DATA MODELING OF INTEREST FOR THE MANAGEMENT OF EMERGENCY SITUATIONS IN CENTRAL ROMANIA

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The management of emergency situations is based, in principle, on the integration of all technical, systemic and last but not the least, operational aspects. Based on this, a proactive approach must consider a huge volume of data, which should be ready for use as information. In this framework, dedicated software is required to be used in correlation with possible working scenarios. This article demonstrates the viability of such analysis with an example regarding the central region of Romania.

Key words: *data, modeling, emergency situation.*

1. GENERAL CONSIDERATIONS

As addressed by Romanian national legislation, as a consistent definition, emergency management means all activities and procedures used by policy makers, public institutions and services responsible to identify and monitor risk sources, evaluate information and situation analysis, develop forecasts, establish alternatives for action and implement them in order to restore the situation to normality. The object of this kind of activity is the emergency situation considered an exceptional event, of nonmilitary character, which, by its scale and intensity, is threatening the life and health of the population, the environment, important material and cultural values, and for the restoration of normality it is necessary to take urgent measures and actions, assign additional resources and a unified management of forces and means.

Emergency management in the current context of society's development, especially urban areas, requires more than the existence of competent institutions equipped with the latest technology. Science is also needed to understand how the world works and how to succeed in developing effective procedures for taking the best decisions [3]. Basically, the specific decision-making mechanisms must use

the most appropriate instruments, given at least a minimal set of universal constraints, among which outstanding are the time, quality and resources at their disposal. Among these instruments, dedicated software are highlighted, with increasingly diversified ways of operation, the most famous being the GIS (Geographic Information Systems). In such an environment, in terms of methodology, the representation of the real world in a conceptual data model involves four levels of generalization or simulation [3]. Initially, the reality is modelled based on the real issues (buildings, roads, lakes, people, etc.) and includes all perspectives which may or may not be relevant to a particular application. Then, the conceptual model is focused on the human factor, often partly structured, and involves selecting the objects and processes that may be considered relevant to a particular scenario. Representing reality as a chart or list is the third level of simulation and the physical model - the last stage of simulation - in GIS environments is the fact that data exists physically in computing systems and are represented by files or databases.

The data model provides both for developers and users or beneficiaries a common understanding. From the point of view of developers, a data model is a means of representation of a problem in a particular area, from description to implementation, while for the user a full description of the system's structure is provided, independent of the type of data used in the implementation. GIS offers a wide range of operations aimed at generating the various models used in specific applications in a particular area.

2. CASE STUDY

Identifying actions to return to normality in the shortest time, state analysis, monitoring the achievement of specific operations are restricted by the time variable. For an acceptable rate of reaction it would be better if the various situations occurred rely on a minimum set of data that can be collected long before the incidents and that can be restricted depending on the nature or specifics of the emergency situation. The minimum set of data can be generated on different thematic layers and the generally accepted information refers to [4]:

- administrative limitations
- transport infrastructure: land, sea and air, if required;
- hydrological network determined by the lakes and streams of surface, which, on the one hand, should allow identification of high-risk flood areas or analyses to identify the sources of water use in agriculture;

- location of critical infrastructure - government buildings or constructions, museums and recreation areas that can accommodate at one time large groups of people;
- elevation of terrains - raster image allowing terrain analysis for example, identifying optimal or alternative routes, location of sensors so that an area can be monitored;
- the use of land.

Based on data from the minimum set, mathematical models [1-2] can be constructed, and then a map-based approach can help in the decision making process in emergency management.

The minimum set that should be as comprehensive as possible can be used in building maps by embedding relevant data in different thematic layers. The operations that allow analysis can be applied to each layer independently or operations that unify information on two different layers can be defined. At one point, a class of information can be deleted or deselected. Removing irrelevant data for a particular situation is preferred, instead of collecting new data under time pressure, because the process of collecting and processing can be longer and more difficult.

Generating a comprehensive geospatial database for the Central region is envisaged, especially Brasov county, which can be used to risk management for the various threats that may arise in the region. Within the centre region of the country, including Alba, Braşov, Covasna, Harghita, Mureş and Sibiu counties, Braşov County is best developed in terms of economy and population.

The administrative limits of the cities of Brasov County, and the towns of the bordering counties were obtained from shapefile [5]. Initially, based on the need to develop possible contingency procedures anywhere in the county of Brasov, it was agreed to generate a "buffer" region containing all urban or rural areas at a maximum distance of 10 km to the county limit. In the event of an incident, it is likely that forces located in surrounding counties have a lower response time due to a shorter distance to the point of interest. After generating the buffer zone of the administrative limit of Braşov County, a Selection by location enquiry was generated - this allowed only the selection of administrative regions which are located inside the buffer zone (**Figure 1**).

Fig. no. 1. Segment of the map – administrative limits of the cities of Braşov county and surrounding areas, at a distance of up to 10km

Transport infrastructure, an element of major importance for the considered area consists of the road and rail network. Braşov is among counties in the central area with the highest population density, with a GDP per capita higher than the national income average obtained from well-developed tourism industry, but also with major transport infrastructure. It is, followed closely on these indicators by Sibiu. On the opposite side there is Covasna, due to its less developed transport infrastructure. Therefore, if the state of our transportation infrastructure is proportional to the economic development of a geographical area, the vulnerability is also great. A possible incident can cause huge damage. In other words, a clear picture of rail and road networks can reduce the risk of undesirable incidents and supports the decision-maker. Transport infrastructure is used both for transporting passengers, and cargo. Goods/commodities may have some degree of toxicity or flammability, and a possible incident may affect the inhabitants of the localities crossed by transport networks. On the other hand, an evacuation scenario is built on certain safe, unaffected routes.

A selection based on the location of the data set corresponding to the road network in Romania [6] and the buffer zone considered allowed the selection of routes in the region of interest. For a clear picture, the entire road network must be classified based on the type of road (national, county,

inside county) as each segment, depending on its type, makes driving at a certain speed possible. Similarly, applying a selection by location between the Romanian railway network and the buffer zone considered, a representation of the railway network was obtained. The classified road network and the rail network will be separate thematic layers of the map of Brasov county and surrounding region within a range of 10 km from the administrative borders of the county. An undesired incident that would disrupt traffic on a section of road could allow the determination of alternative routes or where required evacuation of people from an area, the optimal route between two points on the map could be determined. In addition, the section of the road with the highest degree of vulnerability could be determined, based on the rate of incidence of the history and characteristics of the road, but, in order to do this, other thematic layers would be needed, such as bridges over the railway or roads crossing a watercourse or areas with high degree of landslide.

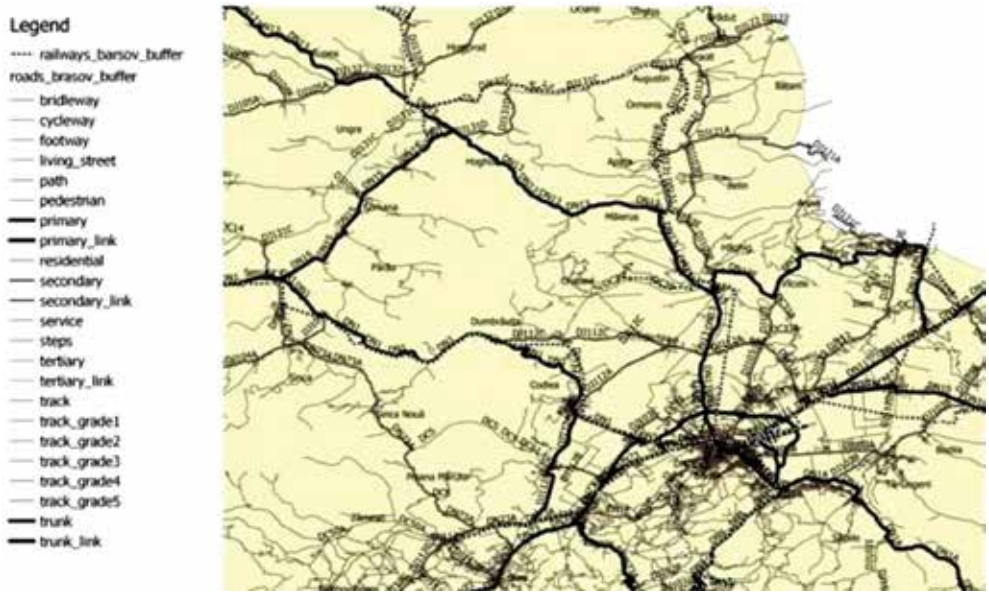

Fig. no. 2. Classified transport network, depending on the type of the road

The hydrological network (**Figure 3**) is determined by surface watercourses and natural or artificial lakes. Although high flood risk areas can be determined based on raster data, a complex image in vector format of the hydrological network allows the identification of populated localities or areas that could be affected by flooding. The entire state is located on the middle of the Olt River, with main confluents the Black River

(Râul Negru), Timiş and Bârsa; the streams have a low flow due mostly to the mountainous relief. However, floods are possible especially in times of year when heavy rain falls or snow melts quickly. When floods occur, road segments that make access to various localities may also be affected or damaged. Viewed from another perspective, an image of the surface lakes and barrier lakes in particular, which supply the region's localities with drinking water, can provide a clear image in case of an unwanted event. A critical situation occurred in drinking water basins can have very serious repercussions on the population of the area.

Fig. no. 3. The hydrological network determined by waterways and lakes

Braşov County falls into the category of regions with large numbers of tourists, especially during the times when winter sports are practicable or when national or regional large scale events are organized. Therefore, a thematic layer is required for emergency management containing the location of governmental institutions, buildings of utmost importance - malls, museums, theatres, churches, hospitals, recreation centers, or recreational areas - parks, stadiums, which at certain times of the year or during certain hours, may be regarded with high vulnerability due to the number of people participating in various activities. The location, in terms of geography, maximum capacity, and access routes allows a clear assessment of the impact dimension and responsible security forces can act having all the necessary information. On the other hand, in case of an incident, safe buildings could be used for short-term shelter of the population. The

most comprehensive and current location of buildings of utmost importance can be downloaded from the OpenStreetMap (OSM) - thanks to the plug-in with the same name in QGIS environment. As buildings are represented on the map by multi-polylines vector-type structures, from the downloaded data set, only the layer represented by multi-polygons is added to the map of appropriate buffer zone considered (**Figure 4**).

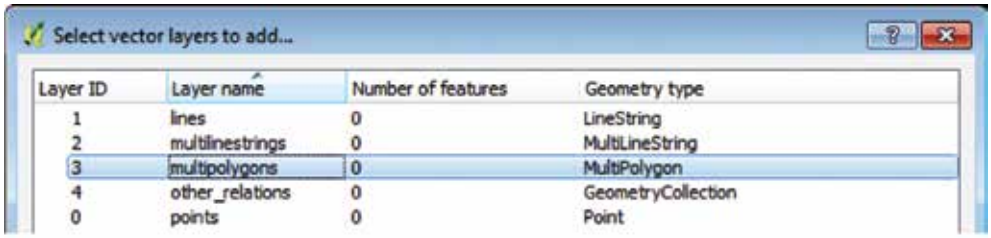

Fig. no. 4. Adding a polygon-type thematic layer

The very important institutions, from the dataset downloaded from Geofabrik [7], there are obtained, based on a query of location selection and of a query by *building* value feature, a feature that contains the use of the building.

"building" = 'cathedral' OR "building" = 'chapel' OR "building" = 'church' OR "building" = 'college' OR "building" = 'commercial' OR "building" = 'hospital' OR "building" = 'kindergarten' OR "building" = 'postal_office' OR "building" = 'public' OR "building" = 'school' OR "building" = 'supermarket' OR "building" = 'synagogue' OR "building" = 'train_station' OR "building" = 'university'

Fig. no. 5. Major buildings obtained based on a selection enquiry depending on the characteristic

In addition, there are emergency situations in which it may be necessary to approximate populations in a given area to determine the extent to which it should be acted if necessary. From the residential areas, the population can be estimated using specific GIS functions that allow determination of the inhabited areas. Combining this value calculated with the height of the buildings allows estimating the number of people in a certain area.

Fig. no. 6. Estimating the inhabited area

If until now, the minimum data set was built only on the basis of vector data, an overview image and a feasible rigorous analysis cannot be done without raster data containing the elevation of terrain (Digital Elevation Model) and the use of the land.

The raster image [8] corresponding to the elevation was downloaded from the UGS agency's website (United States Geological Survey) and is very useful in obtaining detailed information for evacuation operations or damage assessment after an event or for the planning or identification of vulnerabilities in order to reduce or minimize impacts to high-risk areas. Reduction of the risk of an event is similar to a prior identification of areas with high floods, or determining the risk of avalanches based on rainfall and the degree of inclination of hills. Initially, the raster image was reduced to the studied area by a clip-type operation, and then the layer associated to the hydrographic network was added. In the raster image, high altitude areas are represented by bright pixels. The lower altitude is represented by the darker pixels.

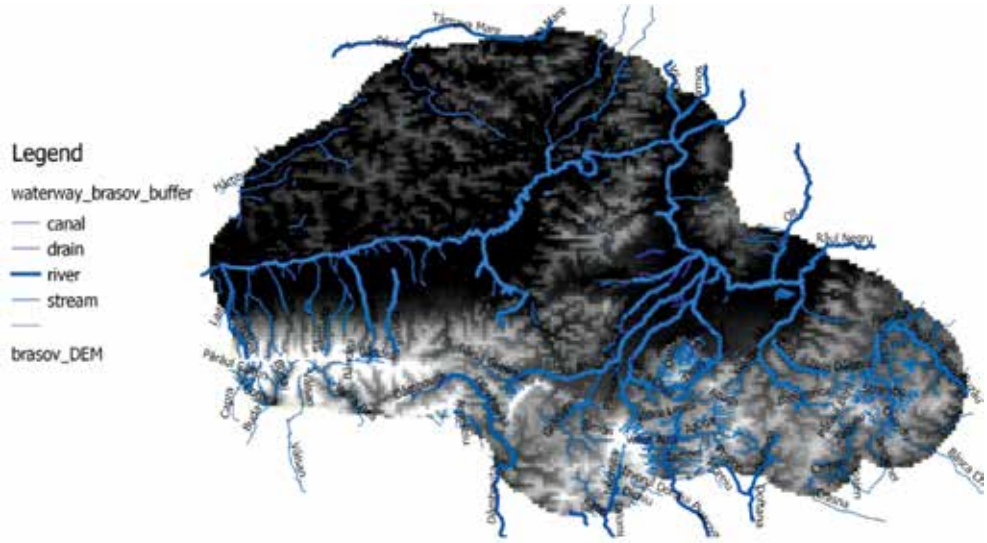

Fig. no. 7. Elevation of terrain and the waterway network

An important element from the minimum data set category relates to the use of the land. Corine Landcover [9] raster data can be useful in rescue operations, specifically in identifying landing areas, depending on the type of land and its size, if necessary. In a marshy area, for example, the landing of aircrafts is impossible. Another approach is to identify woodland and analyze neighborhoods in order to limit fires that may occur in dry seasons.

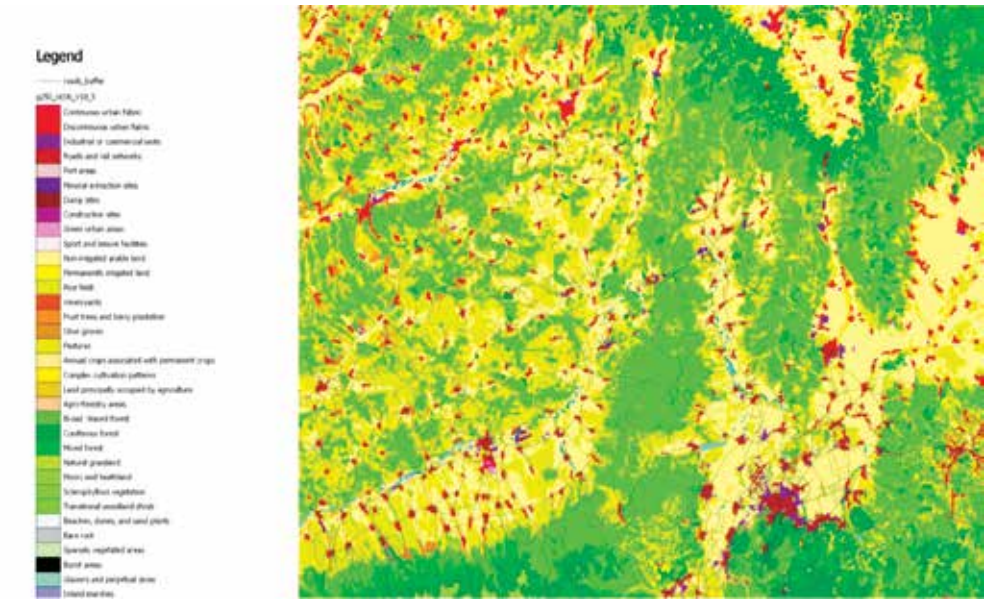

Fig. no. 8. The use of land in the selected area

3. CONCLUSIONS

The first step in emergency management is to identify vulnerabilities and reduce the risk of unwanted events. These operations can be carried out successfully if for a specific area there is a minimum set of data in combination with GIS applications to enable the collection, analysis and visualization of spatial data. Vector and raster data, downloaded from various sources, can initially undergo operations in order to narrow the scope to a particular area of interest. The analysis by combining various thematic layers allows the identification of vulnerable areas and can be used in specific emergency management operations pre or post event. The purpose is to minimize the risk of a possible event, or if the event occurred, to reduce the size of the damage, to protect the population in the affected area and to return to normality as soon as possible.

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