THE CORRELATION BETWEEN THE SURVEYING PROFESSION AND SUSTAINABLE DEVELOPMENT

Clara-Beatrice VÎLCEANU[1], S.I. HERBAN[2], C.C. MUŞAT[2]

[1,2]"Politehnica" University of Timişoara, Faculty of Civil Engineering, Department of Land Measurements and Cadastre, 2A-Traian Lalescu str., 300223 Timişoara, Romania
E-mail: beatrice.vilceanu@yahoo.com

***Abstract:** In the context of changing demographic, technological, economic conditions, of unplanned urbanization, of insufficient development, unrational use of natural resources, everywhere around the world, as well as in Romania, the consequences of natural disasters will be more and more serious for human civilization. This paper has as goal the presentation of methods and materials specific for surveying engineering that are in close connection with environmental engineering and have to be used for continuously monitoring areas affected by disasters. Although sometimes the surveyor's contribution to certain projects for disaster risk management, meant to develop early-warning-systems or risk maps, is not adequately appreciated, as he is only seen as supplier of measured geometric data, the surveyor has a significant contribution, through his abilities regarding modeling of dynamic systems like construction or slopes and GIS data interpretation. For all these reasons, the old view must be put aside, and the novel element of this paper is brought by underlining the important role that the surveyor has in monitoring the earth surface prone to natural disasters. By means of presenting state of the art technologies, like remote sensing, satellite-based positioning or GIS, the paper shows its high level of topicality. Moreover, the paper's originality is given by the proposal that the surveyor should always take part in reaching decisions regarding courses of action in disaster risk management. The methods and instruments presented in this paper indicate the stage researches have reached, they are diverse and cover a wide area, making possible even the monitoring of the entire planet. These are geodetic engineering, satellite-based positioning, photogrammetry and remote sensing, GIS and geoinformatics and land management. Although varied and very elaborate, these methods have limits, namely they only help monitoring, anticipating and reconstructing after disasters, but they cannot be used to avoid such calamities from taking place. The importance of this paper also lies in stressing the importance of the surveying profession and the practical applications it has in disaster risk management, thus contributing to achieving sustainable development.*

***Key words**: sustainable development, surveying, disaster risk management, monitoring, GIS, disaster.*

INTRODUCTION

In Romania, the country's various regions have developed differently over the years, this leading to a social and economic imbalance between the levels of development found in different regions. Therefore, a necessity for achieving regional development is ensuring sustainability in all regions of the country, which involves taking into consideration environment factors in the social and economic growth process.

Upon joining the E.U., Romania has set as goal the implementation of development policies based on the sustainability principle. One of these development policies is represented by that present in the environment field which contains, besides requirements for environment protection, both disaster prevention measures and the actions necessary for reconstructing affected areas.

Natural disasters that have affected Romania over the years are earthquakes, landslides, floods, soil erosion. Other common problems are: forest health, water pollution from mining and accidental pollution caused by the chemical industry, thermal processes or oil refineries.

Sustainability is achieved by means of evaluating the present state of environment factors and the development of new technologies that can ensure management of environment reconstruction and facilitate the adopting of optimal decisions to that purpose.

MATERIAL AND METHODS

About 80 % of daily decisions on national or local level, in different fields of activity, like demography, spatial planning, environment, hazard areas, infrastructure, housing, property evaluation etc. are spatially or geo-referenced. The modern surveying engineer assists in acquiring, managing, visualizing and analyzing geospatial data related to disasters. Combined with new technologies and methods, the challenging profession delivers the basic principles for disaster risk management within the disciplines geodetic engineering, satellite-based positioning, photogrammetry, remote sensing, geoinformatics and land management (Fig. 1).

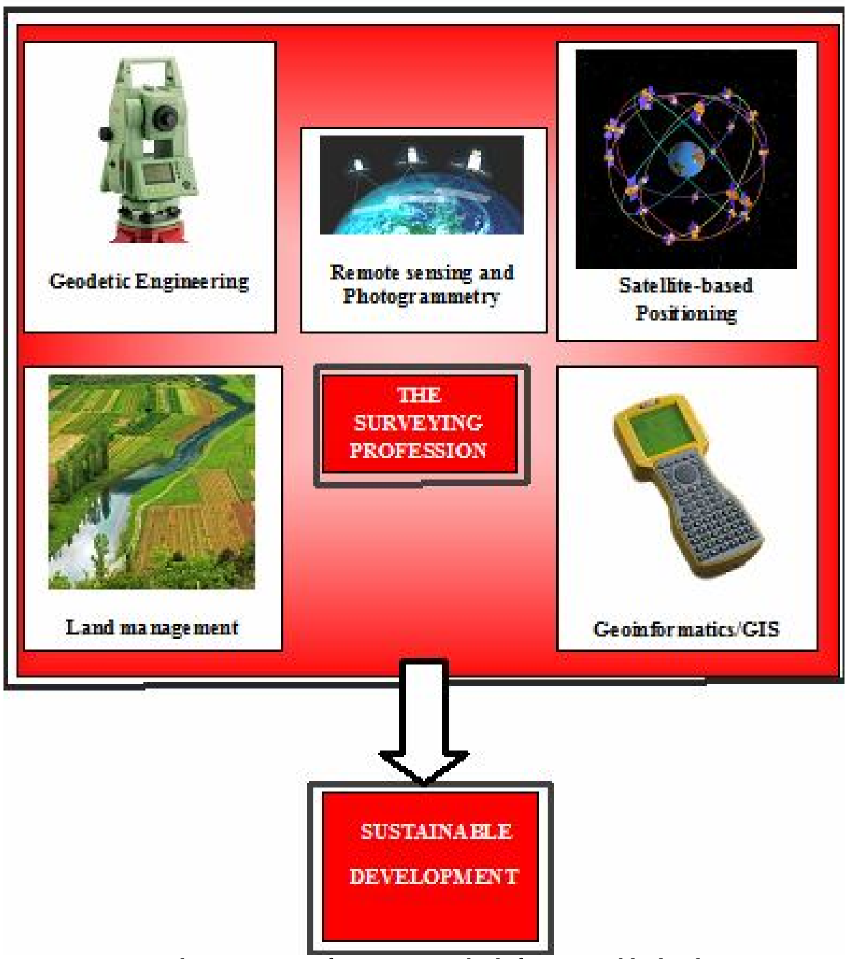

Figure 1. The importance of surveying methods for sustainable development

- **Geodetic Engineering**

Disasters that are monitored and forecasted by geodetic means are earthquake, volcanic eruption, landslide, tsunami, dam or bridge failures, aiming to build up *early warning systems*. Usually, when talking about realizing an early warning system, a team of specialists from various fields is created, namely civil engineers, geologists, geophysicists, hydrologists. There is an absolute need for a geodetic engineer to cooperate in this multidisciplinary team for delivering the geometric quantities needed – positions of objects in absolute sense or in relation to other objects or in distances between points on one object – and describing the quality of the data.

- **Remote sensing and photogrammetry**

Photogrammetry is an efficient tool in monitoring spatial objects due to location, form and shape. The terrestrial photogrammetric methods have a significant contribution in determining and monitoring, documenting and analyzing the damages in the structures after different disasters such as earthquakes or landslides. Through photogrammetry, orthophoto images are obtained, one can work both in local and regional systems, terrain digital elevation models are created, the direction and tilt of geological strata and the position of points are determined, thus helping to determine the deformations of the building and helping to decide whether a damaged building will be kept for retrofitting or be demolished.

Aerial photogrammetric data acquisition techniques give very accurate data about the damaged area and, by using the latest technology like InSAR and LiDAR, large amount of data is provided very fast, weather and day light independent.

Earth observation satellites have demonstrated their utility in providing data for a wide range of applications in disaster risk management. Pre-disaster uses include risk analysis and mapping; disaster warning, such as cyclone tracking, drought monitoring, the extent of damage due to volcanic eruptions, oil spills, forest fires and the spread of desertification; and disaster assessment, including flood monitoring and assessment, estimation of crop and forestry damages, and monitoring of land use/change in the aftermath of disasters.

Remotely sensed data also provide a historical database from which hazard maps can be compiled, indicating which areas are potentially vulnerable. Information from satellites is often combined with other relevant data in geographic information systems (GIS) in order to carry out risk analysis and assessment.

- **Satellite-based Positioning (GPS)**

For monitoring large areas or regions, on which tsunamis or volcanic eruptions have occurred, satellite based positioning methods are applied. When developing tsunami warning systems, one has to integrate terrestrial observation techniques like seismometers and tide gauge measurements by GPS as well as marine measurements on GPS buoys and with ocean bottom pressure sensors and a processing centre.

- **Land management and land use planning**

Until now, traditional landslide, flood, earthquake defence was planned without taking ecological constraints into consideration, so these disasters destroyed property and threatened people's lives. The authorities had to develop an improved planning methodology based on the working hypothesis that there is a spectrum of objective, for the development of the areas affected by disasters, which is located between the contrasting objectives 'protection of use by man' and 'sustainable development of nature'. With its specialized skills and knowledge, the professional surveyor can substantially contribute in land planning and management, in real estate transactions, building and land law or reforms and landscape conservation. Moreover, the digital cadastral map is a precious tool for all management and planning projects. It supports data related to properties, land and natural resources as well.

Among other things, the surveyor, as a land manager, assures the detailed information at the individual land parcel level and participates in: asset management; conveyance; credit security; demographic analysis; development control; emergency planning and management; environmental impact assessment; housing transactions and land market analysis; land and property ownership; land and property taxation; land reform; monitoring statistical data; physical planning; property management; public communication; site location; site management and protection.

- **GIS and Geoinformatics**

A GIS makes it possible to link, or integrate information that is difficult to associate through any other means, available at a glance in the control units for emergency situations and in the mobile rescue units as well. This spatial data available in digital form guarantees the speed and efficiency of rescue operations because it contains all the needed elements: the location of the event, the road network, the number of the affected people, the location of most nearby hospitals, the capacity of those hospitals etc. GIS is an essential tool in the data analysis and the subsequent disaster assessment and can be used in all phases of emergency management, like mitigation, preparedness, response and even recovery.

Special tasks which can be performed in such a GIS system may include:

- Use of spatial data and object related data from various sources;
- Integration of mobile action force information in near real-time;
- Providing adequately processed intersected data including decision support signals for control centres and field staff;
- Information retrieval and intersection support;
- Decision process support;
- Scenario projection of retrieved intersected information;
- Database of predefined scenarios;
- Extension of existing databases and cadastres;
- Connection of existing disaster management systems via open standard interface;
- Logging of activities for the purpose of documentation.

RESULTS AND DISCUSSIONS

By means of the fields of study and methods mentioned in the previous section, the surveyor engineer brings his contribution to environment protection as follows:

- **Geodetic Engineering**

Adopting data gathering methods with a view to creating early warning systems depends on the width of the surface monitored. For areas of relatively small sizes where landslides have taken place or constructions like bridges or dams are set, higher accuracy is required and instruments like tacheometers as well as other specialised instruments like digital levels, total stations, tilt meters or inclinometers are used. The geodetic engineer has to process, evaluate and adjust the geodetic measurements, including models and analysis of time-dependent measurements as well as deformation analysis (Fig. 2), develop and implement algorithms for data fusion, partly in cooperation with other disciplines that deliver measurement data too (e.g. geotechnical measurements), model, describe, measure and propagate the quality of geodetic data and participate in taking decisions within the disaster risk management process in the multidisciplinary team.

- **Remote sensing and photogrammetry:**

Taking into consideration the fact that the largest geographic data collections are satellite images and due to the capacity of InSAR and LiDAR systems to operate independently of weather conditions, day and night, numerous applications for disaster risk management have been developed, like disaster monitoring, landslides evaluations, evaluations of seismic movements, evaluation of the ground subsidence (Fig. 3), observations of important coastal areas.

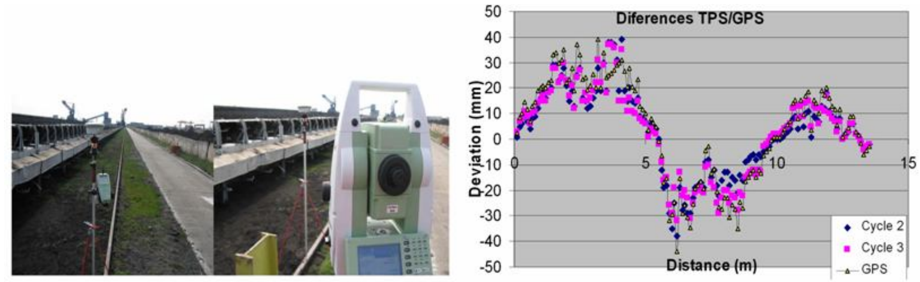

Figure 2. Monitoring settlements for engineering projects and the displacements measured by GPS and total station

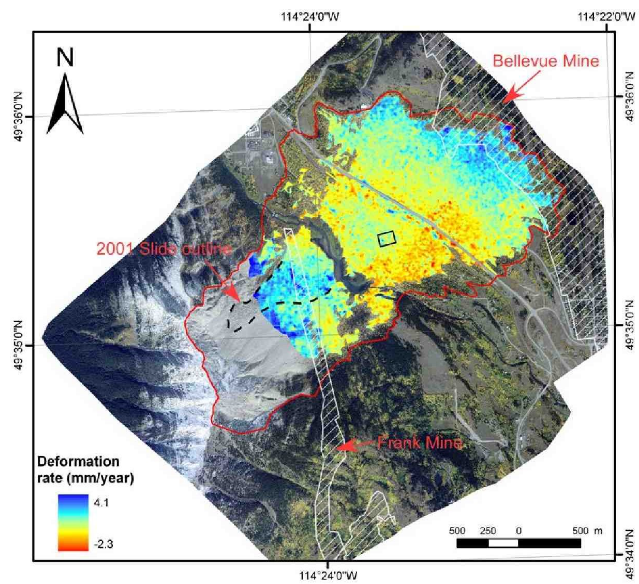

Figure 3. Map showing the rates and patterns of deformations of mines in Canada produced by using InSAR technology

- **Satellite-based Positioning (GPS)**

The advanced GPS methods allow latitude, longitude and altitude measurements being determined in a relatively short period of time with centimeter precision. A practical application of GPS methods could be used when there are modifications in inaccessible areas on site and the digital maps available do not include these modifications. Thus, by means of GPS, these measurements can be easily conducted (Fig. 4), the topology can be created with the help of special programmes in order to be recognized by a GIS and afterwards they can be implemented in it in order to be further processed.

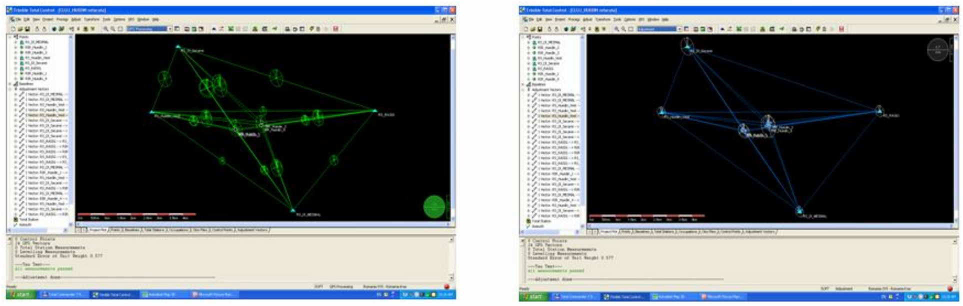

Figure 4. Sketch of the thickening geodetic network by GPS measurements (processing and adjustment stage)

- **Land management**

Having accurate information available, it can provide strategic planning over very large land areas and perform analysis any time changes appear on the land, as a consequence of disasters occurred. The planning comprises in developing effective land use models that are necessary for a sustainable urban and rural development (Fig. 5), assess the distribution of measures for improving agricultural land, water, and the environment, create sustainable infrastructural, economic and ecological conditions for developing urban and rural areas, undertake damage assessment of the destroyed or harmed buildings and public facilities in the aftermath of a disaster.

Figure 5. Land management by means of GIS

- **GIS and Geoinformatics**

Traditional skills of a surveyor, like quality awareness, are a valuable contribution and can help to support the quality assurance of spatial data and of spatial information processes as well. Spatial data processing needs the data management capabilities of surveyors. In the field of land information systems (Fig. 6), surveyors possess a sound experience in maintaining huge spatial databases at a very high level of reliability since a long time. This knowledge can be used to support the implementation of other but, technically spoken, similar spatial information systems which provide for an absolutely indispensable base for the effective disaster risk management.

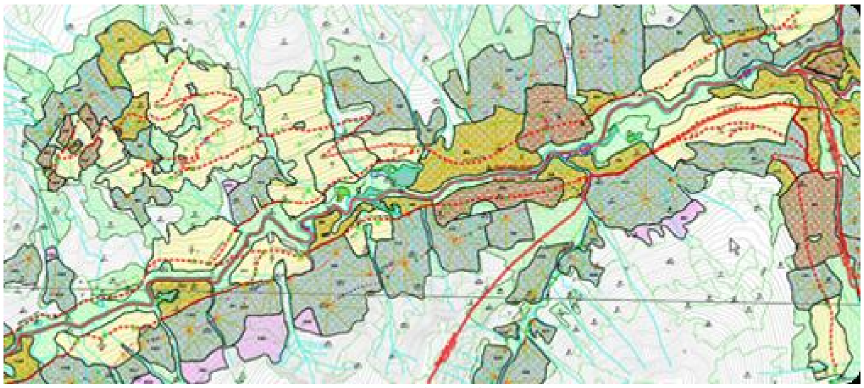

Figure 6. Example of GIS for land planning

Having in mind the wide prospects of the surveying profession, it can bring its contribution to sustainable development through:

- Acquisition of disaster-relevant data by using different data sources such as airborne and satellite data; radar and (multi-spectral) images;
- Hazard assessment and design of monitoring and/or early warning systems as part of Geographic Information Systems (GIS) and other computer-based information systems;
- Development and implementation of preventive measures of land use planning and land management to reduce disaster damage;
- Cadastral reconstruction using Global Positioning Systems (GPS/GLONASS) and/or tacheometry in the post-disaster phase.

The multidisciplinary approach in obtaining sustainable development implies the collaboration and networking between the different disciplines and techniques, e.g. because of the fact that geographic information systems use airborne and satellite data as well as radar and (multi-spectral) images and also, co-operation and partnerships among institutions (i.e. local authorities) civil society and private sector.

CONCLUSIONS

The knowledge of surveyors regarding modelling of dynamic systems like construction or slopes is needed for the evaluation and optimization of these dynamic models describing the behaviour of the monitored objects.

Using GIS techniques in sustainable development makes possible the storage and easy processing of spatial data gathered from various sources (geodetic measurements, GPS measurements, airborne data, data obtained by means of scanning or sensor technology) that characterize a certain territory, effecting a complex monitoring of the areas affected by disasters and allows the taking of the most appropriate environment protection and preservation measures, falling into the duty of surveying engineering.

It is clear that a very important part of ensuring sustainable development is represented by disaster risk management. Different scientists from different fields bring their contribution but, in Romania, that does not always include the surveyor engineer. Taking into consideration the methods presented in this paper, that the surveyor handles and may put into practice within a team that also includes other specialists, the obvious conclusion is that the surveyor should always take part in reaching decisions regarding courses of action in disaster risk management.

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