THE IMPACT OF GEODETIC AND TOPOGRAPHIC MONITORING ON LANDSLIDES RISK ASSESSMENT

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***Abstract**: Environmental protection and the effects it produces in the environment has become an important task for the institutions of the European Community after the Maastricht Treaty for the European Union ratification by all Member States. The EU is already very active in the field of environmental policy with important directives like those on environmental impact assessment and on the access to environmental information for citizens in the Member States. In this context, environmental changes are of growing significance and have therefore become the target of geodetic and topographic monitoring. Natural hazards like landslides, avalanches, floods and debris flows can result in enormous property damage and human casualties in mountainous regions. Geodetic and land measurements data can serve as a useful tool in this field by means of which catastrophes like: earthquakes, volcano eruptions, landslides, hurricanes, the falling down of hydro dams or bridges can be monitored and anticipated. Internationally, there are constant preoccupations coming from trade companies and scientific world with creating digital terrain models for areas affected by disasters with sufficient accuracy at a reasonable cost. This paper describes an interdisciplinary project in which a particular area, situated in south-western Romania, affected by landslides, is being monitored with methods specific for land measurements. Thus, the impact that terrestrial measurements have on environment matters is being stressed. The identification of areas that are exposed to land sliding, with the purpose of monitoring and stabilizing them, is a necessity for environment protection. Up to now, terrain samples have been taken in order to determine in a lab the specific geotechnical parameters so as to characterize slope behavior. Also, the monitoring of the land slide by means of a total station begun and the Digital Terrain Model resulted, after processing the data. During the next stage we will establish the characteristic elements of the landslide, such as the size of strains and dislocations, the rate of strain, the volume of the earth mass, which define the specific of the risk for landslide, which is considered different from one area to another.*

***Keywords:** environment protection, hazards, geodetic monitoring, digital terrain model, DTM, landslide monitoring*

1. Aims and Background

Nowadays, Environmental Protection has become a technical discipline which is correlated with Biology, Ecology, Chemistry, Land measurements and many others. As a consequence, scientists and engineers are trying to understand the environment as a system with various interactions.

A direct consequence of our failure to protect the environment and of Global Change is the higher incidence of natural hazards. These are becoming more and more destructive and occur more often as a consequence of the lack of sustainability and climate change. That is why environmental protection and the effects it produces in the environment has become an important task for the institutions of the European Community after the Maastricht Treaty for the European Union ratification by all Member States.

2. Hazards

There are dozens, sometimes hundreds of hazards all over the world, daily. Presently, the losses following hazards are growing constantly and are accompanied by serious consequences as regards human survival, dignified life conditions and means of existence and also the loss of goods gathered with difficulty in the development process. Some of these disasters are triggered by people and can also be stopped by them, therefore we can say that the human factor has various possibilities to act.

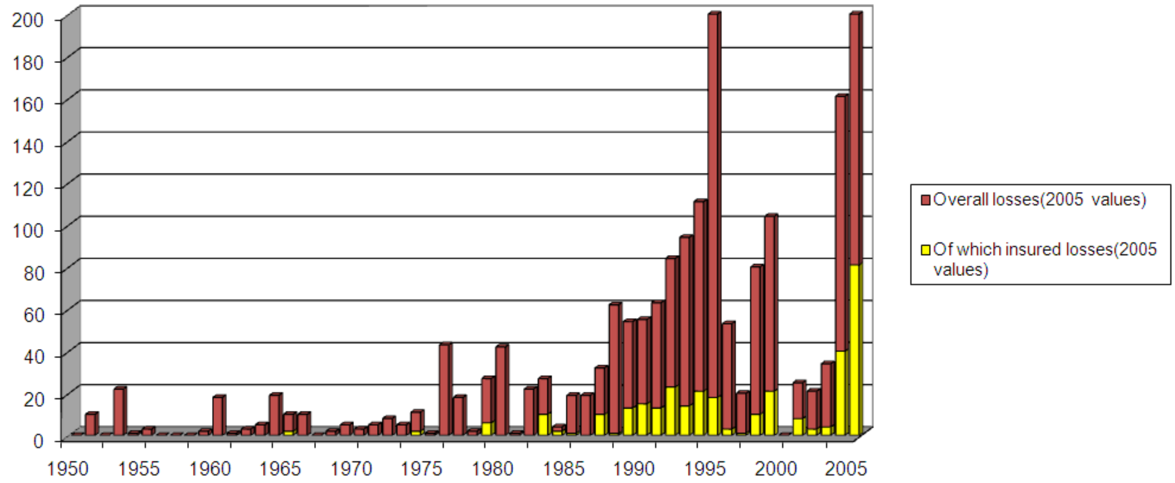

Figure 1 Natural catastrophes 1950 – 2005 according to FIG (Fédération Internationale des Géomètres)

In this context, environmental changes are of growing significance and have therefore become the target of geodetic and topographic monitoring. Geodetic and land measurements data can serve as a useful tool in this field.

3. Platforms used for disaster monitoring

Reducing disaster risk can be achieved through monitoring objectives, surfaces, regions or even the entire planet with the purpose of warning the population that could be affected by the hazard at the right time. A very important role in disaster monitoring is played by geodetic methods by means of which catastrophes like: earthquakes, volcano eruptions, landslides, hurricanes, the falling down of hydro dams or bridges can be monitored and anticipated.

Geodetic methods are the oldest and most common methods even today for gathering land data. They usually help determine coordinates of a point [1], which explains why this method is used for monitoring various disasters.

Photogrammetry is suitable for obtaining orthophoto images [2] and creating digital elevation models for a terrain, being the method that is used most often for gathering data when it comes to large projects, which also comprise environment matters.

The advantages of photogrammetry as compared to classic topographic methods are:

- obtaining a significant amount of data, with the possibility of exploring vast and hard to reach areas;
- quick evaluation of the extent of some disasters and the damage the cause;
- the coordinates of every point can be determined without any effort or additional costs.

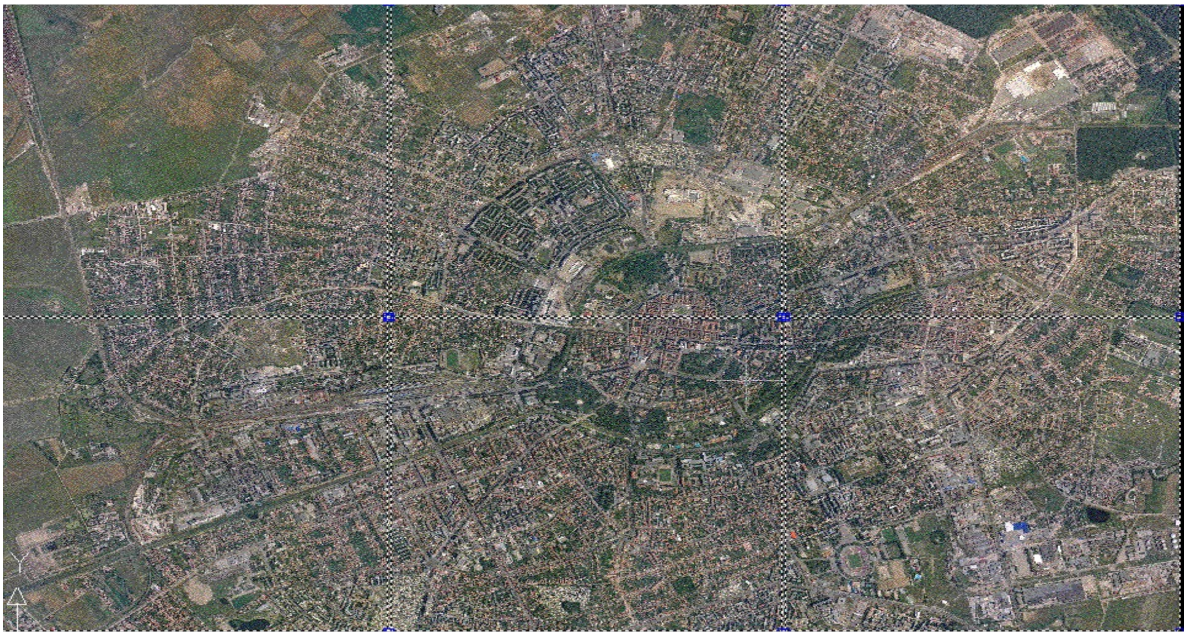

Figure 2 Timişoara's Orthophotoplan in colours with 11 cm space resolution

Most of constructional and geotechnical engineering measuring and test tasks can be perfectly performed with aid of the available **GPS technologies**. Depending on the disaster that is being monitored – landslide, flood, hurricane – a periodic observation method for monitoring several times per year is adopted and the obtained data is processed.

The advantages of using GPS technology [3] are:

- almost constant precision, regardless of how far apart the points are;
- there doesn't have to be visibility between points and it can be used regardless of weather conditions;
- gathering of data for making up risk maps and disaster prevention models, with reduced costs.

Satellite remote sensing offers satellite images, the use of which, in 3D, is imposed by the need to study and track in real time the environment and of course natural hazards. Due to the capacity of the radar systems to operate in all weather conditions, day and night, and also due to the coherent nature of the data, numerous very important applications have been developed: mapping, hazard/crisis monitoring, landslides and earthquake evaluation, observing seas and coasts etc.

InSAR technology comes in different forms. We have as follows: *Standard InSAR* for DEM generation, *Differential InSAR* (DInSAR) for ground deformation mapping allows the monitoring of slow ground movements which involve large portions of the land surface, such as subsidence phenomena, fault movements and along volcano displacements, tectonic movements and *Permanent/Persistent Scatterer Interferometric Synthetic Aperture Radar* (PS-InSAR) for displacements over individual coherent targets.

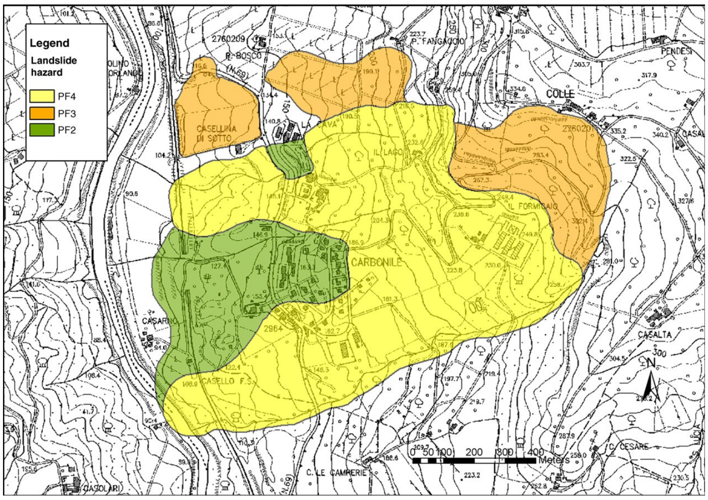

Figure 3 Updated landslide hazard zonation of the Carbonile area [4] (PF increases from low (2) to high value (4)) in Italy produced by the AdBA through the combination of PS measurements and field surveys (the map splits the entire slope into 3 classes (from PF2 to PF4) of danger, based on the radar measurements)

The main benefit of the interpherometric analysis is the possibility to check the effectiveness of the remedial measures that have already been adopted.

- LIDAR is an optical remote sensing technology which measures properties of scattered light to find range and/or other information of a distant target.

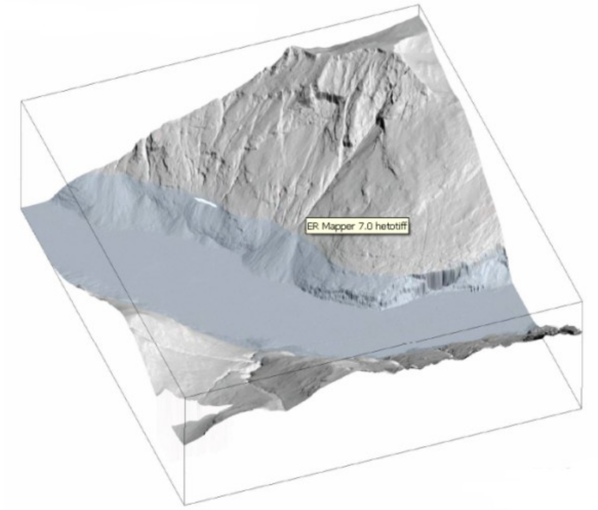

Figure 4 Digital Elevation Model using Lidar in Canada

Major advantages of Lidar are:

- Lots of data points; makes for a very good approximation of the surface;
- Can penetrate through gaps in trees and provide detailed topography of bare Earth;
- Can provide detailed information of vertical distribution of canopies;
- High resolution submerged topography in relatively clear and shallow water
- Data gathering through LIDAR is not conditioned by weather conditions, just like aerophotography, and it is even possible during winter months, if there is no snow.

The main advantages of satellite remote sensing are mainly connected to ”real time” work, or work very near to ”real time” characteristics, for tracking dynamic phenomena like: evolution of cultures, of environment factors, control of natural calamities and disasters, management of irrigation systems and so on.

4. Creating DTM for monitoring and preventing landslides in south – western Romania

The digital model is a complex product [5] that can have immediate applicability in various fields like: telecommunications system analysis, pipeline design, military operations, agriculture, hydrology, geology and geomorphology, territorial organization, geodesy, cartography, environmental studies.

Out of the methods described in the previous section, the geodetic procedures have been used for monitoring landslides, categorized as exogenous hazards, in the Orşova area, Mehedinți County, Romania, that have appeared because of inappropriate anthropic activity [6].

The topographic measurements were performed using the LEICA TPS 1200 total station resulting in a data file with planimetric coordinates and absolute quotas of points measured, that were subsequently imported in AutoCad Civil 3D.

After importing the points, the first step consisted in creating a surface for which the contour lines (Figure 5) were effected using a gap of 5 meters.

Figure 5 Contour lines for the studied area

In the next phase, the volume (Figure 6) was calculated using the composite method, based on points on both surfaces, because it offers the most correct volume measurement between 2 surfaces, and in the end we were able to create the DTM (Figure 6).

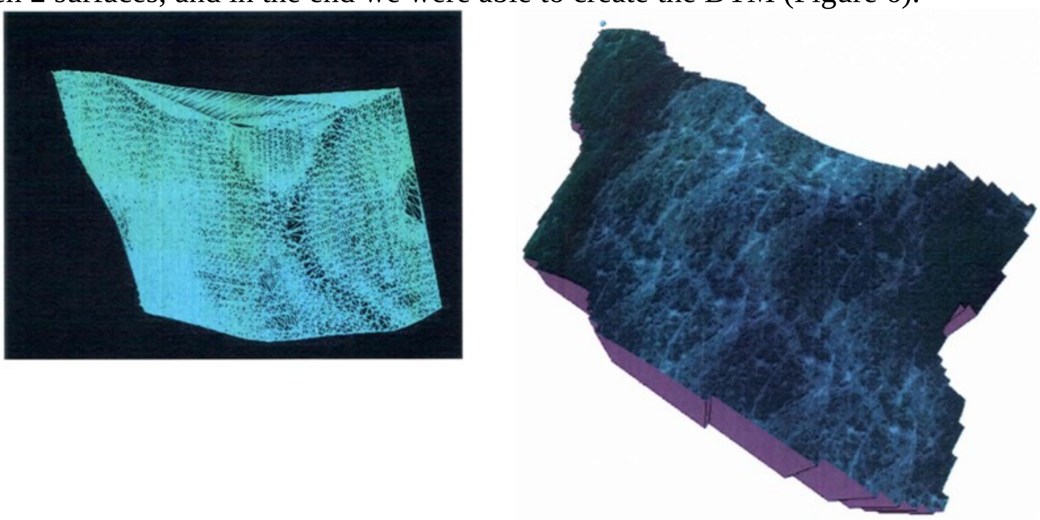

Figure 6 The volume and DTM for the studied area

5. Conclusions

This paper analyses the complex relationship between environment issues and their monitoring through methods specific for terrestrial measurements and leads to the conclusion that permanent monitoring of the disaster affected areas has become a requisite nowadays for risk detection and early warning for the population and authorities with the objective of training them in order to properly handle the full impact of the disaster.

The configuration of the terrain affected by disasters gives the incontestable basis for the considerations of topographical and geodetic monitoring.

The platforms used for monitoring presented here have a tremendous role and value when it comes to disaster management, mitigation, response and its environmental and socio-economic impacts and benefits. They also offer security.

6. Acknowledgment

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