THE USAGE OF TECHNOLOGIES IN TERRESTRIAL MEASUREMENTS FOR HAZARD MAPS

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Abstract: In the context of natural phenomena (earthquakes, floods, landslides etc.) bring economical and social prejudices year by year, watching on them and taking decisions becomes mandatory for reducing the material and human lives loss. Making hazard maps represents a tool used on wide global scale but also particularly in our country. This paper work has the purpose to reveal the interests of certain authors related to the usage of the new technologies of terrestrial measurements (GPS technologies, photogrammetry, cartography and of remote sensing) in order to make these hazard maps.

Key words: terrestrial measurements, risk, hazard maps, management.

INTRODUCTION

Hazard maps are digital maps scaled 1:25 000 to 1:50 000, representing wide areas at local level purposed to determine high risk zones for earthquakes, floods, landslides, fires etc. In this work paper we are only giving attention to hazard maps for floods and landslides. Starting with hazard maps, risk maps are realized at higher scale (1:5 000-1:10 000) which are even more complete and they allow a detailed analysis of the loss evaluation and they can also be used for obtaining building permission and making general and local urbanism drafts.

Digital maps designed for hazard and risk maps control are generally made of graphical data basis (the digital map itself) which is being attached the attributes basis structured on connected areas regarding the general features of places situated in the area zones affected by natural hazards such as earthquakes, landslides, floods and also those ones of potential areas (Stoian, 2006; Stoian, 2007). This way, the content of these maps starts to be shaped and it has the following structure (figure 1).

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http://istgeorelint.uoradea.ro/Reviste/Anale/anale.htm
Figure 1. Digital map support for hazard map making

Figure 2. The digital map representing the relief in the Municipality of Cluj-Napoca

- geographical localizing, natural area, geomorphologic data, hydrographical network;
- dynamical parameters of the land, geological features;
- territorial structure, categories of usage;
- localities affected by natural risks contented by law 575/2001;
- technical infrastructure, categories of works situated on the county area;
- hydro technical works having a defending role against floods;
- hydro technical works which can affect the pass regimen;
- works of landed improvement;
- works regarding the communications and transport networks for road traffic, railway traffic and maritime traffic;
- works of crossing river’s inflows.

Categories and the structure of buildings, highness regimen, construction materials. The representation of the relief which has a great importance for hazard maps it’s made of level curves or by representing the digital pattern of the land / yard (figure 2).

The methodologies of usage for data acquiring regarding plotting of hazard and risk maps were based on classical and modern tools, starting with GPS technologies for making the support system within the geodesic datum adopted (Krasovski - 1942 ellipsoid, protection system Stereo 70, Marea Neagră 1975 altitude system, 1990 edition) technologies of making ortophotos based on photogrammetric flights made between 2005-2010 and satellite multispectral recordings, for analysis and interpretation.

THE CONTENT OF HAZARD MAPS

In the very present phase of editing hazard maps for floods there are used recorded information and data from credible and pertinent sources whose goal is to localize the areas which are likely to be flooded only by highlighting the localities which had been affected, depending on the type of flooding and also the physical and valuable loss made on different levels (Prăvălie & Costache, 2013). The data referring to the hydrographical county network, the features of hydrometrical stations located on the main rivers are extremely important for estimation and authenticity regarding the flooding management and also for treating and checking mathematical patterns related to hydraulics calculations and managing wide waters (Bălteanu & Alexe, 2001). Also, watching the hydrographical network has an important role in the following are:
- the analysis of hydro basinal already existing systems and of those which are proposed to be realized;
- technical issues of local committees for defending against floods and for emergency situations;
- technical data of the defending plan belonging to habitational areas.

The data quantum given to hydrometrical stations can be assimilated only for the localities situated in the proximity of the stations. The data regarding flooding curves for various probabilities crossed along the river’s pan studied to bound floodable areas are made and approved by MMGA, ANAR in conformity with the attachments, responsibilities and competences given by law and they can be fulfilled after delivery.

The features of lithology geological stereotypes, which are added to those of geomorphological type and their climacteric particularities, lead, talking about certain variable dimensioned domains, high values of slipping probabilities, which leads to their circumscription in a group of lands exposed to hazards, to landslides (Coșarcă et al., 2006).

For example, in conformity with „Guide regarding macro zoning of Romanian territory from the view point of landslides risks, 1999” the landslides from Cluj county are, generally, to be considered in the short depth category 1 to 5 m, rarely in the superficial (less than 1 m) and deep (5 to 20 m) categories, mainly progressive, in areas with highlighted and regressive slopes in the versants that limit the mellows reactivated or primary. So that the following layers and features had been proposed (table 1).

In order to give examples for the meaning of extracting information from attribute base, we chose the period most affected by floods, in Cluj, year 2002. The main features of the hydrometrical stations located on the county’s rivers relevant for the chosen period, are shown in table 2.

Regarding landslides there have been made studies that include interdisciplinary research elements (Murariu et al., 2009 a, 2009 b; Stoian et al., 2007). The purpose of these studies is that
through value estimation and geographical distribution of the risk coefficients $K_x-K_h$ (table 3) and by mentioning the group of potential (low, average, high) to establish the probability level of slips, which would lead to identify, localize, and bound the areas which are exposed to the slipping hazard. Finally, there have been made measure proposals to prevent and reduce the effects of landslides, as the Law 575/ 2001 regarding the Plan of national territory management- the 5th section, natural risk areas- asks.

**Table 1. Database for hazard mapping**

<table>
<thead>
<tr>
<th>THE LAYER</th>
<th>THE FOLDER’S STRUCTURE</th>
<th>DATA RESOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The relief</td>
<td>Curve ID</td>
<td>Physico geographical scale raster 1:50000 given by CNC</td>
</tr>
<tr>
<td></td>
<td>Altitude</td>
<td></td>
</tr>
<tr>
<td>2. Vegetation covering</td>
<td>Vegetation ID County Name Type Surface</td>
<td>Physico geographical raster scale 1:50000 given by CNC</td>
</tr>
<tr>
<td>3. Land usage</td>
<td>Land ID County UAT Type Surface</td>
<td>Physico geographical raster scale 1:50000 given by CNC</td>
</tr>
<tr>
<td>4. Administrative territorial units (UAT)</td>
<td>UAT ID County Name</td>
<td>Physical geographical raster scale 1:50000 given by CNC</td>
</tr>
<tr>
<td>5. Localities, characteristic data</td>
<td>Localities ID Population Building type Construction material Building regimen Building period Building period Physical state</td>
<td>Physical geographical raster scale 1:50000 given by CNC</td>
</tr>
<tr>
<td>6. Cadastral and nonCadastral rivers</td>
<td>River ID County Drainage area Name Length Surface Average height Average slope Altitude spring Altitude coihncence</td>
<td>Romanian Cadastral Water 1992</td>
</tr>
</tbody>
</table>
Table 2. Characteristic data of hydrometric stations (Cluj County)

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td><strong>CLUJ</strong></td>
<td><strong>17 localities</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iara, Aghireșu, Baciu, Valea Ierii, Căpușu Mare, Mărișel, Măguri Râcițău, Beliş, Chiuiești, Mociu, Cluj-Napoca, Vănițori, Ciucea, Mărgău, Călățele, Săcuiu, Băișoara</td>
<td><strong>06.03-09.03.2002</strong></td>
<td>Blast</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>4-30.07.2002</strong></td>
<td>Spils from the slopes, hail, wind</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>01.08-15.08</strong></td>
<td>Flow of pr. Visag, discharge from the versants</td>
</tr>
</tbody>
</table>

- 314 houses and adds on establishments
- 7 social objective
- 152.3 km DJ + DC
- 37 arches and footbridges
- 400 ha infield
- 7 hydrotechnycal constructions
- phone networks
- electric networks
- 1 km. Water network
- dead animals
- fountains
To quantify the hazards due to landslides, have been followed the following purposes (Olaru et al., 2009):
- calculating the coefficients of influence and drawing thematically maps using GIS;
- calculating the medium hazard coefficient and plotting the hazard map for slipping by over putting the thematical maps in GIS.

**Table 3.** Mentioning the coefficients which have a contribution to the risk evaluation for landslides (Dordea, 2007)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Criteria</th>
<th>The potential of landslides</th>
<th>The probability of landslides and the risk coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LOW</td>
<td>MEDIUM</td>
<td>HIGH</td>
</tr>
<tr>
<td>Ka</td>
<td>Lithological</td>
<td>Clify bolds, massive, compacts or broken</td>
<td>Most of the depositions which are part of the covering rock formations (diluvial, colluvial and proluvial deposits) and from the layering rocks category pelitic stratified rocks, such argillite, clays and marly limestones, chalk, metamorphic rocks, especially epizone schists and less mid-zone schists, strongly altered and exfoliated, certain magmatic segregation strongly altered etc.)</td>
</tr>
<tr>
<td>Kb</td>
<td>Horizontal relief plan, affected by crummy erosion, vales that form the hydrographical network being in an advanced maturity stage</td>
<td>Mound relief, specific to piedmonts and elevated plane areas spited by hydrographical areas next to vales which have a certain maturity stage, bounded by medium sized and generally medium or small dips versants</td>
<td>Relief characteristic of zones of hilly and mountainous, heavily affected by a dense network of young valleys high slopes, valleys The majority of the Sub-vente (direction parallel to the layers)</td>
</tr>
<tr>
<td>Ke</td>
<td>Structural</td>
<td>massive rocks structures of magmatic segregation origin, layered sedimentary rocks, with horizontal layers, metamorphic rocks covered by horizontal layers</td>
<td>Most folded and faulted geological structures are affected by cleavage and cracks diapir structures, areas that mark the top blades saraij</td>
</tr>
<tr>
<td>Kd</td>
<td>Hydrologic and climatical</td>
<td>Generally arid areas with low average rainfall. Flows spilled into the river valley whose watersheds extend the hilly and mountainous areas generally controlled by precipitations. The prevailing riverbed sedimentation processes, lateral erosion occurring only during floods.</td>
<td>Moderate precipitation amounts. The main river valleys reached the stage of maturity while their tributaries are still in youth stage. During floods there is both vertical and lateral erosion. Important depositions of solid flow.</td>
</tr>
<tr>
<td>Ke</td>
<td>Hydrogeology</td>
<td>Water flow occurs at very Moderate groundwater</td>
<td>Groundwater flow occurs</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Kf</th>
<th>Seismic</th>
<th>Earthquake intensity of on MSK scale less than 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kg</td>
<td>Silvan</td>
<td>Arboreal vegetation coverage more than 80%. Deciduous forests with grand trees.</td>
</tr>
<tr>
<td>Kh</td>
<td>Anthropic</td>
<td>On the slopes there are not great construction executed, water accumulations are missing</td>
</tr>
</tbody>
</table>

MODERN TECHNOLOGIES USED FOR IDENTIFYING AND BOUNDING THE HAZARD AND RISK AREAS OF THE NATURAL PHENOMENA

Technologies based on sensors which are used in photogrammetry and remote sensing, are one of the most proper means operational available used in order to find out digital dates to represent the relief (Alexe & Holobăcău, 2003). They offer flexibility to the patterning process and bounding the altimetry data, ensuring the necessary precision and realizing a high automatising level based on few quality parameters, results and final costs, very closed to their optime value (Ionescu, 2004; Zăvoianu, 1999).

Using altimetric data extracted from the satellite images for identifying and bounding the zones of hazard and risk of natural phenomena, represents the capacities and bounding of the photometrical analytical and digital technology and also the changes which follows as a result due to the new digital cameras coming, specific elements which define the superior ascendent evolution and dynamics of this technology and its usage in the context of identifying hazard and risk zones of natural phenomena.

An aerial image defines a perspective view upon the land, as this is seen from upside, view which is also known under the name of orthogonal. If the image of the photogram is taken exactly vertical, for example taken a photo with a camera which has the optical axe on the same position as the vertical direction of the place, the higher planimetric details will have on the photogram image a different scale compared to the one of details located to a lower altitude reported it the sea level (Linder, 2003).

The size or the magnitude of the movements dued to the relief, to the details photographically recorded on the photogram’s recorded image, is a focal distance function of the objective or the camera’s imaginary optics, the height of the represented detail (plotted) and the distance of the detail towards the centre of the image (Stoian & Bărliba, 2009). The movement dued to relief is hidden and corrected by stereophotogrametical ways, which through their inner nature, take into account these variables (figure 3). Furthermore, is the aerial photograms are not seriously taken vertically (practically they are seldom vertical or nadiral, because of the platform’s dynamics which is carrying the sensor or the airplane) so that there also show movements dued to the longitudinal and transversal incline of the platform in the exposing moment or the one of taking the image of photogram (Turdeanu, 2000).
The effective result is that planimmetrical maps are not usually clear when made under the horizontal aspect, if during the map plotting it is not taken into account the fact the land altitude’s effect. The exception from this rule is represented by the administrative bounds, lot bounds which...
belong to certain keepers and also other asymmetrical planimetric details, which do not appear on
the images taken while flying and there are not practically plotted stereophotogrammetrical but based
on measuring angles and distances, realized using topographic technologies (Coșarcă et al., 2006).

**Figure 5.** Obtaining hydrographical networks by working with satellite images

**Figure 6.** Highlighting the objectives flooded by torrents
So, because the administrative bounds and also lot limits belonging to different owners are not visible on aerial or satellite images for their plotting are always used the topographic upheavals. All these requiring of the topographic plotting can be satisfied through stereophotogrammetry or combined with digital altitude data produced by IFSAR (Interferometric Synthetic Aperture Radar) equipment or the ones belonging to LIDAR (figure 4).

In this way another good example is the one of obtaining the hydrographical network (figure 5) obtained by the aero walked LIDAR ad also through digital data which came through sonar equipment (Mihai, 2009; Stoian et al., 2005).

To the file containing data obtained through digital pattern it is added the data vectorial kit composed by localities, roads, railways. Using the determination functions of the running off and those of followings based on digital values from the digital models it can be anticipated the flow and length of a flood, of a bad weather and also the places, localities or the communication ways (figure 6).

CONCLUSIONS

Hazard maps ensure conditions of minimum acceptable risk based on some watching strategies of phenomena producing survival conditions for the population and the protection of the environment, in which the cartographical draft, to be more specific making thematical digital maps, based on calculating risks items and especially the integration of a very large informational volume included in the informatical geographical systems (GIS).

The maps gain these way analytical and practical features, growing their social usage side apart from those of scientifical and practical importance, being usually named as land’s mathematical patterns.

The patterns are used in order to study real or abstract physical phenomena, to create real and precise images of the reality but especially to create a virtual prototype, which describes the structure and the habit of natural phenomena in different conditions.

The interest for plotting risk maps on international level and national level, lately, has become bigger and bigger. Hazard maps are defined as being maps which indicates year by year the probability of natural phenomena apparition: earthquakes, floods, landslides.

Evaluating the potential of producing hazard is strongly linked by giving a certain frequency of observed apparitions based on the main features, which mainly depend on the data base quantity, on their quality, the data quantum, which implies a high degree of precision and detailing of the characteristic areas of hazard maps.

REFERENCES


The Usage of Technologies in Terrestrial Measurements...


*** Ghid privind macrozonarea teritoriului României din punct de vedere al riscului la alunecări de teren, 1999, GEOTEC S.A. București.

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