FAILURE FACTORS FOR THE USE OF GEO-INFORMATION DURING NATURAL DISASTERS

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Keywords: *natural disaster management, geo information (GI)*

Abstract: *The severity and frequency of weather-related natural disasters have increased, thus showing how important is disaster management. Geo-information (GI) can help us better understand natural phenomena but there are obstacles which prevent humanitarian originations and individuals from taking full advantage of it. In this paper based on an extensive review of disaster management literature, some key failure factors were identified. The purpose is to offer an overview of these factors using the framework of project management and to point out areas where improvements could be initiated. The findings show that there is an abundance of papers describing the use of new sources of geo-information and new processing techniques. But the lack of skills, awareness and time hinder their use. There are also issues with the visualization, compatibility, availability and sharing of geo-information, which have to be approached.*

ФАКТОРИ ЗА НЕУСПЕХ ПРИ ИЗПОЛЗВАНЕТО НА ГЕОИНФОРМАЦИЯ ПО ВРЕМЕ НА ПРИРОДНИ БЕДСТВИЯ

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Ключови думи: *управление на природни бедствия, геоинформация*

Резюме: *През последното десетилетие важността на управлението на бедствия се увеличи, тъй като природните стихии се проявяват все по-често и нанасят все по-големи щети. Геоинформацията може да ни помогне за по-доброто разбиране на природните явления, но съществуват различни пречки, които възпрепятстват хуманитарните организации и отделните индивиди да се възползват напълно от нейните преимущества. В този доклад въз основа на обширен преглед на научната литература за управление на бедствията, бяха идентифицирани някои ключови фактори за неуспех. Целта е да се предложи обзор на тези фактори използвайки управлението на проекти като рамка за класификация и по този начин да се посочи в кои сфери са необходими подобрения. Изводите показват, че съществува многообразие от нови източници на геоинформация и нови техники за обработката ѝ. Но липсата на умения, информираност и време възпрепятстват използването им. Също така съществуват пречки при визуалното представяне на информацията, при оперативната съвместимост на различните данни и при дотъпността и обмена на геоинформация, които също трябва да бъдат взети под внимание.*

Introduction

Climate changes have increased the severity of weather-related natural disasters. Land and sea temperatures have risen, precipitation patterns have changed making some regions more inclined to floods and storms [1]. These developments together with global conflicts and disease outbreaks have highlighted the importance of monitoring and managing disasters. There is a lot of spatial data available that can contribute to the better understanding and management of disasters. But it is questionable if we make use of it in the best possible way. As Dawes et al. [2] have noted, the importance of having data in the right format and at the right time has increased, however there is much room for improvements. Their findings were based on a research of the World Trade Centre attack in 2001 but are still valid today. More recent natural disasters such as the Haiti earthquake, Typhoon Haiyan and Cyclone Pam have shown that (geo-)information derived from mapping, crowdsourcing and social media can save human lives [3, 4, 5]. But there are still many factors – both organisational and technological, limiting the use of GI to its full extent. The purpose of this paper is to identify these factors using the framework of project management, thus showing areas where improvements could be initiated. The main research question therefore is:

What are the factors that prevent humanitarian organizations and individuals involved in disaster management from taking full advantage of geo-information?

In order to answer this main research question, the following subquestions are addressed as well:

- How is GI used to support disaster management in its different domains?
- What are the expectations of GI users?
- Where do these expectations fail to overlap with the capabilities of current GI disaster management tools?

First, the methodology is outlined. In the next two chapters, a closer look is taken at how geo-information is used describing the different applications and limitations. Subsequently, the user expectations are discussed and it is showed where these are not met. Conclusion and some recommendations are given in the last chapter.

Methodology

This study is based on a literature review in the Scopus database covering scientific papers from the last five years. The literature search was concentrated on specific case studies describing the applications and limitations of geo-information and resulted in 97 documents of which 19 were identified as relevant. For the assessment of the needs of geo-information users, 101 documents were found. However, only few were relevant to geo-information. Therefore, also other sources of information were used, more specifically the reports of ALNAP (Active Learning Network for Accountability and Performance in Humanitarian Action).

Applications

Using geo-information for the purposes of disaster management is not a novelty. From simple multicriteria overlay analysis and mapping techniques to data fusion, simulation models and real-time data from remote sensors and mobile devices, the use of geo-information has evolved tremendously. There are many areas of application – hazard prediction and modelling, susceptibility mapping, risk assessment and mapping, public awareness and education, scenarios development, emergency planning and training, real time monitoring and forecasting, early warning and alerting [6].

The types of spatial data used are diverse. Widely used across the different domains of disaster management are data about land use, soil, slope and aspect, altitude, the location of houses, shelters, rivers and roads [7, 8]. But there are also data which are specific for the particular domain – for example the different indices. The Topographic Wetness Index (TWI) is used for flood susceptibility mapping [7]; different indices algorithms are used for the automatic recognition of build-up regions [9].

The sources of geo-information are also diverse – statistical databases, ground observations, (satellite) imagery and its products, social media, etc. The spatial and temporal resolution of satellite images have improved and even ad hoc acquisition of new satellite data is possible within less than 8h [10]. There are also simulation models such as fire spread models [11] and hydraulic models [12], which make use of spatial data in a new way and supplement traditional spatial analysis. Spatial Video Geonarratives are also a new source of spatial data, where participants are guided through an area familiar to them and are asked to discuss different issues such as consequences of a tornado, but also health and crime related problems. GPS-enabled cameras and word geotagging software are used to create spatial data from the recordings [13]. Crowdsourced information from (social) media also gained popularity as a tool for near real time mapping [14].

There are also new techniques emerging for the processing of remotely sensed data – for example the object-oriented analysis technique [15]; GEOBIA (object-based image analysis) is considered to be “the most innovative new trend for processing images” [16]. 3D visualizations also emerge not only as a technique for representation of geo-information but also for analysis purposes [17, 18]. Specialized data models are used for a better overview of the data available [19]. Data fusion is another technique applied in order to overcome data limitations [20]. There are geo web applications able to combine information and services from different sources (mashup) including real time data from mobile devices [21].

Limitations

There are some limitations in the use of geo-information. For the use of satellite imagery the main drawbacks are the lack of openly available [18] and up-to-date data [22] and the fact that satellite images are not always sufficient to estimate damages, so additional data such as multi-view image or video are needed [23].

Besides having up-to-date data, other limitation for the use of geo-information is the lack of high resolution datasets such as road networks, digital elevation models but sometimes also additional information such as the location of critical facilities [20, 22, 24]. Thus, spatial analysis on a finer level encompassing also local communities is not possible and accounting for the fact that “hazards do not stop at the county boundary” is difficult [25]. For the use of simulation models, the computational costs of finer-grain modelling and simulation at a local scale are high and different software packages may be needed in order to perform this type of analysis [11]. Open source tools offer flexibility to some extent but expertise is required to build and manage them and it takes time to fix bugs [19].

Another issue is the conversion of data. Many of the data sets could be used automatically but often data conversion is required because source data sets are not standardized [18, 19]. There is a need of pre-defined core data sets (such as address and parcel information), pre-organized sharing relationships and standards, and interoperable systems [26]. Standards and data policy also hinder the use of mashup technology. Data security, http proxy standards, the use of common coordinate system are all topics that have to be addressed [21].

The use of social media is not equally spread among rural and urban populations and different socio-economic groups. So, relying solely on it as a source of information can lead to a bias in the data [27]. The reliability of such information is questionable because it is “captured by untrained persons and therefore poorly structured and not standardized” [6]. Spelling mistakes in the local place names are an obstacle in the spatial analysis [20]. Low awareness and lack of knowledge and capacity to process the data are also an issue for using crowdsourced information. There are as well some purely technical obstacles such as outdated software and hardware and limited bandwidth [14]. Web applications which use real time data from mobile devices require real time synchronization between the application and the server, and reliable network [21].

The lack of skills for dealing with spatial information across government agencies has to be approached as well [26]. For example, GEOBIA although accurate is time-consuming [15, 24] and difficult for non-experts [24]. Often in order to make use of these new methods the operational chains within management organizations have to be changed [12]. Confidentiality and ethical issues may also arise during the use of geo-information as it may reveal the identity of the participants or other sensitive information that may harm local business and local residents [13].

User expectations

There are not a lot of research papers on the expectations and actual needs of GI users. The study of Burston et al. [28] is one of the few researching the needs of emergency managers. Their study found out that emergency managers are dissatisfied with the visualization of warnings and the misinterpretation caused by the lack of harmonization across information platforms. For them it is important to have enough time for preparation and a warning system should “ensure that people can be gathered as soon as possible”. Emergency managers also would like to have time series information about the warnings and finer spatial resolution. They have expressed their concerns that for remote areas interpolation of data is required, which reduces the reliability of the warning system. Therefore higher resolution of (spatial) data has to be provided [28].

ALNAP offers a series of documents with lessons learned from recent disasters, which are rich source of information about the needs of people involved in disaster management as they are often based on interviews with operational humanitarian practitioners. In an assessment of the Nepal earthquake, it was identified that some baseline datasets should be available at the beginning of a disaster [29], for example up-to-date maps of the infrastructure [30]. The data should be publicly accessible via the web and it should be ensured that new data collected is compatible with the data already available [29]. Data management systems should enable the quick extraction of information and the conversion to different formats according to the needs of the users [31]. Data should be shared as soon as possible [14]. Visualization is also important because in the aftermath of a disaster there is an information overload [14] and it is difficult to comprehend all the information available [29, 31]. The technology used at the time of a disaster should be fully mastered. If this is not the case, more traditional technologies should be preferred [30, 31]. Information gaps and limitations of the scenarios, assumptions and assessments should be acknowledged and clearly outlined [31]. In the research of Burston et al. [28], emergency mangers also perceived that uncertainty is not adequately communicated in forecasts. Collecting information that is too detailed is not beneficial [31]; it is “better to have moderately reliable information and "good enough" analysis on time than "perfect" information and analysis that comes too late" [32].

The mismatch of expectations and reality

Analysing the applications and limitations of geo-information and the needs of geo-information users, the following mismatches were identified:

- Current visualization of disasters does not fully meet the needs of geo-information users. There is advancement in the use of 3D visualization for both presentation and analysis of data but it still fails to outline the uncertainty of forecasts, the information gaps in the different scenarios and assumptions, and the temporal aspects of data.
- For geo-information users time during disasters is critical. Therefore the collection and analysis of data should not be too detailed and should not be aimed at achieving the most accurate and comprehensive analysis but rather a moderately reliable one. Because of this time-consuming techniques for processing geo-information may not be suitable even if they provide accurate results.
- People involved in disaster management do not always have the skills to use certain technologies or techniques. In such cases more traditional well known technologies and techniques should be used. Manual mapping and weighted overlay analysis may be preferred because they do not require any expert skills [33]. Because of this some innovations in the area of geo-information may not be applied during a disaster until they reach a certain maturity level.
- Despite the abundance of geo-information, there are still some basic datasets missing, the data available is not current or does not meet the needs of the users in respect to spatial resolution.
- Sharing data with other stakeholders such as other humanitarian organizations or media [34] is important. However, there are some compatibility issues between different information platforms and data formats, which hamper it.

According to the classification framework of Moe and Pathranarakul [35], disaster management can be viewed as public project management, where disaster management phases are presented as parts of a project life cycle. Using this framework the mismatches identified above can be addressed in different phases of a disaster. Organizational changes and the lack of skills and awareness to use certain technologies and techniques should be approached in the initiation phase; outdated software and hardware, limited bandwidth and network issues, compatibility issues between information platforms and data formats, data issues (not available, not reliable, not up-to-date, with low spatial resolution) should be approached in the planning phase; visualization of uncertainty, information gaps and temporal aspects, lack of time for using time-consuming techniques for processing, confidentiality and ethical issues should be approached in the execution phase.

Conclusion and recommendations

GI is used in many domains – for flood and wildfire evacuation and recovery, assessing human vulnerability to cyclones and storm surges, post-disaster recovery, (real-time) damage detection, landslide monitoring, earthquake emergency response just to mention a few. However, GI tools do not always meet the needs of their users. A pull approach should be considered, where emergency managers are actively involved in the development of new GI technologies and techniques.

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