APPLICATION OF GEOGRAPHIC INFORMATION SYSTEMS IN CRISIS MANAGEMENT

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ABSTRACT

This paper aims at highlighting the main features of a crisis and suggests the important objectives of crisis management – to be well-prepared for a crisis, ensure a rapid and adequate response to the crisis, maintain clear lines of reporting and communication in the event of crisis and present agreeing rules for crisis termination. Geoinformation technologies are emerging very fast. Meteorological and earth observation satellites, communication satellites and satellite-based navigation and geographic information systems may help to improve prediction and monitoring of potential hazards, risk mitigation and disaster management, contributing in turn to reduce losses of life and property. Remote sensing and earth observation satellites have already demonstrated their flexibility in providing data for a broad range of applications: weather forecasting, vehicle tracking, disaster alerting, forest fire and flood monitoring, oil spill detection, desertification monitoring, and crop and forestry damage assessment. Monitoring and management of recent natural disasters have greatly benefited from satellite imagery and geographic information systems

KEYWORDS: crisis management, early warning systems, geographic information systems

1. Introduction

Present world is described with high speed and broad spatial range of changes, with complex interdependences between running processes. This places a lot of challenges for timeliness, accuracy and high quality of decisions and actions. Basic for the implementation of these requirements must be an early warning system with incorporated information technologies. On account of this, an early warning system will be able to obtain, analyze and systematize information and knowledge, which will later be submitted to all leaders for decision making in the beginning of disasters.

2. Essence and Main Characteristics of Crisis Management

A crisis, irrespective of its nature, is characterized with period, possible increase and jolt. Crises always originate and develop very quickly, with shortness of time for reaction or recovery of the broken laws of the ecosystem.

Crisis management is aggregation of principle decisions and activities of different character, which include:

– control of security risk factors;
– analysis and early warning for possible crises;
– elaboration of planning documents for using national forces and interaction with international institutions;
– planning of a national system for crisis management and undertaking measures for refinement;
– preparation and realization of after-crisis strategy (program);
– analysis of crisis and effectiveness of measures undertaken from institutions.

Crisis management is the ability of the government and local administration, with created effective ruling structure of planning and coordinating, to implement functional duties. The main objectives of crisis management are:

– contribution to engagements and efforts of the international community to reduce risk factors for security and stability, blocking and resolving continuing crises and conflicts and permanently removing preconditions in the future;
– risk factors prevention of any matter;
– readiness for action of respond forces;
– management of continuing crises, prevention of military conflicts.

These objects are attained through creating a system of agencies, mechanisms and forces, aimed at resolving the following tasks:

– preliminary preparation of government and the system for action in case of a crisis situation – "prevention";
– reduction of crisis factors and crisis propagation – "correction";
– getting control of escalation and spread of crises – "counteraction";
– decreasing the intensity of crises – "reduction";
– planning and implementing measures for prevention – "reconstruction".

Non-military crises, depending on the realm of manifestation, may be: disasters, industrial (human-made) that arise out of socio-natural calamity, failure and contamination, epidemics and religious discrepancy. As a rule, real crises combine different types with one dominant.

Disasters and catastrophes can be further defined as extreme geophysical events (Kamarashev, 2014). These are events, in which the geophysical parameters of the environment change and take extreme values. It is obvious that not the absence of a geophysical phenomenon, but the changes of the parameters define the presence of a disaster. A hazardous event may occur either in a rapid change of geophysical parameters, or in a continued deviation from the normal values.

There is definite interdependence between separate disasters. A number of events can create the following disasters (Manev & Ruseva, 2005), or to give a precondition for them.

A typical example is an earthquake, which may create a tsunami, to provoke a landslide, to arouse a volcano, to cause flooding, etc. – Figure no. 1.

3. Early Warning for Beginning Crises

The essence of early warning, as a stage of crisis reaction, is giving timely and effective information for coming and immediate threat of disasters to a definite group of people – authorities, reaction forces and population (Nedevski, 2010).

Warning is a process of collecting and exchanging information between command and control operatives for possible events, on the basis of which an immediate

preparation of reaction forces commences (isaca.org).

The main objective of early warning is to limit the risk of threat of coming disasters, get control of the current situation and reduce the consequences.

The essence of early warning lies in revealing the earliest indications for emerging disasters on time and notifying the government and army forces in order to make a decision on preventing the citizens (*esri.com*). This makes the early warning systems (EWS) an important tool in national security conception and a real basis for crisis prevention.

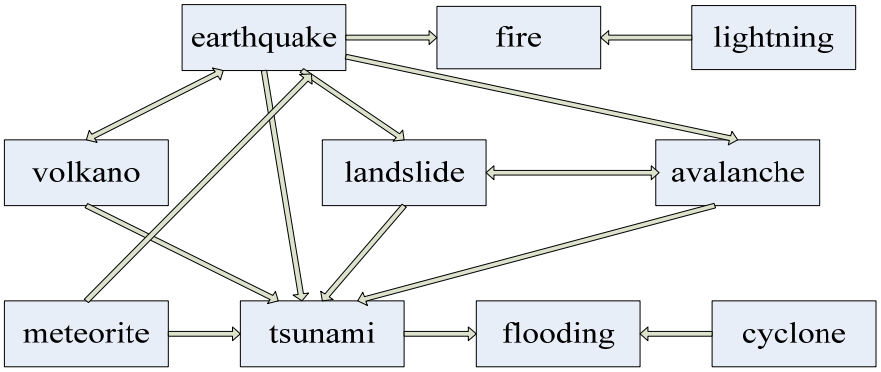

Figure no. 1 Interdependence between different disasters

In broader sense, the EWS embrace some chain processes:

– disaster monitoring;

– building a system of parameters and criteria for giving an account of the processes connected with the formation and growth of crisis situations;

– creating a system of preventive actions, which may avoid intensification of some crisis processes;

– creation of a reliable and effective mechanism for population defense.

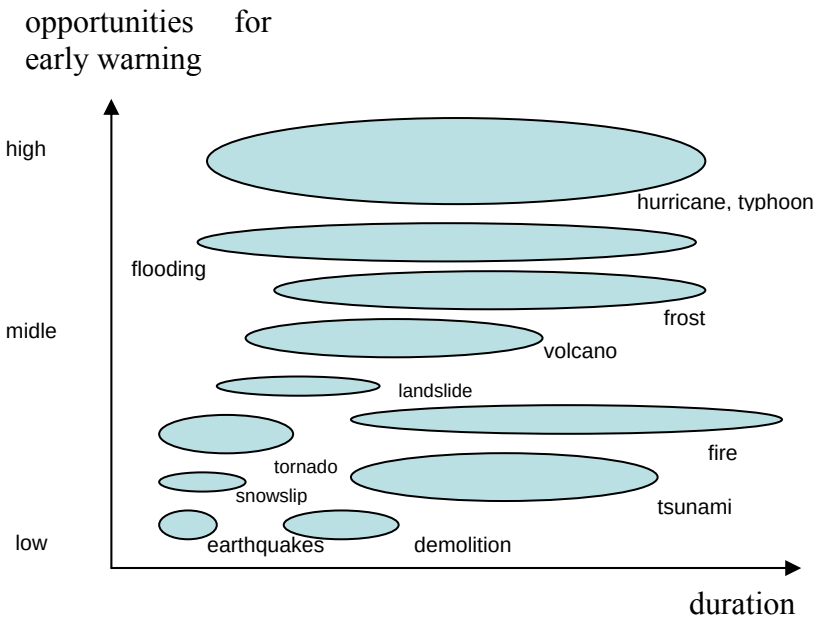

Figure no. 2 Interdependence between opportunities for early warning and disaster duration

The main task of EWS is to establish a system for observation, control, analysis and prognosis, which keeps a close watch on treats, providing the incoming information on time and taking measures for prevention of potential events.

It is well known (Nedevski, 2010; *esri.com*), that the opportunities for early warning depend on the basic physical parameters of disasters. The easiest for prognosis are meteorological events and the hardest (some even not possible – earthquakes) are geological threats – Figure no. 2.

4. Possible Elements of Early Warning Systems

The early warning system contributes to reduction of economic loses and disaster risk for population by providing information that ensures protection to sociality, individuals, critical infrastructure and private property. The pre-emptive information gives an opportunity for fast reaction in the beginning of a disaster. Good integration between EWS, evaluation and management of risk and action planning is a starting point for the real process of defense and prevention, reduction of human loses and economic damages.

After analyzing the objectives, principles, characteristics, main tasks and EWS requirements, a functional structure for the EWS can be suggested. The elements which must be included in the system are:

– agencies and resources for obtaining information, monitoring and processing;

– risk identification and evaluation;

– creating a methodology for evaluation of critical infrastructure;

– zoning the territory according to risk factors;

– designing models for engagement in advance;

– modeling decisions for reaction in possible disasters;

– communication system for information in defense mode.

– After integrating these specifications in the national early warning system and creating a known information picture, it is possible to:

– coordinate all activities of the special structures and businesses for preventive and remedial measures;

– interact with similar systems in other countries.

5. Geographic Information Systems for Early Warning

Using spatial information is a benefit at all stages in crisis management. The data for objects and phenomena positions and the attended characteristics give an opportunity to determine all specifications of the disaster, prognosticate its propagation, plan actions limiting the unfavorable consequences and ensure control for restoration work.

The basic element in Geographic information systems **(**GIS) is an object from land. The data for such an object is three types. The graphical data gives an account of object' position, shape and size in space (geometry), and also presents its graphical characteristics (symbols, color, line width). As far as geometry is concerned, we can divide objects into: point, linear and areal. Objects may be modeled through vector or raster data.

Attributive data, which can be descriptive (object features) and administrative, is presented through familiar data models: relative, hierarchical, network, etc.

The subject aspect determines the inclusion of thematic information from a known descriptive field in GIS. The thematic information of the environment is unlimited, and this gives an opportunity for using GIS as a universal information system for resolving diverse tasks. Besides, it is

exactly this thematic information that is basic, and the space information serves as a linking section in unification, comparing, searching and interpreting different thematic data.

The time data gives an opportunity of studying the changes in objects and events and dynamics of the running processes.

The GIS embraces data for broad territories, processes and people, supports relations, which exist between them, and gives a chance for space analysis. GIS technology (Valchinov, 2003) ensures information for a particular part of the terrestrial surface, above and below it, the relation between objects, the presence and opportunity for the creation of new ones, and prognosticating the changes that may occur after a period.

Depending on goals and tasks, GIS may embrace different data (concerning sort, range and accuracy) and be oriented to a specific field of application. Such a basic GIS is necessary, containing all possible elements represented on the topographic map and their characteristics, for the purposes of early warning system. Complying with the requests and needs of individual users in the process of gathering data, supplementary elements and attributes are added. They are integrated in a united system with a main geo data base. From this basic GIS, application GIS are also made, intended for solving specific tasks. A basic GIS serves for:

– formation and support of constant geospatial data in standard form for processing and exchange;

– a basis for application of automated systems and modules for analysis and prognosis of geographic information, creation of publisher originals and other geospatial products;

– providing geo-information for terrain, needed for situation analysis, decision making, warning of leaders, planning prevention, tracing a developing disaster;

– unifying digital geographic data needed for all analysis systems, management and monitoring.

The geographic information system for EWS needs is intended for providing with geospatial information all elements of national security system in joint tasks implementation.

The main object of GIS is to create an effective spatial data infrastructure for a crisis management system, based on current and perspective information and geo-information technologies, (MC 296/1 NATO Geospatial Policy, 2006) and satisfy world standards.

The specification of an early warning process imposes the following basic requirements on GIS:

– collecting initial digital geo-information data from different institutions and organizations;

– entry and storage of geo-information data in information bases; updating geo-data through monitoring systems and remove sensing;

– improvement of service quality and quickness, assisting government in making decisions, concerning the processes taking place in a definite territory;

– exchange of data between information bases of a particular system;

– making analyses and prognoses of geo-information data and submitting the results.

GIS includes different types of digital geographic information:

– vector data (graphics and attributes);

– raster data – an equivalent of topography maps and town plans;

– raster data – orthorectified pictures;

– relief digital data;

– geodesy sets data;

– vertical obstacle data.

6. Geographic Information System Structure

On the basis of analyses results of previous chapters, the following functional structure of applied GIS for purposes of early warning system is suggested:

– "input geographic information";

– "editing initial information, organization and structure of database";

– "analysis of spatial definite data for terrain and database management"

– "creation and control of map publisher originals";

– "broadcast of digital products";

– "propagation of digital geographic data".

All phases of crisis management depend on data from a variety of sources. The appropriate data has to be gathered, organized, and displayed logically to determine the size and scope of emergency management programs. During an actual emergency it is critical to have the right data, at the right time, displayed logically, to respond and take appropriate action. Emergencies can impact all or a number of government departments. Emergency personnel often need detailed information concerning pipelines, building layout, electrical distribution, sewer systems, and so forth. By utilizing a GIS, all departments can share information through databases on computer-generated maps in one location. Without this capability, emergency workers must gain access to a number of department managers, their unique maps, and their unique data. Most emergencies do not allow time to gather these resources. This results in emergency responders having to guess, estimate, or make decisions without adequate information. This costs time, money, and – in some cases – lives. GIS provides a mechanism to centralize and visually display critical information during an emergency.

GIS and remote sensing are examples of ICT tools being widely used in almost all the phases of crisis management activities. In the planning phase GIS can be used to identify and pinpoint risk prone geographical areas, as a GIS-based 3D map provides much more information compared to an ordinary 2D map. Earth observation satellites can be used to view the same area over long periods of time and as a result, make it possible to monitor environmental change, human impact and natural processes. In the mitigation phase, GIS is helpful in monitoring. GIS also play several roles in the recovery phase. It can identify the damage, assess it and begin to establish priorities for action (triage). GIS can also ensure uniformity in the distribution of supplies (medicine, food, water, clothing, etc.) to emergency distribution centres. They can be assigned in proper amounts based on the amount and type of damage in each area.

7. Conclusions

1. Advisable decisions for action in case of disasters depend on: preliminary preparation of a system for extraction of geospatial information; organizational structures; elements and functional relations. The spatial identification of the changes of geophysical parameters of natural events is a complex process including GIS, remote sensing and data processing.

2. A functional structure of GIS is suggested, which meets the requirements for current, well-structured geo-information, imposed by early warning systems.

3. The cartographic products, the spatial modeling of the terrain, the geographic analysis, the semantic generalization of geo-data are a base for the formation of a spatial-oriented scheme for global application in crisis management.

GIS unifies traditional operation with database, like request and statistical analysis, with visualization advantages and spatial analysis, which maps offer. These opportunities distinguish GIS from other information systems and give a unique opportunity for using them in a broad spectrum of tasks, connected with analyses and prognoses of events and processes.

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