



The implementation of the GIS tools in crisis management

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ABSTRACT

The aim of this article is to present the possibility of the implementation of the GIS (Geographic Information System) tools in crisis management. Crisis management is the management in case of emerging a threat or a crisis situation, regarding public bodies or local government units, as well as private subjects. It is a multi-stage process consisting of preventing and planning, reacting and removing negative effects of a crisis situation. In each of the stages the GIS tools may find their application. They may be used for creating spatial analyses, threat visualisation, gathering and processing numerous pieces of data. The authors describe the possibility of the implementation of the GIS tools in crisis management in the process of planning, threat analysis, alarming about threat, evacuation, taking up protective and rescue operations, and removing negative effects and recreating the original state by losses estimation.

Keywords: GIS, crisis management, GeoEvent, crisis situation

1. INTRODUCTION

Crisis management is an important element of safety management. It is connected not only with operations of public authorities on various central or local levels, but also with every institution or corporation. It may be applied to various subjects, public as well as

private, as it concerns management in the circumstances of threats or, in other words, crisis situations. Crisis management consists of several basic stages. In principle, phases of prevention and preparation, reaction, and recreation are enumerated [1].

In each of these phases the GIS tools find their application. GIS (Geographic Information System) helps making crucial business and organisational decisions all over the world. Recently GIS develops in every area of human life, starting with environmental science, through safety science, ending with corporation management and much more [2,3]. In crisis management the GIS tools may be used for creating spatial analyses, threat visualisation, gathering and processing numerous pieces of data, especially those containing location or spatial elements [4].

2. CRISIS MANAGEMENT

Issues of crisis management apply mainly to taking up the right actions connected with emergence or even the possibility of emergence of a potential crisis situation. A crisis situation is the state of increasing destabilisation, insecurity, and threat, and is characterised by the possibility of losing control over it [5]. A crisis situation is also described as circumstances or phenomena characteristic of which is imbalance (e.g. social, military, economic) causing the necessity of intervention [6]. Accordingly, it concerns the emergence of a threat having an adverse impact on the level of security and functioning of a given subject. Because of this, crisis management is necessary. There are numerous definitions of crisis management among various scientific studies. According to the dictionary of National Defence University, crisis management is reacting to crisis (future or ongoing) and removing its effects through such activities as foreseeing and anti-crisis planning, reacting on everyday events, and reconstructing after damages are made [7]. It stands for a process leading to overcoming difficulty posing a threat to the existence of a given institution/subject [8]. Definitions of crisis management may apply to:

- operation of a given subject in a difficult situation, disturbing normal functioning,
- operation during natural disasters and technical breakdowns,
- conflict relations between subjects of political, military, social, or economic nature [9].

It is worth mentioning that crisis management mainly covers various planning and organisation operations. The existing legal definition should also be mentioned. It characterises crisis management as: "public authorities' activity being an element of national security guidance concerning crisis situations prevention, preparing for taking control over them through planned actions, reacting in cases of crisis situations emergence, removing their effects, and reproducing critical infrastructure and assets"¹.

There are three or four phases of crisis management in scientific literature, depending on authors. In the case of three-phase process these are: pre-crisis state (related to preparation and crisis prevention), crisis state (acting during a crisis), post-crisis state (removing the effect of a crisis) [10]. In the case of four-phase: prevention, preparation, reaction, recreation [5]. In this article the authors adopted the three-phase division. The first one is related to prevention, namely actions eliminating the emergence of crisis situations and preparation, namely actions

¹ Ustawa z dnia 26 kwietnia 2007 r. o zarządzaniu kryzysowym, Dz.U. 2017, poz. 209, tekst jednolity

leading to full readiness to counter them. The second one is reaction, covering actions during a crisis. The last one concerns removing all the negative effects and restoring control over the situation. The GIS tools and analyses carried out thanks to them may become essential in each of the phases.

3. PRE-CRISIS PHASE - PREVENTION AND PREPARATION

The stage of prevention is mainly connected with identifying and analysing potential threats in a given area, creating adequate documentation including public safety legislations, realising, controlling, and supervising the prevention activities. In addition, the stage of preparation is above all connected with planning, adopting adequate procedures, preparing forces, assets, and other organisational-law solutions concerning a potential crisis situation, threats monitoring, etc.[5] Stocktaking, evaluation of risk (identification and moulding), and prediction of losses and damages are being done [11].

The most important element of this phase is planning, covering not only the undertakings of crisis situations prevention, but also plans of reaction in specific situations and plans of recreation. The possibility of emergence of a crisis event forces the appropriate institutions to use all resources to prevent such events or to minimise their negative effects. Therefore, it is crucial to guide people, to have the ability to use the available forces and resources [12]. In this context a crisis management plan, making it easier to guide a given situation, is extremely important. Crisis management plans describe the range of preparatory actions needed for their realisation (e.g. training courses, practising), make it easier to react, recreate, soften the effects of an event [13].

They have to be created before the emergence of a potential threat, as it is important for everyone involved in a crisis situation to be aware of their tasks and expertise. This facilitates not only the work of the people taking part in the reaction, but also of the people in charge during a threat. The process of planning itself involves creating, implementation, and verification of the crisis plan. It should be based on a professional evaluation of threat [11]. Appropriate counteracting the emerging threats is impossible without planning. A properly created plan is a document describing readiness and various variants of action [12]. It should be legible, understandable, elastic, adjusted to the changing conditions of a situation. In the process of crisis management, subjects may create crisis management plans concerning safety in general, but also crisis management plans in case of emerging particular events. The GIS tools may be useful mainly during threat analysis, which is a crucial element of the crisis management plans creation [14].

The GIS-type software proves useful during potential threat analysis. Making decisions becomes easier with the GIS thanks to combining numerous pieces of information in one place. Crisis management plans are created at all levels of administrative division of the country (Poland) and in numerous institutions [14]. An analysed area is often so big, that it would take hours, if not days, for a human to conduct an analysis, while the same analysis with the usage of the GIS-type software takes only few minutes. Landslides may serve as an example of a threat. Figure 1 shows a scheme of conduct in the process of mapping out landslides on the territory of Warmian-Masurian Voivodeship. Every analysis needs to be based on reliable data. Right here the saying "garbage in, garbage out" should be quoted. ADEM (Digital Elevation Model), forested and shrubby areas, road network, and built-up

areas will be necessary in the landslides search. This is the input data for the analysis and should be up-to-date. Next stage is the choice of appropriate criteria for looking for areas, in this case landslide areas.

Criteria:

- areas of significant downslope
- meteorological data (areas with intensive rainfalls)
- excluding forested areas from the search (ground density thanks to the roots)
- excluding strengthened slopes from the search
- other, chosen by the user

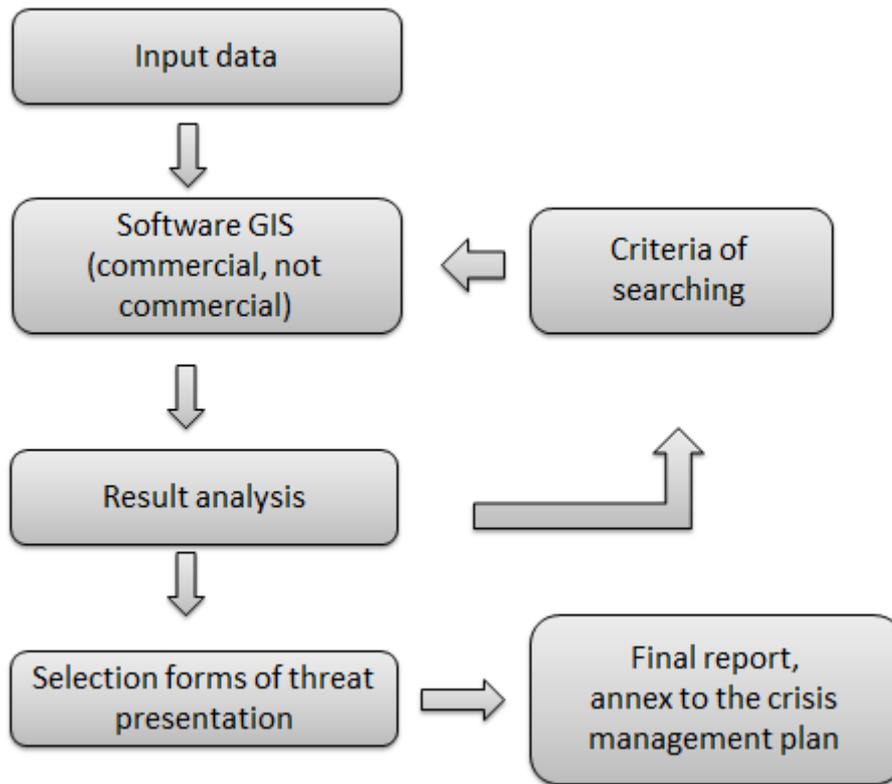


Figure 1. Landslide search scheme in the GIS software

Source: own elaboration

Using the tools in the GIS-type software a user can conduct almost any analysis one can think of. If the tool is not made available enough by the producer, own tools can be modified or made with the usage of a programming language, e.g. Python. This is how GIS-type (Quantum GIS) open source software works [15,16]. The speed of conducting analyses and their modification with additional search criteria are great advantages of this type of software [17]. Next and at the same time the last stage of mapping out a phenomenon is a cartographic presentation. A map is the basic source of information about an area and presents numerous pieces of information in one place [18]. The GIS-type software is in the lead thanks to many

intuitive phenomena visualisation tools and, by extension, thanks to creating final reports which serve as graphic appendices in crisis management plans.

Another essential element of the first phase of crisis management is monitoring. It provides information about threats, which is necessary in the process of decision-making, especially because of the time-pressure. Properly organised monitoring is preventive in nature, it enables preventing threats, but also makes it easier to respond to their emergence at the very beginning of a crisis situation [19].

4. CRISIS PHASE - REACTING

This phase is to be dealt with if a real crisis situation emerges. It is mainly about alarming and warning, taking up protective and rescue operations, making decisions, counteracting crisis, monitoring the development of situation. Evacuating people to assembly points prepared in advance is an important stage as well. Providing people's safety, which is mainly about rescuing, taking care of the victims, taking people from danger zones to safe areas, is the priority [11].

Time is important in many elements of crisis management, including evacuation. This is why it is important to plan it in advance. Moreover, some actions related to softening the effects of the event emergence, e.g. preparing safe places for the evacuees, have to be realised quickly as well [13]. This is why they should also be set and prepared in advance. Thanks to a large event visualisation tools base the GIS-type software finds its application in making evacuation plans. It enables the simulation of people's movements around a building, enriched with taking into account the obstacles disturbing unperturbed movement of the people in danger (e.g. doors, stairs). Thanks to such information the shortest and at the same time the fastest way from a danger zone to an assembly point can be appointed, which is the most important issue in the evacuation process.

As it is mentioned above, alarming and warning is also essential. These terms are connected with informing people about threats or crisis situations. There are Regional Warning Systems functioning in many voivodeships. Current notification systems are only based on announcements. They are transmitted via mass media and mobile applications. With the current IT development the same announcement could be conveyed in the form of a clear and transparent map. This way an announcement gains its spatial reflection.

Via the GIS tools, all services are able to manage their resources in real time at the stage of protective and rescue operations, thanks to the GNSS receivers stating positions, which are installed in vehicles. Dispatchers and prefects of given uniformed services are at any moment able to manage their assets, guide units being in proximity of a threat, and thereby reduce reaction time of units giving aid.

GeoEvent is the tool of this kind. It enables tracking and managing asset in real time (Figure 2). Additionally, this module is equipped with a number of notifications, which make the work and decision-making of the personnel significantly easier. An example could be an automatic notification sent to the appropriate people in a hospital when an ambulance is 5 minutes away on its way back.

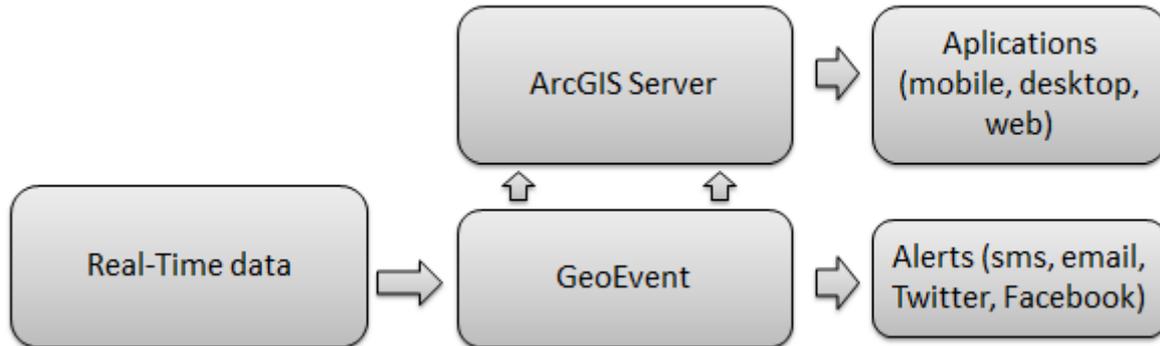


Figure 2. Usage of the GeoEvent module

Source: own elaboration based on esri.com

5. POST-CRISIS PHASE - RECREATION

The stage of recreation, also described as removing negative effects of a crisis situation, is the final phase of crisis management. It includes activities like damage estimation, recreating the state of being from before a crisis situation, rebuilding infrastructure, helping people [5]. This stage, obviously, also requires a plan, based on the needs and the extent of damage.

The GIS-type software also finds its application in this phase. It is useful in estimating damages and losses made by natural disasters. It is possible to estimate losses precisely, thanks to multiple possibilities of obtaining information and a wide range of the GIS tools. This is especially useful while dealing with large-extent losses. The usage of unmanned aircrafts (drones) is a useful and perspective tool in the process of damage estimation. It enables an area review (including inaccessible zones) after the emergence of a crisis situation. Data obtained thanks to drones combined with the capabilities of the GIS-type software yield significantly more information. Taking pictures with an unmanned aircraft and then combining them with an existing legal standing (cadastral data) is extremely beneficial at this stage of crisis management. This may provide information about e.g. the destroyed surface, the number of landowners of the territories affected by the crisis situation.

6. CONCLUSIONS

Crisis management is a multi-stage process. It is crucial in case of a possible emergence of a crisis situation, as it includes preventing and preparing for an event to occur, as well as reacting and removing its negative effects. The job of the people engaged in crisis management becomes easier when every stage is planned in advance and everyone is assigned with tasks and competences. Moreover, an analysis of potential threats is also an important issue, which is dealt with well by the Geographic Information System. It also constitutes a source of information supporting the work of the people providing security, including

dispatchers and prefects. Thanks to numerous tools, the GIS-type software is able to support tasks in the case of planning for an emergence of potential threats, reacting in real time, and removing the effects of crisis situations. Moreover, thanks to GIS, people taking part in crisis management can conduct both simple and complex spatial analyses, which in many cases influence the decision-making during all phases of crisis management. To sum up, The GIS tools have wide range of applications, not only in the processes mentioned in this article, e.g. planning, threat analysis, alarming about threats, and removing negative effects in losses estimation, but also in other crisis management processes.

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