http://dx.doi.org/10.15576/GLL/2023.3.7

GLL

Geomatics, Landmanagement and Landscape No. 3 • 2023, 7–17

USE OF CARTOGRAPHIC DATA IN CRISIS MANAGEMENT

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Summary

The subject of the research in this paper was a review and identification of types of cartographic documentation used in crisis management in Poland. The analysis focused mainly on assessing the usefulness of cartographic data for visualising the scale of natural phenomena such as floods, landslides, droughts, wind, and others. The most important map that serves as a reference base for various types of industry-related works, especially derivative geodetic works, is the cadastral map stored in the resources of the Land and Building Register. In this study, the authors concentrate on the possibilities of using cartographic data, with a particular emphasis on cadastral maps, for crisis management purposes. The aim of this paper is to review and provide an expert assessment of the usefulness of cartographic data in emergency situations. The research shows that cartographic data are crucial for each of the mentioned hazards, especially the resources of the Land and Building Register, which allow the visualisation of the spatial and temporal scale of these hazards. The success of the measures taken to reduce the occurrence of floods or landslides, for instance, depends first and foremost on fast and seamless access to reliable and up-to-date information on the terrain. The cadastre is one of the publicly accessible registers providing this data, without which crisis management could not be fully effective. The study was conducted through an online survey using an interactive sheet, dedicated to experts (services dealing with different types of hazards).

Keywords

crisis management • cartographic works • hazard maps • cadastral map

1. Introduction

In the National Crisis Management Plan, 19 major hazards have been defined for crisis management under the security network category. These include the phenomena analysed in this paper: floods, landslides, winds, and droughts. Other serious threats to human life and property are: maritime disasters, radiological contamination (radioactive contaminations), disruptions in the functioning of networks and information systems, hybrid actions, severe frost (when the temperature drops below –15°C), epidemics, chemical contamination, fuel system disruptions, gas system disruptions, energy system disruptions, epiphytotic outbreaks (occurrence of widespread plant diseases in a specific area and time), heavy rainfall, major fires, epizootics (occurrence of infectious animal

diseases in a specific area), collective disorder, and terrorist incidents. The aim of this paper is to review and provide an expert assessment of the usefulness of cartographic data in emergency situations. The research shows that cartographic data are crucial for each of the mentioned hazards, especially the resources of the Land and Building Register, which allow the visualisation of the spatial and temporal scale of these threats.

The most important map that serves as a reference base for many types of industry-related works, especially those derived from geodetic works, is the cadastral map, stored in the resources of the Land and Building Register [Zwirowicz 2010]. This article focuses on the possibilities of using cartographic data, with a special emphasis on cadastral maps, for crisis management purposes. Trystuła [2012] asserts that '(...) the success of the measures taken to reduce the occurrence of floods or landslides, and other threats, depends first and foremost on fast and seamless access to reliable and up-to-date information on the terrain.' The cadastre is one of the publicly accessible registers providing this data, without which crisis management could not be fully effective. The whole mechanism consists of three stages that, among other things, allow for crisis prevention and preparation. The initial phase is designed to take steps to develop, among other things, the databases necessary throughout the crisis management process. Felcenloben [2010] believes that the cadastre, which contains legally required data about specific parameters of transparency and reliability, comprises a significant layer of information that should be adopted in property management mechanisms and, in a future perspective, be a basic element of geoinformation systems for state management.

According to the Act of 17 May 1989 – the Geodetic and Cartographic Law – the Land and Building Register (real estate cadastre) is an information system designed for the collection, updating, and uniform provision of information throughout the country on land, buildings, premises, their owners, as well as other entities that own or manage these lands, buildings, or premises. It is also a foundation that 'provides information about a territory (...) on a continuous basis, bringing tangible benefits to the state, whose data are used in property management and spatial planning.' [Konieczna 2013, p. 151]. The real estate cadastre also plays a crucial role in mitigating the effects of natural disasters. 'Cadastral information collections supported by additional data from other sources play a significant role in situations related to natural disasters that can and do occur in certain areas of the country' [Trystuła 2012, p. 122]. Modern technologies allow for the integration of all information using the Geographic Information System (GIS). These data can be useful, among other things, for making spatial analyses or determining, for example, flood hazard zones [Konieczna 2013]. Mączewski and Wilkowski [2011] argue that in an emergency, it is precisely cadastral data that serve as the basis for a rapid and effective assessment of losses and damages caused by a specific phenomenon.

According to the Act on Crisis Management of 26 April 2007, 'crisis management is an activity of public administration bodies that is a part of national security management. It involves preventing crises, preparing to take control over them by means of planned actions, responding to emergency situations, mitigating their effects, and restoring critical resources and infrastructure.' Natural disasters are becoming increasingly common, not only in Poland but also around the world. 'Volcanic eruptions, tornadoes,

earthquakes, floods, landslides, and tsunami waves are phenomena that humanity has partially learned to predict but still cannot fully contain. All one can do is warn and take measures to minimise their impact' [Żuber 2006]. Crisis management is a multi-dimensional concept. According to Article 3, point 1 of the Act on Crisis Management of 26 April 2007, an emergency is a situation that 'negatively affects the safety of level of people, property on a significant scale, or the environment, and substantially limits the functioning of relevant public administration bodies due to inadequate forces and resources.' The Act on Crisis Management served as the basis for the development of the National Crisis Management Plan. It introduces essential modules that facilitate the planning process and decision-making in emergency situations. Modern technologies allow for the integration of data from various sources, making it possible to carry out detailed spatial analyses, such as the designation of flood hazard zones [Konieczna 2013]. This is also discussed by Mika and Siejka [2014]. On 2 August 2008, the Government Security Centre (Rządowe Centrum Bezpieczeństwa, RCB) was established. It is a budgetary state unit under the authority of the Prime Minister. It operates on the basis of the Act on Crisis Management of 26 April 2007 and the Regulation of the Prime Minister of 11 April 2011 on the Organisation and Operation of the Government Security Centre. Detection of contamination and alerting the population are also important issues in this area. In Poland, the main legal document regulating this issue is the Regulation of the Council of Ministers of 7 January 2013 on systems for detecting contamination and warning of its occurrence, as well as the competence of authorities in these matters. It outlines the functioning of the entire system and defines key concepts necessary for understanding the operation of the National Contamination Detection and Alert System (KSWSiA). The establishment of the KSWSiA mechanism was aimed at preventing the consequences of natural disasters, technical failures, or terrorist actions that could result in chemical, biological, or radiological contamination.

The aim of this paper is to analyse the degree of usefulness of cartographic data, with a special focus on cadastral data, in crisis management.

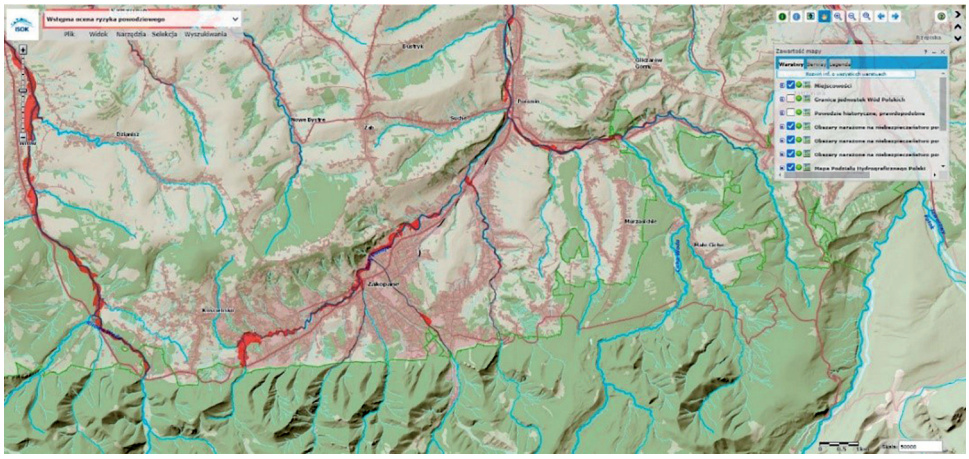
2. Subject and scope of the study

The study focused on reviewing and identifying the types of cartographic documentation used in crisis management in Poland. The analysis mainly involved assessing the suitability of works for visualising the intensity of natural phenomena such as floods, landslides, droughts, wind, and others.

Firstly, the legal and technical background of flood hazard maps and flood risk maps was examined. The responsibility for the preparation of such documents lies with the President of the National Water Management Authority, by the Water Act of 20 July 2017. These maps were prepared in December 2013 in accordance with the requirements of Directive 2007/60/EC of the European Parliament. They were reviewed in 2014 and the final versions were handed over to the administrative units in 2015 [Państwowe Gospodarstwo Wodne – Wody Polskie 2021]. Flood hazard maps show areas with a certain probability of flooding. Flood hazard maps are supplemented by

flood risk maps. These documents determine the potential extent of damage caused by floods and also present objects at risk of flooding in certain cases. According to the now outdated Regulation of the Minister of the Environment, the Minister of Transport, Construction and Maritime Economy, the Minister of Administration and Digitisation, and the Minister of Interior of 21 December 2012, on the development of flood hazard maps and flood risk maps, data from the Topographic Object Database (BDOT), spatial data sets of spatial information infrastructure, and the state register of cartographic names are essential for the preparation of these maps.

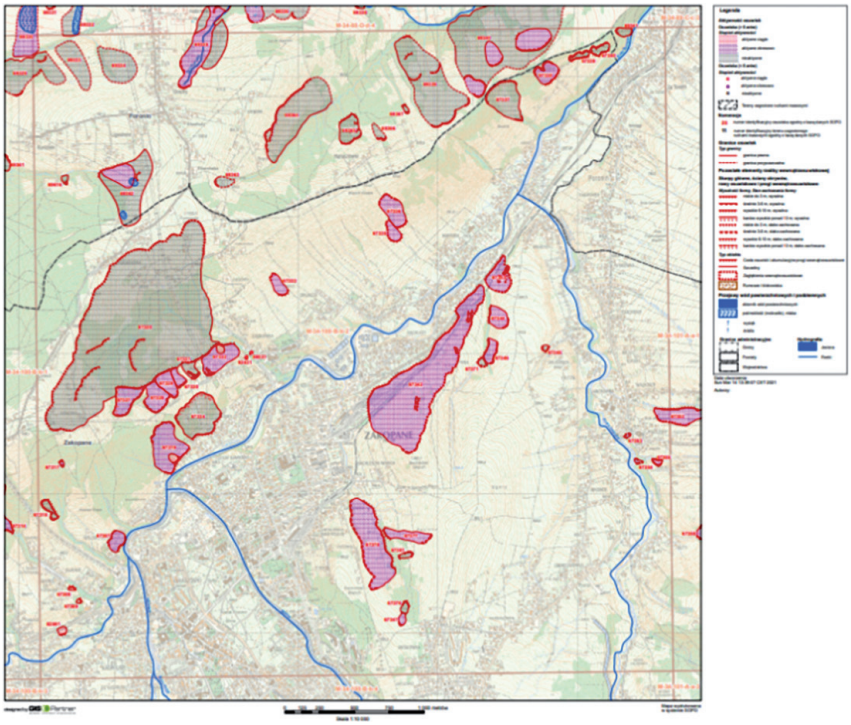
In Poland, there is the Information System for National Security (ISOK). It operates on the basis of an integrated database and a modern module for distributing information to target users. In cooperation with the Head Office of Geodesy and Cartography, as well as the National Water Management Authority (KZGW) and the State Fire Service (IMiGW), the ISOK aims to contribute to the improvement or minimisation of issues related to crisis management in Poland – with a special focus on exceptional threats posed by natural phenomena, including hydrological events. The results of the conducted analyses are the cartographic works that include flood hazard maps, flood risk maps, and hydrological hazard maps. These materials – due to their widespread availability – can be used (as surveys have shown) in crisis management. The ISOK website (Fig. 1) allows any user, including the relevant authorities of course, to identify individual areas at risk of flooding. Under the 'map content' menu there are thematic layers, including a base map, place names, historical flood areas, current floodplain extents, a map of Poland's hydrographic division, boundaries and registration numbers of land plots, national administrative division boundaries, and orthophoto maps. Altogether, these components provide a package of useful information for various stages of prevention and response to natural disasters.



Source: Imap_kzgw [2021]

Fig. 1. Excerpt of hazard map from the ISOK website

Cartographic materials are also used in landslide crisis management. Landslides are caused by the movement of rock or soil masses and gravity. The Soil Erosion and Landslide Protection System (System Ochrony Przeciwosuwiskowej, SOPO) plays an important role in the crisis management of this phenomenon. It aims to identify and document all landslides as well as areas potentially at risk of mass movement across the entire territory of Poland. Additionally, the project envisions the implementation of depth and surface monitoring systems at 60 selected landslide sites. This will serve as a starting point for the preparation of landslide suitability maps, ultimately leading to the development of a complete system for landslide prediction, assessment, and risk reduction, to significantly minimise the damage and destruction caused by landslides. These efforts will also assist local authorities in fulfilling obligations related to mass movements as enforced by various laws and regulations [Państwowy Instytut Geologiczny, Państwowy Instytut Badawczy 2021]. Landslide maps and areas at risk of mass movements (Fig. 2) comprise cartographic-geological documentation of landslides and areas at risk, which pose or may pose a threat to human existence and activities. These works include graphic resources as well as attribute resources in the SOPO database, including characteristics of landslides.



Source: Państwowy Instutut Geologiczny – System Osłony Przeciwosuwiskowej 2021 (Polish Geological Institute – The Soil Erosion and Landslide Protection System 2021)

Fig. 2. Fragment of a map of Zakopane with marked areas at risk of landslides and floods

According to the provisions of the law, the vogt, mayor, or city president prepares a reconstruction plan consisting of a descriptive part and a graphic part. The graphic part of this document is based on the base map or a copy of the cadastral map adopted by the National Geodetic and Cartographic Resource.

The next stage of the research was to determine the utility of cartographic materials in crisis management during wind-related hazards. Wind is a term used to describe 'the horizontal movement of air in relation to the earth's surface' [Ekologia.pl 2021]. This phenomenon is caused by pressure differences or terrain formations and temperature changes. The climate contributes to the formation of tornadoes, which cause the greatest devastation. With modern technology and knowledge, it is possible to distinguish different types of winds based on their relation to different meteorological situations. According to the analyses conducted at the Institute of Meteorology and Water Management (IMGW) as part of the KLIMAT project, maps of high wind hazards in climatological terms are presented as signatures of maximum wind speeds in gusts recorded at stations, as well as those occurring every 10 years. Due to the spatial diversity of this weather phenomenon and the limited measurement network, as well as significant changes in station equipment, data from the WRF-ARW 3.2.1 numerical mesoscale model are used for visualisation [Soares et al. 2012, Ustrnul et al. 2014]. In Poland, thanks to IMGW-PIB ISOK, a forecast map without synoptic verification has been created, showing weather alerts for a specific region. In the multimedia cartographic presentation on the imgw.isok.gov.pl website, it is possible to check the weather forecast for 12 hours, 24 hours, and 48 hours. This map is constantly updated, and provides real-time weather conditions for a specific location. It includes cartographic data on terrain shape and cover, buildings, various objects, as well as special modules showing the type of hazard and issued warnings.

Drought is another phenomenon that can be presented on a map, which is important from the point of view of crisis management. Drought is a sustained period during which there is no or little precipitation compared to multi-year averages. This phenomenon is most often observed in the summer months. Its effects include soil desiccation, reduction or destruction of crops, as well as an increased probability of wildfires [Teraz środowisko 2021]. The 'Stop Drought!' ('Stop Suszy!') project deserves attention, with its main goal being to counteract the effects of drought and ensure an adequate quantity and quality of water for the future. As part of this effort, the first national-level planning document called the Drought Effects Mitigation Plan (Plan przeciwdziałania skutkom suszy, PPSS) was created. It was developed based on the provisions of EU Water Framework Directive guidelines and Article 184 of the Water Act. The PPSS covers the period from 2021 to 2027. According to the Water Act, this document is subject to updating at least every 6 years [Stop Suszy 2021]. Thanks to various cartographic overlays, including orthophotomaps and topographic maps, areas at risk of an emergency can be easily located. Additionally, overlays with land cover, parcel numbers, and server data from the Web Map Service (WMS) provide essential information crucial for dealing with this hazardous phenomenon.

3. Research methods

The study was conducted through an online questionnaire using an interactive spreadsheet, targeting experts in the field of crisis management. The research sample consisted of individuals from the Małopolska Voivodeship, categorised by age criteria into several subgroups. The first subgroup comprised individuals aged 20 to 25, who are mainly studying at university or gaining professional experience. The second age category was 26–30, when people are considered to be gaining their first professional experience. The third subgroup were individuals aged 31–50, who are actively working and possess a broader range of knowledge in the field. The final subgroup included individuals over 50, who were likely to have the most expertise due to their experience. The survey link was distributed to local State Fire Brigades, District Police Headquarters, and also posted in groups related to crisis management and cadastre issues on a popular social media platform.

The survey consisted of 14 questions about the use of cartographic data, especially cadastral information, in crisis management. The first four questions related to the demographics of the respondents: age, gender, education, area of residence, and professional affiliation. The next questions were concerned with the type(s) of hazard(s) occurring in the respondent's areas of residence. Participants were then asked to choose the most useful database(s) from the perspective of crisis management. In the next step, they had to identify the most important database to contain information on the type and extent of a hazard. Additionally, participants had to select a specific number of data points to be included in a database relevant to crisis management in the region. The penultimate three questions focused on the significance of hazard-related issues, information accessibility for general users, and qualified services. Furthermore, the last two questions asked respondents to assess the completeness of the survey and to make their own observations.

4. The results of the study

The conducted study involved 51 participants who were divided into 4 age groups: 20–25 years, 26–30 years, 31–50 years, and over 50 years old. The largest group of respondents was in the 26–30 age category, with 37.3% of all participants. The second largest group was the 20–25 group (31.4%), closely followed by the 31–50 age group. No responses were received from the over-50 age group. More than half of the respondents were women (54.9%). The majority of respondents had higher education (80.4%), while the second largest group had secondary education (19.6%). Other mentioned occupational levels did not appear among the survey participants. Most of the respondents lived near Zakopane (41.2%), Nowy Targ (21.6%), Proszowice, and Olkusz (2%). The last question on the demographic details of the survey was concerned with the workplace of the respondents. The majority of the respondents were from non-uniformed services (49%), followed by the Fire Brigade (24%) and the Police (21%). The lowest number of responses came from individuals employed in the military (6%). In the following question, participants were asked to identify

specific hazards in the area where they live. Heavy snowfall was the most frequently mentioned hazard in their area (63%). Floods and severe frost came second (35%). In contrast, the least number of respondents suggested contamination and chemical hazards in their area (2%). Participants were also asked to choose the most useful database from the point of view of crisis management. The majority (49%) indicated EGiB, followed by MPZP (32%), and then by the study of directions and spatial planning conditions (19%). The subsequent question aimed to identify the database where information on the type and extent of a hazard, such as a flood or landslide, should be included. Based on the gathered data, 45% of respondents believed this information should be incorporated into MPZP, 27.5% into EGIB, 10% into BDOT, and GESUT each (5.5%). A group of 12% of respondents had no opinion on this subject. An important research question addressed to the experts was for the respondents to indicate the type of information they would include in a database for the management of a crisis in the region. This question was multiple-choice. The majority of participants indicated the following data: type of hazard (86.3%) and terrain slope (66.7%). Attributes such as soil bonitation class, land registry designation, property ownership data, and other received the fewest votes – 2 for each issue, which accounted for 3.9% of all responses. The next two questions addressed the accessibility of databases in crisis management. In response to the question: 'Do you think that databases on emergency situations should be available to qualified services?' – as many as 96.1% of participants answered affirmatively. In contrast, opinions were divided on the question: 'Do you think that databases on emergency situations should be accessible to any user?' – 58.8% of participants answered affirmatively, while 41.2% answered negatively. The final two questions concerned the assessment of the importance of crisis-related issues and the completeness of the topics covered in the survey. For the first question: 'Do you think that the addressed issues related to emergency situations are important?', all respondents answered affirmatively. As for the second question: 'Do you think that all issues were covered exhaustively?', a substantial 82.4% believed that they were. The remaining 17.6% believed that the issues were not addressed in a completely exhaustive manner, although they did not provide suggestions for further detailing.

5. Discussion of the results of the study

The conducted analyses show that, apart from identifying real threats such as floods, landslides, and droughts, the most popular answer among the respondents (experts) was heavy snowfall. This outcome is related to the fact that the majority of survey participants declared living in the area of Zakopane. As is well known, this is a common winter phenomenon in the mountains. An important aspect of the analysis was the identification by experts of the most useful database from the point of view of crisis management. Respondents unanimously indicated the EGIB database as the most useful. Participants also suggested the need for supplementing the MPZP with information on the type and extent of landslide or flood hazards. According to the

experts, the database for crisis management in the region should include information on terrain slope and detailed property location (address). Participants agreed that these databases should be accessible to qualified services. All research participants unanimously confirmed the importance of studying emergency situations. Modern spatial information management technologies allow seamless administration of distributed databases. A fundamental system containing information on a given area is the cadastre. This system contains very precise data on cadastral parcels, buildings, or premises, which are applicable in situations where necessary measures are taken in the event of natural hazards [Konieczna 2013].

The cadastre therefore plays an important role in emergencies caused by natural disasters. Thanks to cadastral data, it is possible to inventory information before the occurrence of such events, as well as to register damage after the event. This is also confirmed by Mączewski and Wilkowski: "The aggregation of cadastral data and information on the state of cadastral objects after a natural disaster, collected by the aforementioned sources, allows for a quick and effective assessment of damages and economic losses caused by the natural disaster" [Mączewski and Wilkowski 2011].

6. Conclusions

The obtained results confirmed the expectations. Experts in crisis management stated that the most important database, from the perspective of identifying threats, is the EGIB. Together with information from the Land Registry, it is one of the primary sources of information on the factual and legal status of a property and its owner/landlord. The analysis has demonstrated that cadastral data is very useful in emergency situations, although its broad potential has not yet been fully exploited. The research has shown that cartographic materials, particularly cadastral data, are essential data sources used in emergency situations. The cadastre, as a land information system, should become a part of the Crisis Management System in the future (in conjunction with other databases) and be used not only in the preparation phase but also throughout the various stages of crisis management.

Financed by a subsidy from the Ministry of Education and Science for the University of Agriculture in Krakow for 2023.

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