A Computerized Technique for Multi-Criteria Analysis of Seismic Disasters - GESKEE Database

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Abstract: - Econometric scaling approach of vulnerability and risk on building stock to major seismic events is essential for understanding the impact and the consequences of these earthquakes. It also has a predictive value for loss estimation of next events. Due to use of a large amount of information in such multi-criteria approaches, it is a high necessity to develop computerized techniques to automate the calculation process, to manage the data easier and also to represent the results in a manner as suggestive as possible. Therefore, the paper presents the GESKEE (Global Econometric Scaling using Knowledge on Earthquake Effects) Database developed by authors which is an indispensable tool for econometric scaling approach for seismic risk assessment. For this aim, the database was structured starting from special requirements imposed by GESKEE Disaster Scale (2010 version). As a result, according to necessity of econometric calculation and graphical representation of GESKEE Disaster Scale (2010 version), a flexible and helpful database (GESKEE Database) was developed. Actually, building up this Database was the main key to improving, developing, updating and to a better interpretation of the GESKEE Disaster Scale (from 1998 version to 2010 version). The results are promising and appear to provide an increased predictive value for the GESKEE Disaster Scale. We consider that this application will be greatly useful and convenient for a transparent and a more efficient seismic risk assessment and loss scaling, providing a better understanding of past seismic events impact and so, a real help in calibration of earthquake disaster prevention policies. In order to point out the innovative edge of GESKEE Database, which is an important tool in social and economic quantification of seismic vulnerability of building stocks and earthquake loss, we present some examples of graphic representations and also some interpretations of the results.

Key-Words: - GESKEE Database, GESKEE Disaster Scale, seismic risk assessment, econometric scale, Earthquake, seismic vulnerability, disaster mitigation

1 Introduction

The occurrence of a disaster is characterized by a large number of casualties, homeless and affected persons, huge direct and indirect losses and a loss of social control of events. In such situations, the available resources for rescue and recovery usually become insufficient.

A disaster means more than a severe seismic motion on intensity scales or magnitude. A seismic event may be large but not yet a disaster, if its negative effects are reduced in comparison with the existing elements at risk and resources for rescue, rehabilitation and recovery. The absence of a recognized "earthquake disaster scale" is in contradiction with the progress in the seismic risk and loss analysis [1].Until now, the attempts to date have given partial answers.

It can be considered that the seismic risk assessment and disaster scaling approach should rely at least on three criteria: direct effects on inhabitants (deaths, injuries), social effects on human settlements (homeless/people affected) associated to the physical damage (collapsed and damaged buildings/public works, affected habitat) and/or the economic value of physical damage, including the loss impact on subsequent periods [2].

Besides specific values in probabilistic expressions, a higher level of risk and disaster would require large values of such indicators, and, besides the physical damage, one should evaluate the importance of the dynamic factors of the society, able to provide recovery and risk mitigation in the future.

The most available and valuable data required to develop a Disaster Scale are from the loss reports and usual statistical data. So, such a scale of risk and disasters must provide a ranking and realistically predict the disaster trends, avoiding saturation. This can be easily obtained by using computerized approach.

As a consequence of our scientific research regarding the assessment of economic and social impact of earthquakes on building stock, working to improve, complete, develop, adjust and also to update the last version of GESKEE Disaster Scale (1998 version) [3], we faced a serious problem in handling and processing a large amount of information (input data for about 63 seismic events).

Specific indicators calculation (the econometric analysis) and the graphic representation of data needed to be quickly accomplished and easily managed. Actually, the form in which the output data are obtained and presented is decisive for an accurate and efficient interpretation of results. Therefore, in the research project emerged a high necessity to create a solid database to resolve all these issues.

Computer systems, as well as work equipment and especially, as software, are a valuable tool in the decision-making processes. Nowadays, decision-making is an usual activity. The existence of accurate data and their computer processing is an efficient base in establishing what actions need to be taken in limit situations. However, no responsibility can be entrusted solely to computer techniques, since man is the one who provide the data and the one who interpret the results or at least supervise them. Therefore, the results from these analyses are the basis for decision-making process.

In order to develop this necessary database, some prospects in this field have been done about products that can be used. After comparing them by criteria like performance, viability and user accessibility, we decided to use MS Access to develop the necessary software, since, as part of the MS Office suite, is one of the most popular Database Management System, making it possible to use the GESKEE database on regular computers.

Microsoft Access is a database structure which is capable of combining into a single file type .mdb all Visual Basic Objects: Tables, Queries, Forms, Reports, Pages and Macros. For information storage, the design of Microsoft Access Applications uses separate .mdb files, sharing the application into two parts, namely front-end to include the user interface and back-end that contains the tables of database.

This paper is organized in 6 sections. The first section is Introduction and the second presents Related Work. In section 3 is detailed the Methodology. Section 4 describes the GESKEE database (Fig.1) and some experimental results. Conclusion and further work is approached in section 5 and in 6 is the Bibliography.

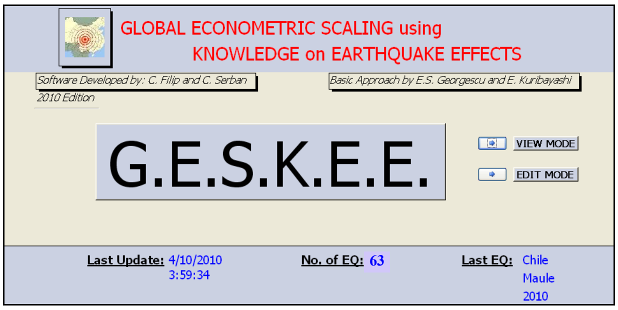

Figure 1 The main form of GESKEE Database

2 Related work

The GESKEE Disaster Scale describes a worldwide scaling approach of risk and disaster extent and patterns, for seismic events and groups of countries, using indicators of relative economic loss and casualties. The 1998 version of the Scale was introduced by the authors of [3]. It contains econometric data and graphic representations for 42 important earthquakes for 1900-1998 periods. It provides information about the level of vulnerability associated to the level of development and economic power of the countries, hazard estimation quality, the development of enforcement codes correlated with economic, social and political circumstances. As an interpretation of all this particular situations, the predictive value of the scale arises.

Although the authors of [3] understood the necessity of integrating the GESKEE Disaster Scale into a Database Management Software System in which to be used for impact assessment, nothing has been undertaken in this direction so far. Actually, lack of such a computerized approach has led to a not updated Scale.

As a result of our research work, we completed, developed, adjusted and updated the GESKEE Disaster Scale (2010 version) [4]. Among other things, this involved processing a large amount of information and an accurate graphic representation in order to obtain appropriate results and useful interpretations. And so, we developed a computerized method to resolve all this issues (GESKEE database).

In our research, we found that there are other databases (NEIC Database [5], RoSERIS [6], IRIS database [7], K-NET [8]) that provide information on seismic events, but they only storage the data, without its processing, ranking or econometric quantification. For example, in In [9] is presented the results of the use of Geographic Information System (GIS) in mapping information on the effects of the Kythira earthquake of 8th of January 2006 on surrounding area of Chania municipality. The end-product of this study is a thematic map of the expected damage on the Chania City (Greece) from an earthquake in the Kythira area with energy comparable to the January 2006 earthquake.

Most of earthquake-induced geotechnical hazards have been caused by the site effects relating to the amplification of ground motion, which are strongly influenced by the local geologic conditions such as soil thickness or bedrock depth and soil stiffness. In [10], an integrated GIS-based information system for geotechnical data, called geotechnical information system (GTIS), was constructed to establish a regional counter plan against earthquake-induced hazards at an urban area, Daegu, in Korea.

For this reason, we are entitled to believe that the database we developed meets the GESKEE Disaster Scale requirements of graphic representation and automatic calculation of econometric indices according to the standard methodology presented in detail in [4].

3 Methodology

The concentrated form of the GESKEE Disaster Scale proved to be a general tool in order to explain the relationship between the classical measure of a seismic motion, the loss size, the country's economic level of development (i.e. economic power), the disaster impact and the patterns of post-disaster recovery. GESKEE Disaster Scale (2010 version) measures the relative economic loss using the GESKEE Indicator – Normalized Relative Economic Loss (NREL) [4].

This GESKEE component presented for the first time in [2], is used to assess the economic impact of earthquakes over different countries during the current and past century. The relative assessment of earthquakes economic loss impact using this indicator relies on equation (1):

$$NREL = ILOR \times \frac{GNP_{ref}}{GNP} \tag{1}$$

where: ILOR – Incremental Loss Output Ratio

$$ILOR = \frac{EL}{GNP} \tag{2}$$

GNP – Gross National Product of a country
GNPref – Gross National Product as reference (e.g. GNP of USA)
EL – earthquake (economic) loss value

This scaling approach aims at using loss size and impact indicators for comparisons between contemporary countries, different historical periods of the same country or individual countries in their evolution.

The logarithm of GESKEE Indicator (log (NREL)) is calculated using GESKEE database for 63 earthquakes, from which 42 earthquakes were recalculated from the first version of the Scale [3] and 21 earthquakes from the 1999-2010 period (including Haiti and Chile 2010 earthquakes) [4], and presented as a continuous and nominally endless scale grouped by countries.

The ILOR data and earthquakes magnitudes of specific events have been analyzed using graphs and regressions. The dispersion of the value is quite high, but some envelope ranges are more significant. Using GESKEE database we obtained the envelopes related to geographical clustering and to the development level clustering.

Using table (1) presented in [2] it can be seen the trends with predictive value, function of the range of log(NREL), development group, economic loss and relative economic power of the country affected. This table is used in ranking and classification of affected countries by log(NREL) in GESKEE Disaster Scale and it is also used by GESKEE database.

Table 1 Trends with predictive value, function of the range of (log NREL), development group, economic loss and relative economic power [2]

World Bank Income Group and other country patterns	Magnitude	$ILOR = \frac{EL}{GNP}$	$\frac{GNP_{ref}}{GNP}$ Ref=USA	Usual range of (log NREL)
Low-income and lower middle-income countries or in difficult circumstances	5.4 - 8.0	10% - 50%	2% - 0.05%	(0.7)-(3)
Middle-income and upper middle-income countries, oil exporters, tourism based economies	5.7 - 8.1	3% - 10%	10% - 2%	(-0.5)-(0.7)
High-income industrial countries, quite large countries	6.5 - 8.3	0 - 3%	≥10%	≤ (-0.5)

The factors generally considered as affecting the earthquake losses size and impact could be summarized, as follows [1]:

1. Factors affecting the direct losses size and impact:

⇨ the size of the damaged area, the physical damage degree/vulnerability of the natural and man-made environment elements, the actual damage, life loss and injuries, the incidence of past disasters;

⇨ the ratio of the damaged area vs. the country area, the ratio of suffering population to the country's population, the share of the affected economic branches in the local, regional and national product, and in foreign trade income;

⇨ the specific pattern of the past disasters influence on the country's development, function of the return periods of strong earthquakes, the early use of seismic design codes and their updating, effective application and observing, official endorsement of land use planning, rehabilitation and seismic risk mitigation activities, quality control etc;

⇨ the density of population, settlements, socio-economic facilities and economic output in the affected area;

⇨ the value of property losses and their distribution between sectors, the size of the national wealth and national product/income and the ratios between them;

2. Factors affecting the indirect and long-term size of losses and impact:

⇨ the type of economic system, methods of planning and management, the complexity of the economic input-output relationships between the major sectors of the country's economy and the resulting patterns of development, including the reference to the UN classification function of GNP per capita;

⇨ the trend of economic development and growth rates in the preceding years;

⇨ the existence of a disasters prevention legislation and loss recovery system through insurance and government incentives (tax exemption, condolence money, compensation, etc.);

⇨ the conjunction with other factors, as world recession, inflation, political instability, etc;

The ratio of losses to the GNP is reasonable to be used, but actually only a part of the property loss (fixed assets and lost inventory) is involved formally in the economic production. So, a comprehensive analysis should separate the loss in specific shares and to report the lost assets the National Wealth and the lost outputs of goods and services to GNP.

The literature which deals with the correlation between catastrophic losses and economic growth is wide and is basically based on neoclassical frame work. All catastrophic events, economically speaking, produce a downward jump in production. For example, the models presented in [11], [12] underline the idea that a catastrophic event brings about a permanent shift in the growth path of the economy. Such effect is called a “level effect”. In [13] is described an investigation of the relationship between seismic velocity structure and distribution of the seismicity in the front of the Hellenic Arc and also a histogram that show the relationship between magnitude and depth of the seismic events in the area that have been studied.

The economic impact of natural hazards, view as very low frequency but high impact events, are difficult to model in a general approach (because hazards strike are unique in the way they impact a different place; damages are difficult to quantified especially in poor areas; the largest economic impact is on stock variables, capital and labor, while economic indicators measure flows) [14].

4 The GESKEE Database

According to necessity of econometric calculation and graphical representation of GESKEE Disaster Scale (2010 version), a flexible and helpful database (GESKEE Database) was developed in order to represent an effective tool in improving and updating of the GESKEE Disaster Scale. In order to obtain this Database, it was used, as mentioned before, Microsoft Access, due to its available operating facilities.

The GESKEE database provides a multitude of operations, from the simplest such as data entry, to the most complex, such as sorting and filtering by different sets of criteria, or generating significant reports and charts.

These functions are implemented into two logical modules: the *Edit Module* (Fig.2), which allows users to easily enter/modify/delete data, and the *View Module* (Fig.3), which enables the users to search/filter/view the information.

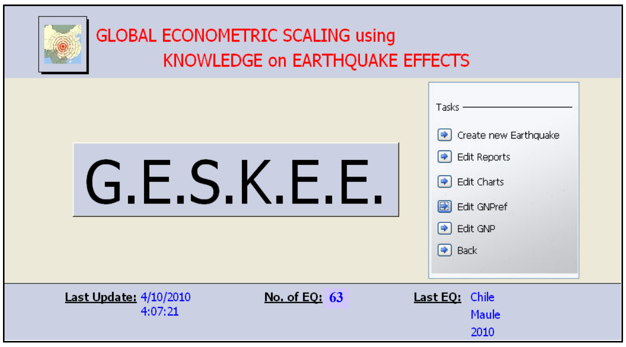

Figure 2 The *Edit Module* of GESKEE Database

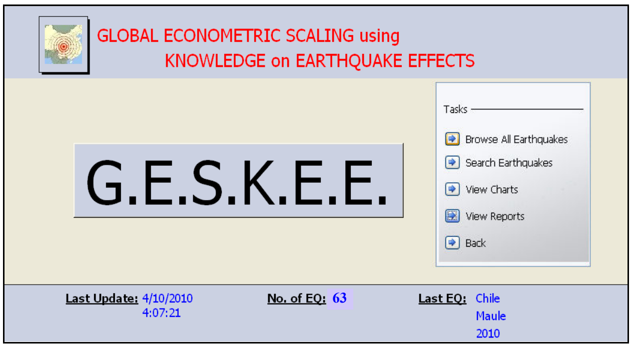

Figure 3 The *View Module* of GESKEE Database

The database we developed meets the requirements of a user who wants to perform an econometric analysis over some seismic events data, and to see the results represented in a highly suggestive and easy to understand fashion. The data needed for processing may be already stored in database, or the user can input it in, through designated database forms. The implemented VBA procedures ensure its accuracy and consistency.

The Database has a friendly interface and the menus and navigation through the system were proposed to be as simple and transparent as can be. Information about the last seismic event for which data were introduced, as well last update of the database and the number of earthquakes included in the analysis are presented in the main menu (Fig. 1-3).

The data that will be processed (input data) are stored in a database; the tables are the fundamental elements that create a relational database. It is essential that each database table to contain specific information related to a single type of object. A table represents a collection of interconnected data that are stored in rows and columns; each line contains one entry - a full entity of data on a particular type of an object. In turn, each record is composed of columns or fields - a field being the smallest data entity.

An example of such table created in Microsoft Access 2003, named Earthquakes, is shown in Fig. 4. Each field must be linked, somehow, to its destination table. Interaction with tables is rarely directly. Therefore, other Microsoft Access objects (queries, forms and reports) are associated to these tables. When the program should display or refer to the data that are stored in the database, a form or a report will retrieve data from the associated table or query and will display the information in a form or a report format.

The information from the tables are related to each other in order to correlate all necessary data, based on primary keys associated with each table, keys that are used including for their indexing.

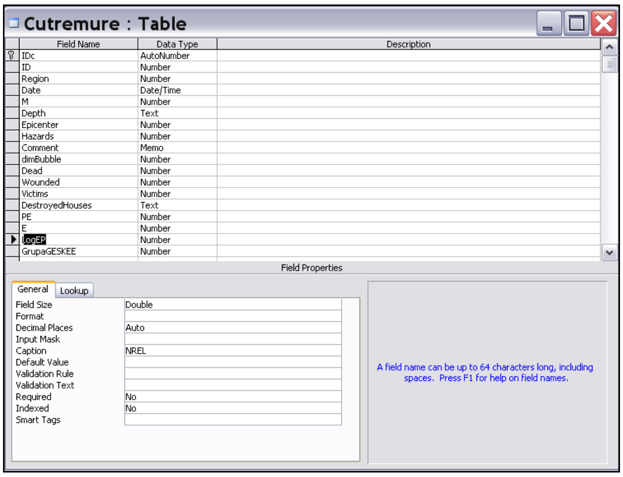

Figure 4 *Earthquake* Table

Database integrity is constituted by the entity and referential integrity. Entity integrity ensures that there are no duplicate records within the table and that the field that identifies each record within the table is unique and never null. Referential integrity ensures that relationships between tables remain consistent. When one table has a foreign key to another table, the concept of referential integrity states that you may not add a record to the table that contains the foreign key unless there is a corresponding record in the linked table. Fig.5 presents the relationships between database tables.

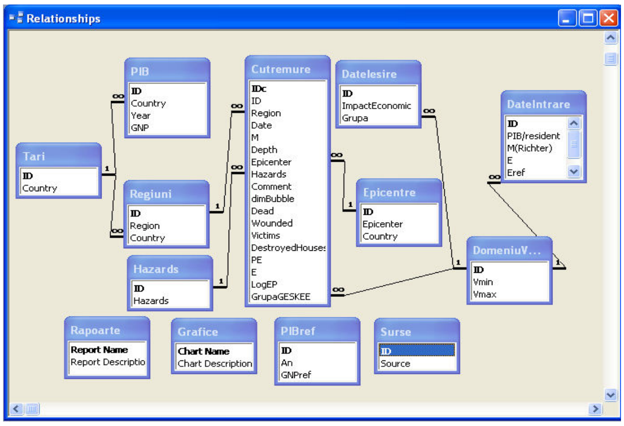

Figure 5 Tables and Relationships

The GESKEE Disaster Scale can be used for impact assessment, using the following steps:

→ *input data* (Fig.6): *Create New Earthquake* (New EQ) – date, region, earthquake size (Magnitude), direct, composite and developmental indicators (GNP), data on casualties and damage assessed loss (EL), patterns of the affected area;

→ *processing of data* (Fig.7): log NREL using Equation (1) and correlation of other data with specific value ranges and casualties ratios, by development groups;

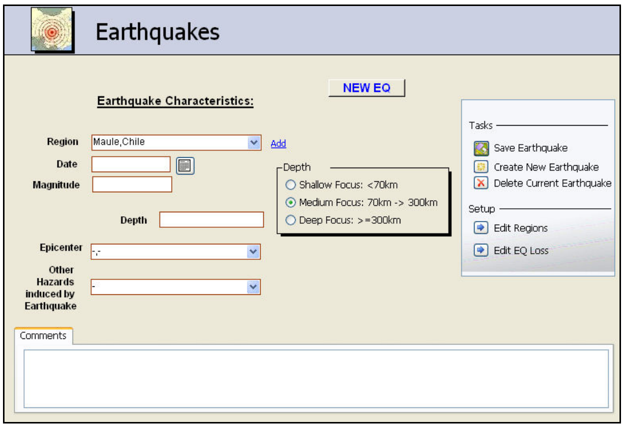

Figure 6 The *Add Earthquake* form

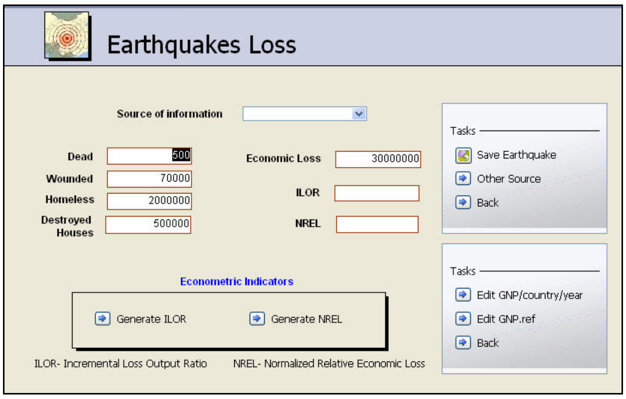

Figure 7 The *Add Earthquake Loss* form

Additional data about seismic loss can be introduced in *Earthquakes Loss* Menu (Fig.7): GNP value of a country (Edit GNP/country/year) and the GNP as reference (Edit GNP.ref), e.g. GNP of U.S.A., selections presented in Fig.8. Entering this data, the econometric indicators can be calculated: *Incremental Loss Output Ratio* (ILOR) and *Normalized Relative Economic Loss* (NREL) (Fig. 7).

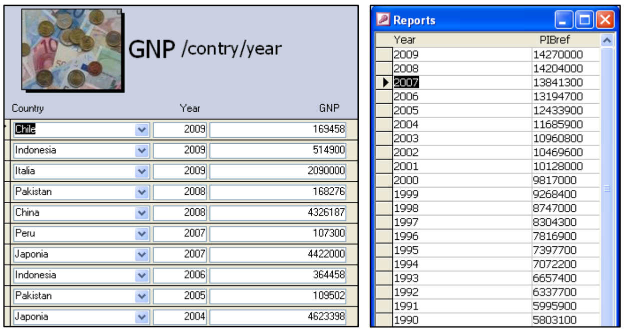

Figure 8 GNP of countries and GNP as reference

From The *Edit Module* of GESKEE Database (Fig.2) can be access *Edit Reports* and *Edit Charts* Options. Fig. 9 presents the default reports and charts that can be accessed. In case of further needs (for example, in case of next Scale update) other reports and graphs can be also be defined.

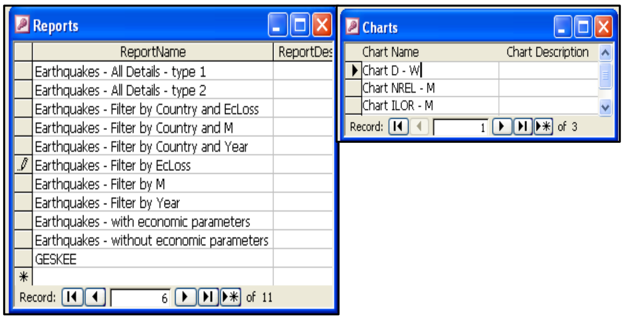

Figure 9 *Edit Reports* and *Edit Charts* Options

Browse All Earthquakes Option from The View Module of GESKEE Database (Fig. 3) displays the information stored in the database on specific earthquakes. Also, filters for selection can be used (for example, by country or by year of seismic event). As example, Fig.10 the browsing information related to all earthquakes from the database filtered by country (Turkey).

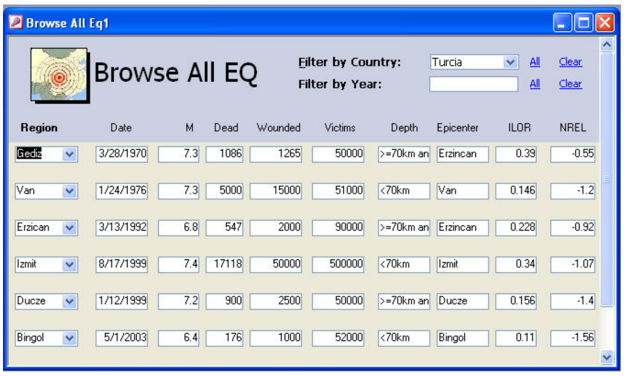

Figure 10 Browsing by country (Turkey) option

View Charts and *View Reports* Features from The *View Module* of GESKEE Database (Fig. 3) allow viewing graphs and reports according to selection that had been made (Fig.11).

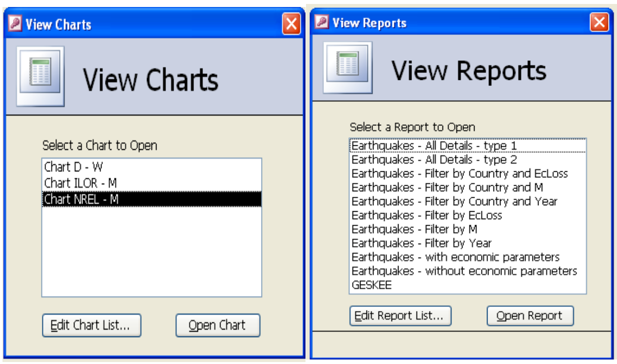

Figure 11 *View Charts* and *View Reports* Features

Additional to graphs and reports that are strictly related to Seismic Disaster Scale (GESKEE) other reports and charts were also created. It can be used for different purposes such as: additional comparative loss analysis, in filtering earthquake by Country and Loss, by Country and magnitude, by country and year of event, by economic parameters etc.

→ *output data*: relative scaling of the seismic event impact (disaster size) versus other national and international disasters, recovery alternatives and needs of assistance, projections of the GNP falls and development implications of the respective loss, recommended rehabilitation policies to be endorsed by the concerned boards (Fig.12 - 14).

This disasters scaling approach can refer to direct, indirect and developmental effects, using specific indicators.

GESKEE Report No. 25 on 02/04/2010

INPUT DATA: INDEX	INPUT DATA: TYPICAL VALUES / DEVELOPMENT LEVEL	VARIATION AREA [log NREL]	OUTPUT DATA: RELATIVE POSITION ON DISASTER SCALE			OUTPUT DATA: THE PREDICTED ECONOMIC IMPACT AND ECONOMIC RECOVERY POLICY
GNP/capita	Low-income and lower middle-income countries or in difficult circumstances	0.7 → 3.5	3.37	Haiti	(2010)	THE IMPACT CAN BE STRONG IF CAPITAL OR LARGE URBAN CENTRES HAD BEEN AFECTED MAY BE FELT SUDDEN DECREASES OF ECONOMIC INDICATORS, AND ECONOMIC RECOVERY (IF IT IS IMPLEMENTED) IS DIFFICULT WITHOUT INTERNATIONAL ASSISTANCE DUTIES ASSOCIATED WITH FOREIGN LOANS FOR RECONSTRUCTION MAY HINDER THE DEVELOPMENT, IF THE LOCAL ECONOMY CAN NOT PROVIDE FOR DEFERRED DEBT PAYMENT AND LOCAL INVESTMENT
MAGNITUDE	5.5 – 8.0		2.80	Nicaragua	(1972)	
$ILOR = \frac{EL}{GNP}$	10 – 50 (%)		2.27	El Salvador	1986)	
$NREL = ILOR \times \frac{GNP_{ref}}{GNP}$	2 – 0.05 (%)		2.23	Guatemala	(1976)	
INDEX THAT CHARACTERIZE DIRECT LOSSES AND THEIR IMPACT			1.70	Ecuador	(1987)	
			1.33	Yugoslavia	(1963)	
			1.25	Chile (var.2)	(2010)	
			1.18	Chile	(1985)	
			1.10	Chile (var.1)	(2010)	
			0.87	Japonia	(1948)	
			0.73	Japonia	(1923)	
GNP/capita	Countries with midium and medium-high income, medium countries, tourism, oil exporting, centralized economy	-0.5 → 0.7	0.68	Peru	(2007)	THE IMPACT CAN BE STRONG IF CAPITAL OR LARGE URBAN CENTRES HAD BEEN AFECTED THERE MIGHT BE NATIONAL ECONOMIC DECLINE ECONOMIC RECOVERY IS POSSIBLE ACCORDING TO THE STRATEGIES AND TO THE ECONOMIC TACTICS ADOPTED, WITH FINANCIAL LOANS WHICH ARE WELL USED
MAGNITUDE	5.9 – 8.1		0.67	Algeria	(1980)	
$ILOR = \frac{EL}{GNP}$	3 –10 (%)		0.60	Iugoslavia	(1979)	
$NREL = ILOR \times \frac{GNP_{ref}}{GNP}$	10 – 2 (%)		0.50	Pakistan	(2007)	
INDEX THAT CHARACTERIZE DIRECT LOSSES AND THEIR IMPACT			0.58	Iran	(1990)	
			0.47	Romania	(1977)	
			0.44	Indonesia	(2008)	
			0.41	Filipine	(1990)	
			0.40	Egipt	(1992)	
			0.38	Iran	(2009)	
			0.30	Grecia	(1981)	
			0.24	Grecia	(1986)	
			0.12	Venezuela	(1967)	
			0.11	Indonezia	(2003)	
			0.082	Romania	(1940)	
			0.03	Pakistan	(2005)	
			-0.15	Mexic	(1985)	
			-0.36	Japonia	(1988)	
GNP/capita	Industrialized countries, countries with high income or large enough to deal the impact by resource redistribution	≤ - 0.5)	-0.55	Turcia	(1970)	THE ABSOLUTE VALUES OF LOSSES CAN BE LARGE IF WERE AFFECTED URBAN AREAS WITH MAJOR NATIONALLY AND INTERNATIONALLY ECONOMIC ROLE, ECONOMIC INDICATORS MIGHT TEMPORARY DROP IN THE AFFECTED AREAS ACCORDING TO NATIONAL AND INTERNATIONAL SITUATION, MAY OCCUR DEPRESSION ECONOMIC RECOVERY IS POSSIBLE WITH LOCAL / NATIONAL RESOURCES
MAGNITUDE	6.7 – 8.3		-0.57	Italia	(1980)	
$ILOR = \frac{EL}{GNP}$	0 –3 (%)		-0.90	Italia	(1976)	
$NREL = ILOR \times \frac{GNP_{ref}}{GNP}$	≥10 (%)		-0.92	Turcia	(1992)	
INDEX THAT CHARACTERIZE DIRECT LOSSES AND THEIR IMPACT			-1.00	China	(1976)	
			-1.07	Turcia	(1999)	
			-1.08	Armenia	(1988)	
			-1.20	Turcia	(1976)	
			-1.26	Japonia	(1964)	
			-1.40	Turcia	(1999)	
			-1.44	China	(2008)	
			-1.45	Japonia	(1995)	
			-1.50	China	(2008)	
			-1.52	Italia	(2009)	
			-1.56	Turcia	(2001)	
			-1.95	Italia	(1997)	
			-2.00	China	(2004)	
			-2.09	SUA	(1906)	
			-2.18	Japonia	(1968)	
			-2.33	SUA	(1994)	
			-2.37	India	(2001)	
			-2.54	Japonia	(1978)	
			-2.82	SUA	(1989)	
			-2.84	Japonia	(1983)	
			-3.07	SUA	(1964)	
			-3.19	India	(1993)	
			-3.32	SUA	(1971)	
			-3.33	Japonia	(1993)	
			-3.39	Japonia	(2005)	
			-3.56	Japonia	(1993)	
			-3.60	Japonia	(1999)	
			-3.73	Japonia	(1994)	
			-4.28	Japonia	(1994)	
			-4.34	Japonia	(1999)	

Figure 12 *GESKEE Disaster Scale* (GESKEE Database Report)

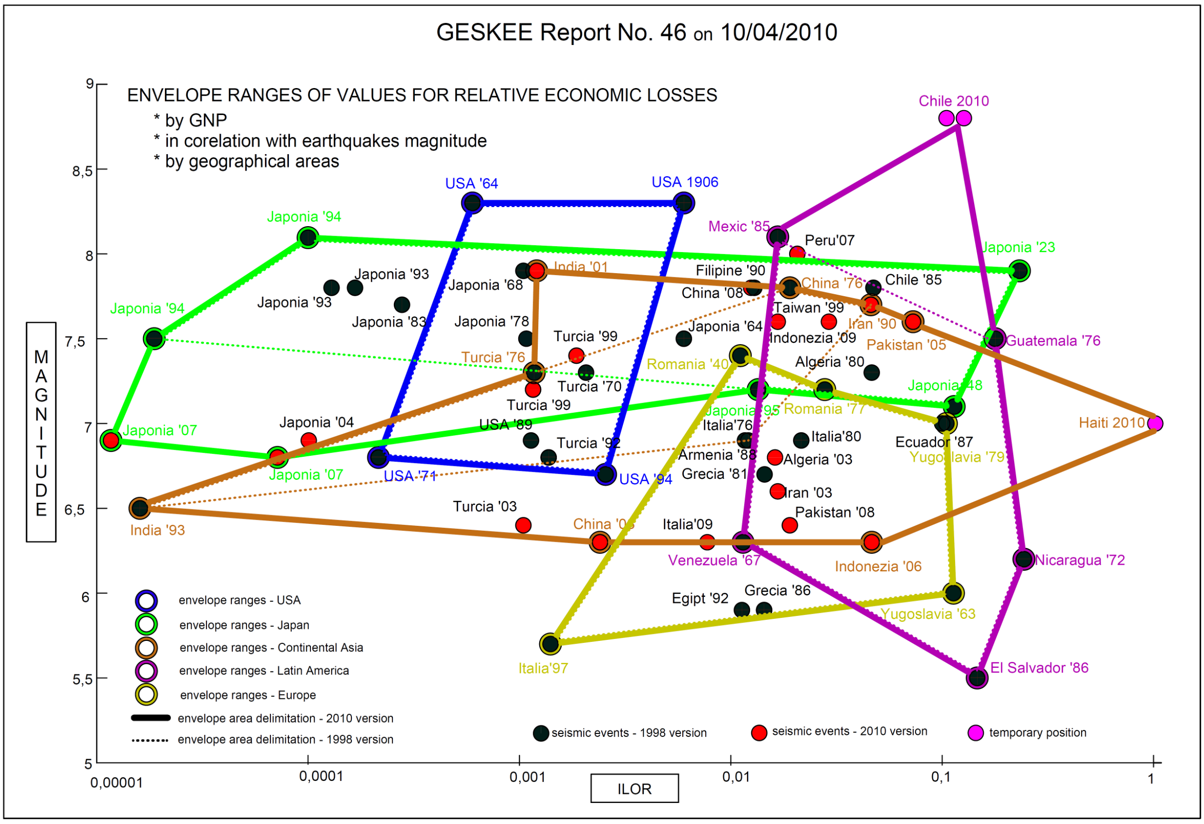

Figure 13 Envelope ranges of values for relative economic losses, in correlation with the magnitude of earthquake for selected countries and geographic zones (GESKEE Database Report)

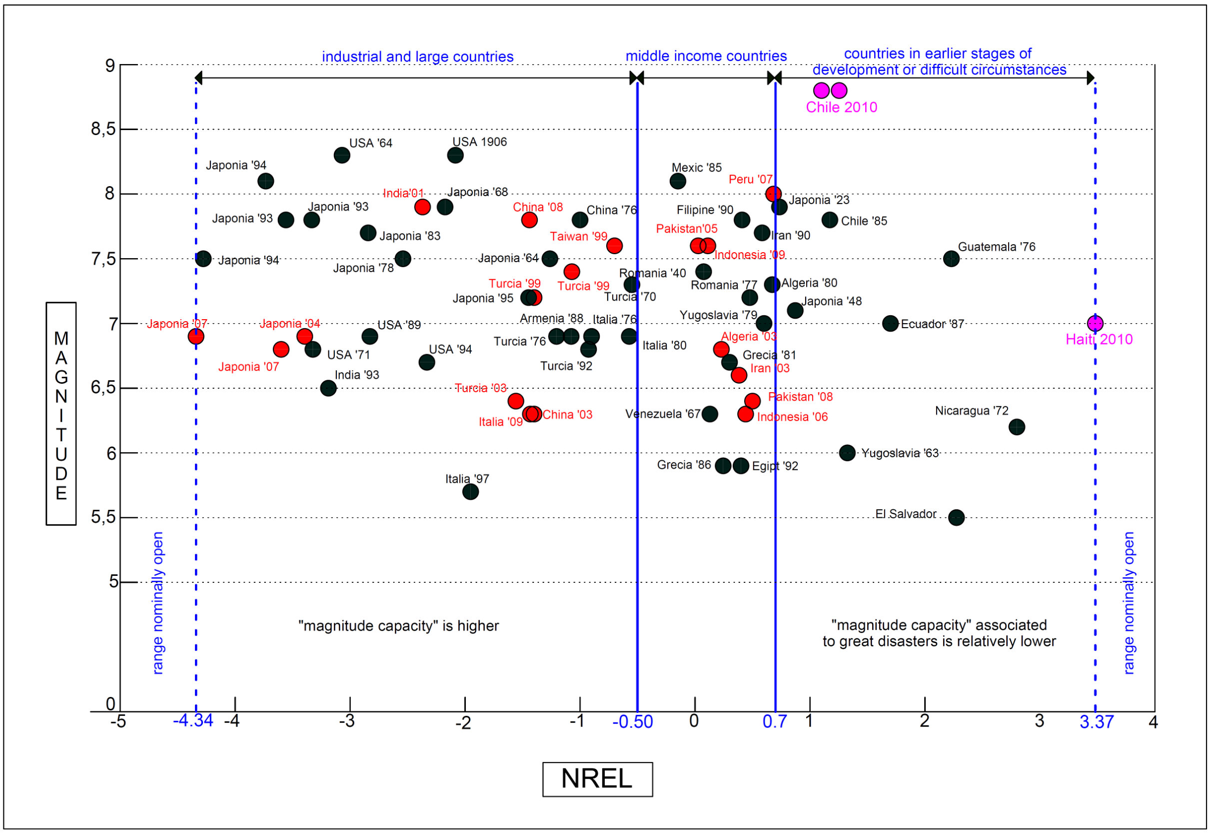

Figure 14 Increase of capacity to cope with earthquake economic impact, expressed as a correlation between log E/P, range of magnitudes and level of development (GESKEE Database Report)

The concentrated form of the GESKEE Disaster Scale (Fig.12) proved to be useful in explaining the relationship between magnitudes, loss size, the country's economic level of development (i.e. economic power), the earthquake disaster prevention policies, the disaster impact and the patterns of post-disaster recovery, geographic setting, with promising results and predictive value.

Each of the indicators included in the scale and in graphic representations (Fig.13 and Fig.14) provides a pattern of risk and disasters.

The trend of earthquake disasters in the world is towards the relative disaster reduction for the countries able to simultaneously provide disaster prevention and development.

Each group of countries, as well as each country, has a “risk and disaster fingerprint” reflecting its impact patterns and its likely response to a given size earthquake, for a given historical age, and geographical location, function of development, topographical settings and specific values of loss indicators.

When the replacement speed of the built stock is not high, the predictive role of past losses analysis can be accepted for periods of up to 10-20 years. While the industrialized, high income countries cope with disasters with large economic losses but usually with reduced life losses and affordable recovery, the countries engaged in development suffer casualties and larger losses in relative terms, that may endanger their future development, if a culture of disaster prevention has not been built in due time.

For example, based on the seismic disaster which occurred in Haiti, in [15] is analyzed an endogenous growth model, taking into account the risk of a natural catastrophe. Based on the fact that an economical growth model leads to an optimal control problem, it must be considered all the necessary conditions for the optimal solution of the economical growth problem in case there exists a risk factor of a disaster occurring.

From fig.14 we can point that countries of Latin Americas suffered relative economic losses in a well defined range. About the last entry in the Scale, (Chile 2010, 27 February), considering the relatively low level of losses in correlation with large magnitude, we can say that this earthquake confirms that the earthquake protection is a vital component of economic development. For this reason, the reconstruction of the most pressing damaged components will take years and a lot of resources from development budget. The Chilean state was and still is on track to healthy development in his regional groups of countries. Given the particular size of earthquake, it has been shown once again that insistent and correct application of buildings codes can reach this goal. This issue is revealed mainly in the limited number of casualties and in the damage level that have been observed. On the other hand, the large number of homeless would be a problem for future social policy in Chile.

5 Conclusion and further work

In this paper we introduced the GESKEE database which is an indispensable tool in social and economic quantification of seismic vulnerability of buildings and earthquake loss. Due to GESKEE database use, the predictive value of the GESKEE Disaster Scale is increased the Scale becoming more transparent and efficient, providing a better understanding of past seismic events impact and so a real help in calibration of earthquake disaster prevention policies.

Among future developments of this software we can mention the analyze and the inclusion of indirect loss cause by seismic events in econometric approach to generate and achieve different regional impact scenarios. We also intend to adjust the software and create a new version that can be used in insurance field, to link and calibrate Seismic Risk and Earthquake Catastrophe Insurance Premiums for our country.

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