that assumes guidelines aimed at reducing the vulnerability of an urban subsystem, which in turn, is aimed to support strategic functionality of emergency planning. CLE may revolutionized the current emergency planning process.

However, analyzing CLE may require a continuous cooperation between authorities, starting from the Technical Committees, which should aid in resolving eventual complexity, and by the Local Administrations (Regional, Provincial and Municipal), which should oversee the implementation and execution of the operations.

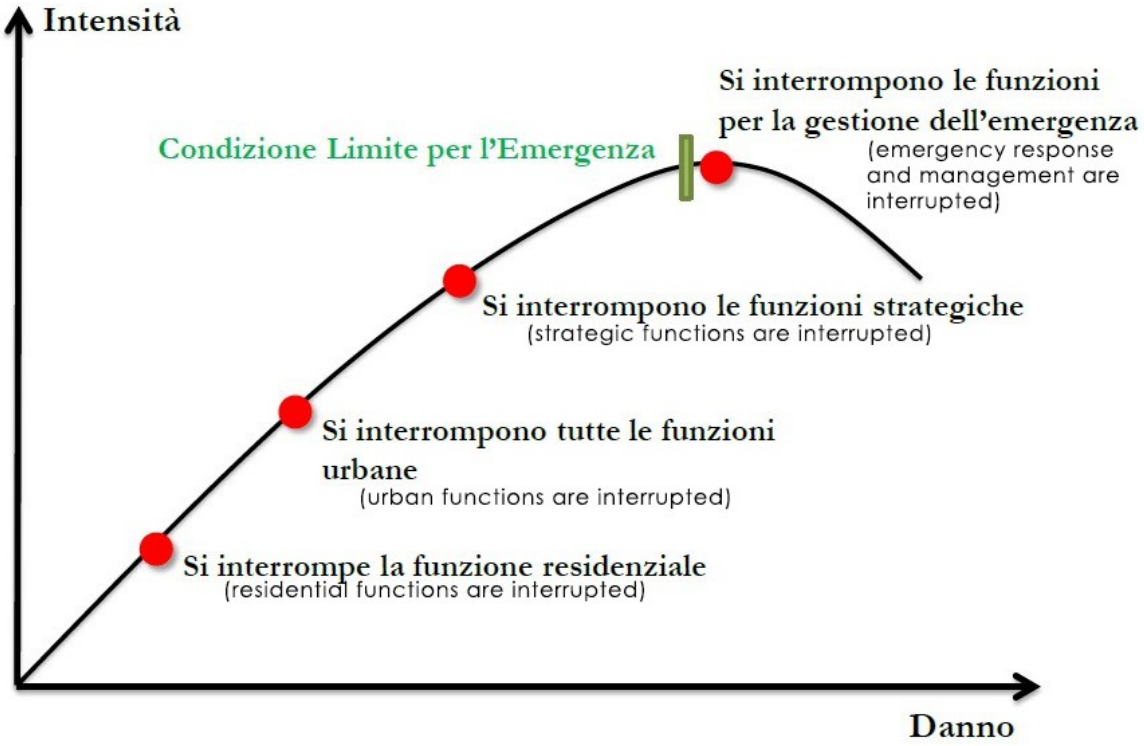


Figure 1 - graphical representation of CLE as prescribed by the Italian Civil Protection Agency

ANALYZING THE CLE:

The analysis of CLE of the urban settlement is carried out using special forms prepared by a specialised Technical Committee, as stated in art. 5 paragraphs 7 and 8 of OPCM n. 3907/2010, and issued thereafter by a special decree of the Dipartimento della Protezione Civile Nazionale

This analysis involves:

a) Identification of the buildings and areas that will provide strategic functions for emergency (ES);

b) Identification of infrastructure apt for accessibility and connection (AC) with the local urban framework, the buildings and areas as stated above in a) and any other critical elements;

c) The identification of structural aggregates (AS) and individual structural units (US) that can interfere with the infrastructure of accessibility and connection with the local urban framework (Article 18 OPCM 4007/2012).

For this purpose, a standardized process of data collection and storage was designed through special folder comprising each types of structure-specific module. Collected data are then represented in digital cartography in shapefile format.

It is composed of five technical modules corresponding to the different structural types to be surveyed and studied. They are:

ES Edificio Strategico / Strategic Building

AE Area di Emergenza / Emergency Area

AC Infrastruttura Accesibilità/Connessione – Road Accessibility/Connection

AS Aggregato Strutturale / Structural Aggregate

US Unità Strutturale / Structural Unit

The analysis is conducted in conjunction with studies of seismic micro-zoning, and therefore starts from the municipal level.

CLE Analysis can only begin once the following documents have been sourced out:

1. Regional Technical Map (Carta Tecnica Regionale - CTR) in at least 1: 10,000 scale and in digital vector file;

2. Existing Municipal Emergency Plan, or Civil Protection Emergency Plan, or other existing plans for the identification of strategic buildings (i.e. LV0 index prescribed in the Circular of the Dipartimento della Protezione Civile - 21 April 2010) and emergency areas.

3. Precompiled descriptive module on strategic buildings and areas of emergency (specific to a certain element that is of interest for the analysis of CLE).

4. Any modules already compiled regarding building vulnerability (i.e. LV1 and LV2 indexes as in implemented by OPCM 3274/2005).

Identifiers within the same municipality and for each shapefile, must not have duplicates.

The standardized methodology applied for the analysis of CLE is divided in three (3) phases:

A) Preparatory phase (phase 1);

B) Data Collection (phase 2);

C) Data Analysis and Database storage (phase 3);

In a much shorter explanation, phases 1, 2, and 3 can be simply summarized as follows:

1. Buildings with Strategic Functions, or ES, for CLEs are identified on the CTR map. These are chosen based on pre-existing Civil Protection or local Emergency Plans.

   Since the analysis of CLE must be implemented on urban planning tools, inclusion of new buildings not previously indicated or identified in existing emergency plans may create implications on future planning of regional regulations (art 18 par 3 OPCM 4007).

   ESes may include: Municipal hall and other command and coordination centers, Medical facilities, Paramedics and Firefighters headquarters.
2. A sequential identification code (identifier) is assigned for every Structural Building (ES) without considering the number of smaller structures present inside an ES (which would be later indicated in section 48b of ES's data sheet).
3. Structural Aggregates (AS), or the number of existing structural complexes, pertaining to the previously chosen ES are then identified.
4. Emergency Areas (AE) (meet-up locations and shelters) are located. These areas should also be derived from existing emergency maps.
5. Infrastructures that connect ES and AE are identified. Like the ES, these should be derived from existing plans and if new infrastructures are to be established, the selection must be carefully done.

   These roads should be limited to those necessary to ensure connection between these elements, in terms of viability of service vehicles and by each building's specific function.
6. Other infrastructures are then chosen to ensure accessibility of the aforementioned elements from the surrounding areas.

   If ever these roads weren't previously selected, new roads should:

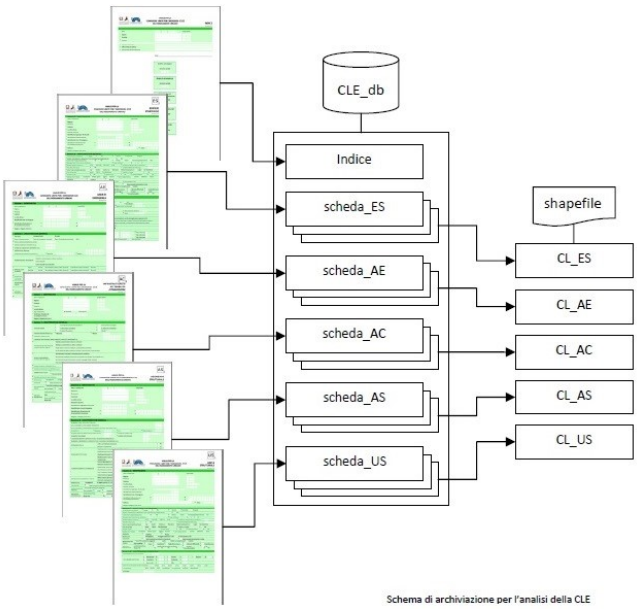
   a. arrive at any intersection with an inter-municipality road;
   b. reach the confines of the urban settlement, as stated in territorial regulations or as identified in the 2011 census conducted by ISTAT.
7. Structural Aggregates (AS) or isolated individual structures considered "interfering" with road infrastructures or with Emergency Areas (AE) are identified.

An AS's interference is determined by the relation of its height (H) with the road's width (L) or its distance (d) from the nearest confine of an EA. That is to say, if H is greater than L or d, the AS can be considered "interfering."

8. Identifiers are associated with the chosen Ass, EAs, and ACs. It is preferred to use the identifiers used on CTRs. However, if new identifiers are to be given on CLE-related structures, they should be comprised of 12 alphanumeric characters, the last two of which should be 00.
9. Data compilation can be initiated by dividing the area of study and forming working teams. Special modules and forms are prepared and distributed to each operator assigned. It is highly encourage to follow the sequence ES – AE – AC – AS – US.
10. Gathered data are then plotted over the corresponding Regional Technical Map and it should correspond to every element and important details (strategic buildings, infrastructures) that the operator was able to collect the analysis phase. All data are carefully controlled by data specialist working inside the Dipartimento della Protezione Civile.

An overview map in a scale of not smaller than 1:15000 should go along with the main map. Should there be a need of a more detailed map, this should be plotted on a scale of at least 1:2000. The reference coordinate system for mapping is WGS84UTM33N.

CLE ARCHIVING



Schema di archiviazione per l'analisi della CLE

In compliance with the provisions of Ordinance 4007/2012, article 18, paragraph 4, a standardized procedure of archiving CLE analysis was created. The same procedures reflect the same algorithms used in Seismic Microzoning analysis.

Data collectec from the previous field surveys are then inserted in a freeware provided by The Dipartimento della Protezione Civile called "SoftCLE." An

updated version of the freeware was released in September 2015.

The software follows the same formats as the paper copies to facilitate and reduce error in digitizing the data. The data storage structure also ensures a direct link to map databases.

It facilitates, furthermore, the data input with some pre-encoded codes, for example, indicating the municipality, the program recognizes and indicates automatically, its corresponding Istat code.

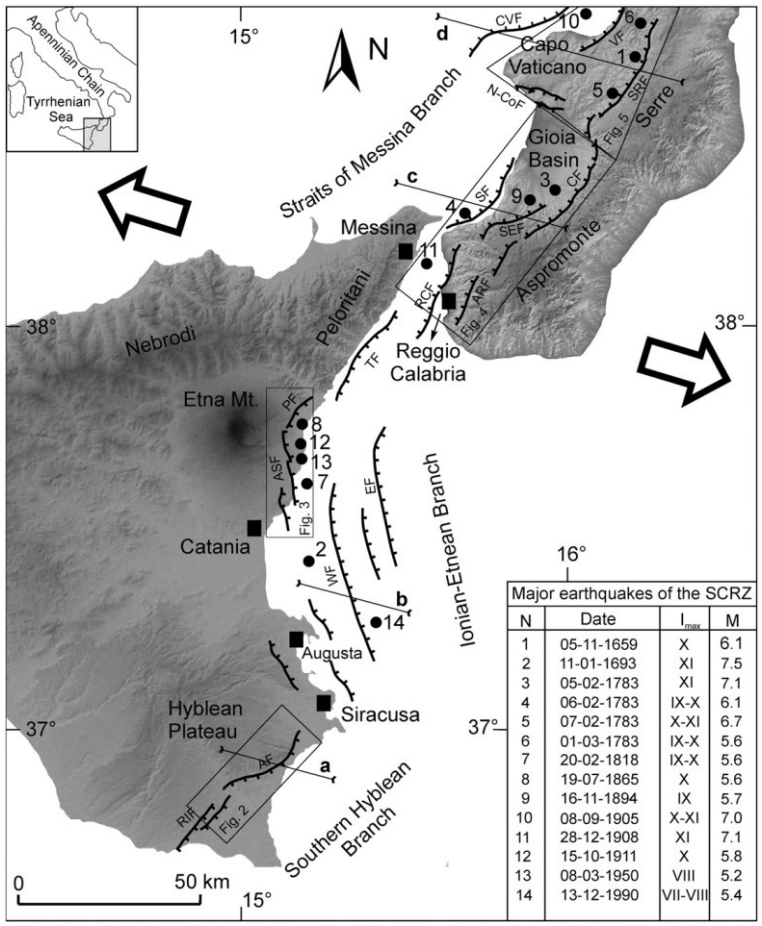
The Dipartimento di Protezione Civile has also published a standardized method of digital representation of data from CLE Analysis. The 278-page book contains detailed instructions on graphical representation, nomenclature, definitions and examples of interference, building structures, road condition analysis, and structural requisites.

THE RESEARCH ON CATANIA:

Despite various efforts to bring and execute CLE analysis to the entire Italian peninsula in the shortest time possible, some municipalities and cities haven't received the necessary funding to initiate with the project proposed by the Dipartimento della Protezione Civile.

One of which is Catania, one of the biggest and populated cities of Sicily. Located on the eastern side of the island, Catania has a long history of strong earthquakes, volcanic eruptions caused by the neighboring Mt. Etna, and seismic events, some of which could be dated since 1169. It lies southwest from the Ionian-Etnean branch of the Siculo-Calabrian rift zone.

The Dipartimento della Protezione Civile classified Catania under level 2 seismic risk



Major earthquakes of the SCRZ

N	Date	I_{max}	M
1	05-11-1659	X	6.1
2	11-01-1693	XI	7.5
3	05-02-1783	XI	7.1
4	06-02-1783	IX-X	6.1
5	07-02-1783	X-XI	6.7
6	01-03-1783	IX-X	5.6
7	20-02-1818	IX-X	5.6
8	19-07-1865	X	5.6
9	16-11-1894	IX	5.7
10	08-09-1905	X-XI	7.0
11	28-12-1908	XI	7.1
12	15-10-1911	X	5.8
13	08-03-1950	VIII	5.2
14	13-12-1990	VII-VIII	5.4

with a seismic index of 0.200 to 0.225. Technically, qualifying Catania as a candidate for immediate Seismic Microzoning and CLE Analysis.

With its geography and seismic index in consideration, the authors designed a CLE analysis on the city's historic center. Catania's center presents interesting details on urban plan and building structures. Moreover, the same methodology prescribed by the Dipartimento della Protezione Civile has taken into considerations.

The present research on Catania has limitations regarding the area of study chosen and the impossibility to plot the output map since it has no approval from the DPC's data quality technicians. However, the output map could be used to begin a comparison with the pilot CLE project spearheaded by the Dipartimento della Protezione Civile and understand the potentiality (or complexity) of Seismic Micorzoning and CLE analysis in disaster risk assessment and mitigation.

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