ZONING OF AREAS AND POPULATED CENTERS FOR REDUCING THE EFFECTS OF NATURAL DISASTERS

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Abstract: *For monitoring natural hazards are necessary zoning of areas within localities to reduce the effects caused by frequent natural disasters such as: floods, landslides, earthquakes, etc.. In all cases for zoning are necessary maps in digital format and the digital model of the terrain - MDT. For damage assessment and decision making it is important that these maps are suitable to the simulation, according to the obtained results from simulations to determine exactly which area will be affected with a high probability. Based on these forecasts we can do multiple scenarios progressing, risk analysis, detailed simulations.*
This involves handling a large number of very diverse data unevenly distributed geographically. Zoning areas within areas and populated centres is intended to reduce the effects of flooding.

Keywords: *digital model; natural disasters; deployment of forecasting, warning and alert systems for cases of flooding*

1. Introduction

For monitoring natural hazards are necessary zoning of areas within localities to reduce the effects caused by frequent natural disasters such as: floods, landslides, earthquakes, etc..

In all cases for zoning are necessary maps in digital format and the digital model of the terrain - MDT. For damage assessment and decision making it is important that these maps are suitable to the simulation, according to the obtained results from simulations to determine exactly which area will be affected with a high probability. Based on these forecasts we can do multiple scenarios progressing, risk analysis, detailed simulations.

This involves handling a large number of very diverse data unevenly distributed geographically.

Zoning areas within areas and populated centres is intended to reduce the effects of flooding.

Flood risk management means applying policies, procedures and practices with the objectives of *identifying risks, their analysis and evaluation, treatment, monitoring and reassessment* to reduce their risk so that human communities, so that all citizens can live, work and meet the aspirations in a sustainable physical and social environment .

Flood risk is characterized by the nature and probability of producing, the exposure of receptors (number of population and goods), the susceptibility to flooding of receptors and their value, resulting that risk reduction needs to be done on influencing its characteristics.

The main problem in the management of flood risk is the one of the *accepted risk* by the public and the decision makers, knowing that there is no total protection against flooding (zero risk), as there is no consensus on acceptable risk. Consequently, *acceptable risk* must be the result of a balance between risks and benefits attributed to an activity as a consequence of risk reduction to flooding, or of a governmental regulation.

Mitigating the consequences of flooding is the result of an extensive combination of preparatory measures and actions before the occurrence of the phenomenon, the management during the flood and post flood (reconstruction and lessons learned as a result of the occurrence of the phenomenon).

As a result, at global level it is used a more complete concept of flood management that includes both flood risk management and management of emergencies caused by floods. In order that the government's, the authorities and relevant agencies, the community efforts, to be coordinated and have the result of a community prepared to face the phenomenon of floods, the flood management must be addressed in an integrated manner.

2. Prevention activities (prevention, protection and preparation)

These actions are focused to prevent / reduce potential damage caused by floods by:

- avoid construction of housing and social buildings, cultural and / or economic ones in potential flood areas, with the presentation of data on the effects of previous floods in planning documentation, adapt of the future developments to the flood risk terms, promoting appropriate practices of the use of land and of agricultural land and forestry;
- producing structural protection measures, including the bridges and small bridges;
- development of non-structural measures (control of the use of minor water beds, basin plans for flood risk reduction use and of measures programs, introducing of security systems etc.);
- identification in detail, of the geographical demarcation of the natural flood risk areas - ***fig. 1***. of an administrative unit of the territory , the inclusion of these areas in the general urban plans and regulations provided for the planning of specific measures for prevention and mitigation of flood risk, the carrying out of construction and of land use;
- deployment of forecasting, warning and alert systems for cases of flooding;
- maintenance of the existing flood protection facilities and of the beds watercourses;
- implementation of protection works against flooding of the rivers in the area of existing bridges and small bridges
- communicating with people and educating them on flood risk and how to act in emergency situations.

3. Operational management activities (emergency management) to be taken during the development of the flood phenomenon.

- detect potential floods and the formation of probable floods;
- flood forecasting for the evolution and spread along water courses;
- warning of the authorities and population on the extent, severity and time of occurrence of the floods;
- organization and response actions of public authorities and population on emergency situations;
- provision of resources (material, financial, human) at the county level for operative intervention;
- enable of the operational institutions, resource mobilization, etc.

Fig. 1. Identification of natural flood risk areas

Activities to be undertaken after the flood phenomenon:

• helping to meet the immediate needs of people affected by disaster and the return to normal life;

• reconstruction of damaged buildings, of infrastructure and of those of the flood protection system;

• review of flood management activities in order improve the planning of intervention that will deal with future events in the affected area and in other areas .

Assessing the vulnerability of exposed elements, material damage and human losses

Vulnerability refers to the ability of an item exposed during the impact of natural hazards. Definition of vulnerability of a natural hazard generally refers to the characteristics of an element exposed to the hazard – road, building, person, economic and social objective - that contributes to the ability of this element to resist and to recover following the impact of natural hazards.

Through GD 447/2003 vulnerability is defined as the degree of impairment of an item or group of items in an area exposed to landslides. Is expressed in a scale from 0 (no loss) to 1 (total destruction). For loss of human lives, vulnerability is the probability that a life located in the area is affected by the landslide activity, and to be lost if the landslide occurs.

Vulnerability of people is a matter difficult to assess, making it normally the subject of socio-economic and administrative investigations that are very extremely detailed, and which unfortunately were not provided by Romanian law and were not done in Romania (until now).

Social vulnerability, which assesses the individual's ability to recover from involvement in natural hazards can be analyzed on four following different levels:

• Individual in domestic environment (refers to the attributes / personal potencies of response);

• Community (refers on the response of the individual with the social environment in which it develops).

• Regional / geographic (distance to the work of the employee);

• Administrative / institutional (the funds allocated to disaster and to prevention studies).

This simplification aims to illustrate that there are various factors that contribute to social risk, due to natural hazards, including those that are relating to the administration of regional environmental hazards in the region or at home, going up to individual attributes.

Table 1.Categories of elements exposed to landslides and the coefficients of vulnerability

buildings (regardless of destination / use)	Of poured concrete, concrete panels	0,05
Housing, urban social, economic buildings	foundation concrete, brick masonry (see rules)	0,2
	Foundation + masonry brick foundation, wood building	0,3
	foundation stone + brick masonry	0,7
	adobe	0,92
Pipes (any type)	parallel to contour lines	0,8
	oblique to the contour lines	0,4
	perpendicular to the contour lines	0,1
electric lines, telecommunications		0,3
Roads	National-maintained roads according to Norms	0,1
	paved county roads- maintained according to Norms	0,3
	communal paved - maintained according to Norms	0,4
	Unpaved Public - maintained according to Norms	0,5
	Unpaved, unmaintained	0,7
Railways		0,1
Lands	Non arable	0,1
	Arable	0,5
Rare forest	Partially exploited	0,5
	Unexploited	0,1
Dams		0,05
Irrigation channels		0,2

In ***Tables 2 and 3*** are written concrete data of the Lower Danube area, the data used to develop risk maps.

Zoning areas and populated centres to reduce the effects of landslides.

In the risk assessment, were established following values of the vulnerability factors, assigned to the elements set out and exposed to landslides - ***Table 1***

Table 2. Data for risk map development in the area of Dunărea de Jos – Loc. Lunca

Data for risk map development		**On location**	**On landslides affected areas**
Number of inhabitants		476	150
Number of buildings affected by landslides		135	35
Number of constructions	Half-timber	-	-
	Wood	-	-5
	Bricks	130	35
	Stone/Concrete	5	0
Coverage of the municipality constructed surfaces			30%
Medium annual precipitation and temperature values			
Indicative value of municipality surface (lei)	Built	4000/ha	1000/ha
	Cultivated	2000/ha	500/ha
Indicative value of the land terrain (lei)	Agriculture	2000/ha	500/ha
	Forest	-	-
	Pasture	2500/ha	
Indicative value of a medium household	Half-timber	-	-
	Wood	-	-
	Bricks	150000	50000
	Stone/Concrete	-	-
Total number of km of roads	Asphaltated	-	-
	Non-asphaltated	4	2
Number of administrative, socio-cultural, educational, sports buildings.		1	1
Total number of bridges	Of concrete	7	3
	Of wood	-	-
Number of dams		-	-
Total number of water reservoirs		-	-
Total number of industrial units		-	-
Total number of km of railways		2	-
Number of railway constructions		1	-
Number of hydro facilities		-	-

Table 3. Data for risk map development in the area of Dunărea de Jos – Loc. Tăuni

Data for risk map development		**On location**	**On landslides affected areas**
Number of inhabitants		398	100
Number of buildings affected by landslides		245	50
Number of constructions	-	-	-
	-	-5	-5
	245	50	35
	-	-	0
Coverage of the municipality constructed surfaces			30%
Medium annual precipitation and temperature values			
Indicative value of municipality surface (lei)	7000/ha	1500/ha	1000/ha
	6000/ha	3000/ha	500/ha
Indicative value of the land terrain (lei)	6000/ha	-	500/ha
	-	-	-
	3000/ha	2000/ha	
Indicative value of a medium household	-	-	-
	-	-	-
	40000	15000	50000
	-	-	-
Total number of km of roads	-	-	-
	14	1	2
Number of administrative, socio-cultural, educational, sports buildings.		1	-
Total number of bridges	5	2	3
	-	-	-
Number of dams	-	-	-
Total number of water reservoirs	-	-	-
Total number of industrial units	-	-	-
Total number of km of railways	-	-	-
Number of railway constructions	1	-	-
Number of hydro facilities	-	-	-

Material losses are considered direct losses, which relate to direct damage to housing and infrastructure and that are easiest to quantify. We have not taken into account indirect losses relating to the economic consequences such as loss of value, rising of unemployment and other indirect economic effects, which are more difficult to assess / estimate

In the present context, one of the most important requirements of seismological research is the realization of a methodology for developing hazard and risk maps.

This requirement derives, on one hand, from the accelerated economic and social developments, which impose also reviews on technical rules of construction, zoning and planning and, secondly, the alignment requirements (harmonized) European standards, based on results of research conducted in the last decade in the related scientific and technical fields.

4. Zoning of areas and populated centres in order to reduce the effects of earthquakes

Another necessity for achieving such a development methodology for hazard and risk maps is that in recent decades, natural disasters, particularly earthquakes, were much more frequent and destructive, affecting large population concentrations. So far, the international community's response to the frequent disasters caused by hazards has been mainly focused on rescue and relief activities of the affected population, actions that in fact, do not solve the problem, but only improve post disaster situations. In this case, scientists in the field of seismology intensified theoretical and experimental studies (*in situ* and in laboratories) for investigation of natural and anthropogenic causes which have contributed to the occurrence of losses of lives and property. Thus, the tradition was continued, that immediately after a major earthquake, to perform inventory and assessment of macro seismic effects, supported through an international cooperation, which enabled the accumulation of a vast material on how large earthquakes act on man and environment, on buildings, construction and the surface of the earth.

From the analysis and processing of information, one have found to be possible to reduce losses of lives and material goods, by taking all the measures required by the situation, through the management (supervision and control) of the post-disaster crisis. But the most important measure of prevention and mitigation of potential future seismic disasters as a solution is the adoption of modern seismic design made based on seismic hazard maps, valued at global, regional and local levels.

Among other fundamental concepts of operating the seismic design of civil and industrial objectives, an important role goes to concepts of seismic hazard, seismic vulnerability and seismic risk.

4.1. *The seismic hazard* is independent of human activity and is beyond human control, being determined only by natural factors, such as produced earthquake magnitude, epicentre distance, depth of the furnace, the direction towards the fault plane relative to the point M in which is calculated the hazard, the relationship between rupture length and magnitude, the maximum possible magnitude of the source, intervals after the earthquakes of this magnitude can be repeated again, the local geological structure given in point *(M).*

4.2. The seismic hazard (H) is a function *P (Y>y)* that describes the possibility that in a given point *(M)* and in a time frame *(T),* the value of the parameter *Y* (that can be : macro seismic intensity, acceleration, velocity of displacement of soil) to exceed the given value *(y)* as an effect of an earthquake (no matter where its furnace is). The seismic hazard can be expressed analytically as a family of point functions or graphically by a family of curves showing the probability of occurrence of different values of the chosen parameter:

$$H = P\,(Y > y) \qquad (1)$$

4.3. Seismic vulnerability (V) is a measure of the ratio between the amount of losses due to damage caused by an earthquake and total (economic and social) value before producing the damage in a given area.

4.4. Seismic vulnerability observed (VO) is represented by the determined seismic vulnerability assessment made after an earthquake caused damage.

4.5. Predicted seismic vulnerability (VP) is calculated on the basis of vulnerability anticipation of a future earthquake, taking into account potential damage to the most vulnerable targets

Seismic vulnerability depends mainly on human activity by how the earthquake protection objectives were constructed and their by their economic value.

It also depends on the wear vulnerability and weakness of the resistance of structures due to repeated subjection to factors that can weaken it (previous earthquakes, industrial vibration, etc.).

The general trend is that vulnerability increases with time, both because of higher value of the targets that can be destroyed (by installing advanced technology, sophisticated apparatus, etc..) and also due to the resistance weakening of old plants.

4.6. Specific seismic risk (r_S) is a function expressing the probability that in a given location to produce in a given time, a certain percentage of total losses (economic and social), as the effect of an earthquake that might take place there, effects characterized of considered parameter values (intensity, acceleration, speed of soil) greater than a certain value.

Specific seismic risk can be expressed by the relation:

$$r_s = H \times V \quad (2)$$

Where: r_s is the specific seismic risk;

Relation (2) expresses a probability of a compound event and is given as a product of elementary probabilities H and V (the law "and-and" corresponding to the fact that they happen simultaneously both the effects described by H and those described by V). To the limit when there are no objects on the soil surface, $V = 0$ so r_s is null.

Another extreme case is when $r_s = 0$ is of an area far enough of seismic sources, so the earthquakes effects (wherever they happen) will not be felt in the area. It results in this case that the hazard will be zero, and according the relation (1) the risk is null, even if the existent values in the area are large.

4.7. The seismic risk (R) is the probability to produce a damage of a total given value ă (V_{tot}) in a point where the specific seismic risk is r_s, so:

$$R = r_s \cdot V_{tot} \quad (3)$$

From (1) and (2) results that one can express the seismic risk *(R)* by means of seismic hazard *(H)* and of vulnerability :

$$R = H \cdot V \cdot V_{tot} \quad (4)$$

4.8. Seism tectonic method of seismic zoning. Establishment of regional maps through the seism tectonic method

Conventionally, based on historical and instrumental seismic data, Romania was divided into nine provinces of physiographic-seismological areas, divided themselves into smaller parts called zones (Mârza Constantinescu, L. & V., 1980) - ***Figure 2.***

In general, it is widely accepted the assumption that *Zona Seismogenă Vrancea*, located in the Eastern Carpathians bend is cantered on an active triple junction following major tectonic units: *Placa Est-Europeană, subplaca Intra-Alpină şi subplaca Moesică.*

Closely related to the outbreaks distribution, we can mention the existence of a strong movement of neotectonic ascension and thickening sedimentary lair, a total of 18 km, of which 12 km are part of the Sarmato-Pliocene deposits (Gavăt et al., 1973).

In the *Vrancea Seismogene Zone*, earthquakes occur inside the crust (in crustal earthquakes with depths less than 60-70 km) and, especially, under the crust (sub crustal earthquakes, with depths exceeding 70 km).

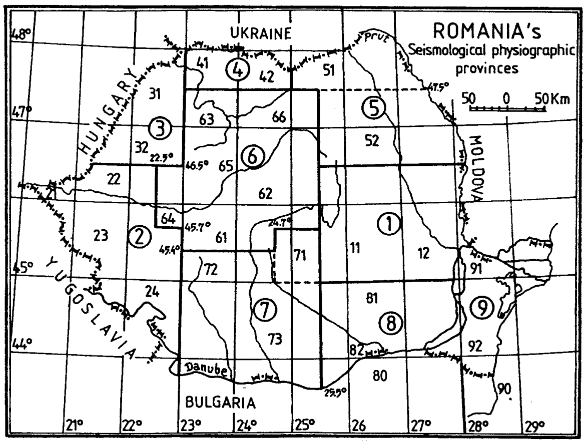

Fig. 2. The provinces

The hypothesis of the active triple junction in the area of curvature of the Eastern Carpathians is supported, on one hand by prestigious papers, regarding the tectonics and seismicity of Romania's territory and, on the other hand, historical information, the hypothesis was verified by characteristic earthquakes genesis in the *Vrancea area.*

Structural development schemes with hydro defence works against floods, up to this period, have been centred on economic and social objectives aimed or at defending specific areas where they are located more complex social - economic development facilities.

The climate changes that followed, showed great intensity of rainfall with long periods of time and floods have generated chains of water flows with residual changes from one flood to another, of the hydro geological characteristics of soil, of riverbed morphology, of structural characteristics of hydraulic works. In this case it was found that losses due to such complex phenomena, with extreme probabilities, are much higher than producing in a single flash with maximum flow associated with a lower probability of occurrence.

Flooding curves calculations are carried out by these studies have a high accuracy level and are based on topographic surveys, hydrological, hydraulic works carried out on the water (roads, bridges, rapids, etc..), and on the effects of existing hydraulic works in the proposed scheme of arrangement and on those proposed to be developed.

If a sufficient number of points where we can write equation (7) exists, then we can create a pattern of anomalies altitudes, so in the future, one can be calculated knowing the ellipsoid altitude, the normal altitude and / or knowing the normal altitude , the ellipsoid altitude. Such a model can be used in practice, either in a flat representation system for projection (equidistant contours) or numerical in an automatic computing application.

5. The theory spline interpolations

It would seem that in the case of polynomial interpolations, the quality increases with the degree of polynomial interpolation used. Unfortunately, this is not generally true, for different functions, polynomial interpolation tend to swing more and more between nodes with increasing polynomial degree. Therefore, it is possible to occur some numerical instability.

Such oscillations are avoided by the method "spline" functions initiated by IJSchromberg in 1946 (Quarterly of Applied Mathematics), widely used today.

The name comes from "draftman's spline"which is an elastic rod (as the fishing lines) folded to pass through the data points and held in place by gravity. This interpolation is a polynomial interpolation "from pieces".

Given *f(x)* on interval J , one divides the interval J in sub-intervals with common extremities "nodes".

$$a =\leq x_0 < x_1 < \cdots < x_n = b \qquad (5)$$

One can look for a function $g(x)$ with which interpoles the function $f(x)$ so we can have in the nodes $g(x) = f(x)$, so $g(x_0) = f(x_0), g(x_1) = f(x_1), \cdots, g(x_n) = f(x_n)$ If the polynome $g(x)$ that describes each of the sub-intervals, allows that $g(x)$ to be several times differentiable, the resulted function is called "spline" .

Generally the method is numerically established, because $g(x)$ oscillates very difficult. The simplest spline interpolations use linear functions, but these features chart is unfortunately a broken polygonal line, which in some cases does not satisfy. For this reason, it is still considered cubic spline functions $g(x)$, on $a \leq x \leq b$, as a continuous function and taking derivative of order 1 and 2 anywhere in between That is why $g(x)$ is formed of *n* polynoms, one for each sub-interval.

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