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GIS INFORMATION IN THE STAGES OF A CRISIS EVENT IN THE COASTAL AREAS OF ROWY, USTKA AND DARŁOWO

INFORMACJA GIS W ETAPACH ZDARZENIA KRYZYSOWEGO W STREFIE PRZYBRZEŻNEJ MIEJSCOWOŚCI ROWY, USTKA I DARŁOWO

***Abstract*:** The article is a presentation of adverse events that may occur during storms as they relate to noticeable climate change. In recent years there has been a constant increase in sea water levels and therefore forecasts and analyses for the coastal area should be made. The focus is on presenting methods for forecasting and mitigating impacts. The possibility of using a geographic information system is described, with particular emphasis on the situation of extreme weather phenomena – storms, in the coastal areas of Rowy, Ustka and Darłowo.

***Zarys treści*:** Artykuł stanowi prezentację niekorzystnych zjawisk, jakie mogą wystąpić podczas burzy w związku z zauważalnymi zmianami klimatu. W ostatnich latach obserwuje się stały wzrost poziomu wód morskich, dlatego należy sporządzać prognozy i analizy dla obszaru przybrzeżnego. Nacisk położono na przedstawienie metod prognozowania i łagodzenia skutków. Opisano możliwość korzystania z systemu informacji geograficznej, ze szczególnym uwzględnieniem sytuacji ekstremalnych zjawisk pogodowych – sztormów – na obszarach przybrzeżnych Rowów, Ustki i Darłowa.

***Keywords*:** GIS information, crisis event, security
***Słowa kluczowe*:** informacja GIS, zdarzenie kryzysowe, bezpieczeństwo

Use of GIS and information contained in the phases of crisis management

The 21st century has been characterized by great technological development and the introduction of many improvements and solutions affecting the lives of everybody. The process of technological dissemination is related to the growing demand for

current and up-to-date information because today information has become a strategic resource.

New technological solutions have improved many decision-making activities and processes, both for individuals and for services and government. It has improved the work of dozens of areas of the state economy, making decision cycles in many sectors dependent on the use of information processing systems.

With the help of software and computer hardware, it has become possible to store, process and analyze the acquired data, both spatial (relating to location) and descriptive (representing exact characteristics).

The effectiveness of state crisis management depends mainly on the correct circulation of information both within and outside the country. This suggests that crisis management systems must be based on recognised international standards. In Poland, so far, the circulation of security-relevant information takes place through web applications or websites developed independently by various commercial companies, organizations and institutions. Due to the use of specific technologies, it is difficult to create a single information infrastructure from these solutions. As a result, solutions from different suppliers cannot, in most cases, cooperate or exchange information with each other.

The methods and forms of obtaining information affect the quality of currently stored files and data necessary for analysis based on GIS applications. Many methods of data acquisition are known, but the safe collection of information is possible only through databases and local servers which are made available to the public and which are protected by security systems.

Several forms of information acquisition have been identified, but the most common one has been digitization, which consists of scanning space and terrain and presenting data on a computer screen. Another method is photogrammetry, which allows instant collection of information.

One of the main systems responsible for data storage and analysis is the Geographical Information System (GIS).[1] This system, through an interactive presentation of data in the form of a digital map, allows tracking of evolving events and processes occurring in the environment and at the same time influences the key decision making at the time of the threat. Hence, it has become crucial to provide information about space and ways to use resources for administrative purposes and there has been a great increase in interest in GIS systems in the areas of public security and crisis management.

The key element in building GIS systems are people who, having analytical skills, use the capabilities of systems to carry out data analysis based on which they provide the information needed to make the right decisions, which improves the operation of emergency services at the scene. Thanks to the very wide range of analytical and visualisation capabilities, GIS systems have found wide application in crisis management systems, which has an impact on improving the security and efficiency of the system in crisis situations. This is because spatial information technology enables constant and rapid access to information and contributes to tasks such as:

[1] https://www.esri.pl/co-to-jest-gis/ [access: 04.12.2020].

- deployment of a network of preventive and patrol units;
- the location of individual facilities and resources held by the security services;
- creating maps with accurate data on crisis events;
- reducing time and improving activities by organizing smooth transit of preventive services to the scene of the event;
- analysis of the likelihood of a hazard occurring;
- statistical interpretation of existing dependencies, through the use of digital maps with access to multiple thematic layers;
- investigating the causes and correlations of dangerous events and alerting the population to such events;
- creating schemes and their constant analysis in terms of the behaviour of specific security actors;
- planning of rescue operations and verification of the decisions taken;
- work on information and the ability to encrypt sensitive data;
- monitoring the risks that may occur, but also identifying vulnerabilities and future hazards;
- the creation of geoportals that have an impact on security building;
- design and work with layered configurations.

Spatial analyses are procedures and operations performed on data sets such as satellite and aerial imagery, point clouds from laser scanning, or data obtained from field measurements. They are at the heart of spatial information systems because they allow data to be converted into useful information that allows patterns, trends or anomalies to be found.

As a result of spatial analysis, the obtained spatial information may take various forms, such as: raster maps, vector datasets or tabular statements. This information is often used in crisis management as a tool to support decision-making. Depending on the crisis management phase and the available spatial data, appropriate spatial analyses are performed to provide the spatial information sought.

The following is an example of an analysis carried out for the purposes of crisis management depending on the type of the crisis event, in this case a storm and its effects in the form of flooding occurring as a result of the so-called retreat at the mouth of rivers.

During the response phase,[2] at the time of the arrival of submersible waves, up-to--date images are compiled with archival images to determine the actual extent of the floods. This information, combined with a terrain sculpture model, enables determination of how deep the water is in different parts of an area. With continuously supplied satellite (optical and radar) data, aerial imagery or drone data, the up to date situation in flooded areas can be monitored. Radar images, which accurately depict the surface of the earth regardless of the time of day, weather and height above sea level, are extremely useful for detecting flooding.

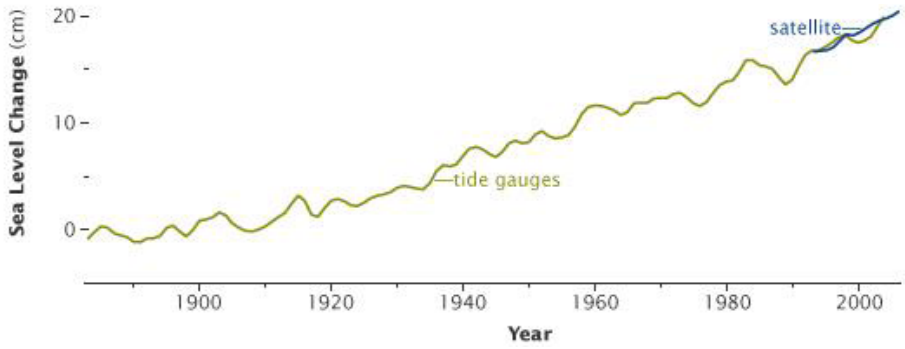
[2] W. Molek, K. Stec, R. Marciniak, *Zarządzanie kryzysowe w systemie kierowania bezpieczeństwem narodowym*, "Pozamilitarne Aspekty Bezpieczeństwa" 2011, t. IV, Wrocław, s. 45.

During the reconstruction phase,[3] spatial analyses are carried out which provide information on the areas affected by the floods and the extent of losses. Thanks to satellite (or aerospace) data and a hydrological model, spatial analyses are performed indicating drain-free spaces and the optimal location of high-efficiency pumps for water pumping after flooding.

Use of Geographic Information Systems in selected crisis events

Based on information from NASA scientists, global warming is accelerating and will continue to accelerate if greenhouse gas emissions into the atmosphere are not reduced. The consequence of this is already seen in sea level rise, which will be catastrophic if the ice sheets of Greenland and Antarctica melt. Higher sea levels have already caused increased coastal erosion and frequent flooding of coastal towns during periods of increased storms (Poland – spring and autumn-winter period).

Fig. 1. Sea level change in years



Source: https://earthobservatory.nasa.gov/features/GlobalWarming/page6.php, [access date: 04.12.2020].

The Intergovernmental Panel on Climate Change (IPCC)[4] estimates that sea levels will rise by 0.18 to 0.59 m by 2099. Referring to this data and adopting the highest sea level rise value, i.e. approximately 0.6 m, it is possible to estimate areas exposed to irreversible flooding on the basis of GIS systems, which are systems supporting decision-making in crisis management. One such system is the Operational Graphics Package (PGO) on which this analysis was conducted.

However, the conditions determining the flood plains involve a certain measurement error, due to the level of accuracy of the vertical altitude measurements adopted

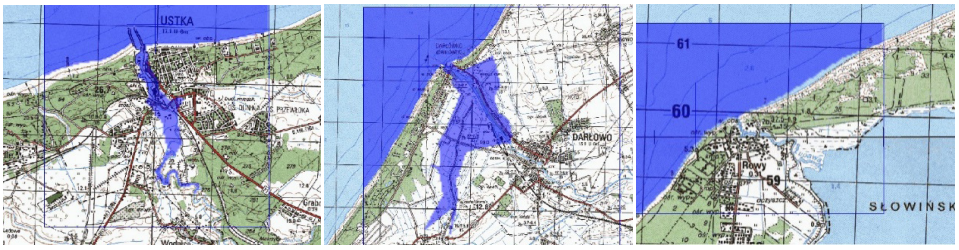
[3] K. Włodarczyk, *Oprogramowanie wspomagające zarządzanie kryzysowe na szczeblu lokalnym*, Zeszyty Naukowe Politechniki Śląskiej, Gliwice 2011, s. 5.

[4] *Special Report Climate Change and Land*, An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems, IPCC 2020, p. 58–68.

in the above-named program, of 1 m. In spite of this, the program allows an approximate illustration of the effects of crisis events, which will be irreversible flooding in the coastal zones in the selected areas in the future, in this case Rowy, Ustka and Darłowo.

The results are presented in Fig. 2.

Fig. 2. Flooding in Ustka, Darlowo and Rowy in the event of a sea level rise of 1 m (simulation based on PGO 2014 program)

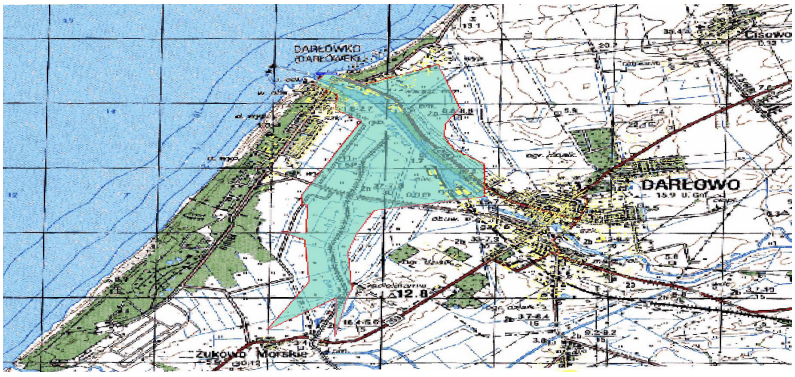


Source: self-analysis based on Operational Graphics Package 2014.

Using the data received, i.e. floodplains, further analyses can be made related to the development of a population evacuation plan or facilities to ensure the functioning of local communities based on another GIS system supporting crisis management, which can be the Arc GIS application.

An example of analysis, based on the use of Arc GIS, of the occurrence of flooding in Darłowo-Darłówko is shown in Fig. 3.

Fig. 3. Isolated flood zone with a sea level rise of 1 m

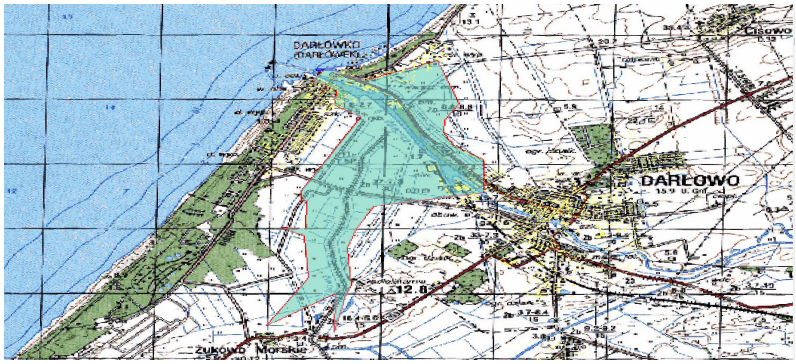


Source: own study based on Arc GIS.

Analysis of flood zones in PGO 2014 made it possible to use the data, from which the layer was created, to perform an analysis isolating objects completely inside the source layer, i.e. the flood zone. As a result, 223 objects located within the border of

the towns of Darłowo and Darłówko were identified which, in the future, will be exposed to flooding, Fig. 3.

Fig. 4. Darłowo. Extracted objects in the flood zone



Source: own study based on Arc GIS.

Based on this data analysis and using the information contained in the object attribute tables, it is possible to plan well in advance projects related to the evacuation of people, animals and property from areas at risk of flooding, as well as the relocation of facilities belonging to critical infrastructure ensuring the functioning of local communities. This is the future.

Today coastal areas are struggling with storms of great force which destroy not only coastal cliffs but also flood urban areas and destroy beaches and coastal defences.

Fig. 5. Destroyed bike path in Kołobrzeg after a storm

Source: https://tvn24.pl/tvnmeteo/informacje-pogoda/polska,28/sztorm-rozprul-morski-brzeg,18372,1,1.html?p=meteo, [access: 04.12.2020].

Strong winds occurring in the Baltic Sea, especially in the spring and autumn - winter periods, cause higher water levels at the mouths of rivers, an effect called

"backwater," i.e. the north wind pushes the water from the sea into the land, which threatens to flood urban (or rural) infrastructure.

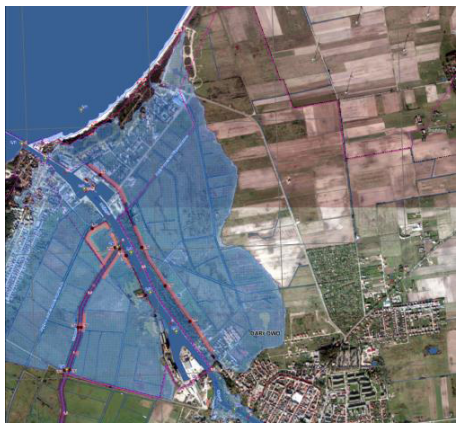
With the many possibilities of obtaining "historical" GIS data on areas at risk of flooding, especially in coastal areas with stormy periods, it is possible to develop maps of floodplains depending on the scale of the storm, based on GIS applications that enable the analysis of threats to objects located in floodplains. This information thus gives decision-makers and emergency management services time to make decisions and take actions to prevent the possible evacuation of populations, animals and property from flood-prone areas.

An information-rich internet portal for GIS data on floodplains – is Hydroportal--ISOK (https://wody.isok.gov.pl/imap_kzgw/?gpmap=gpPDF).

Fig. 6. Ustka. Sea flood risk map, including internal sea water, 1% probability of flooding – once every 100 years

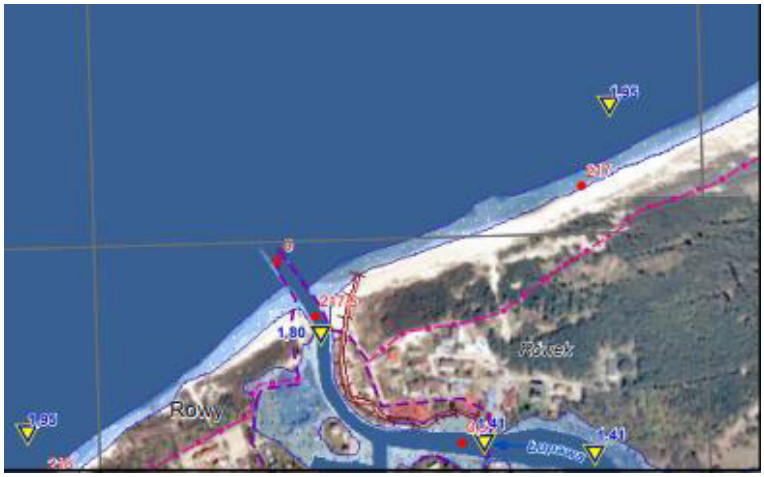
Source: https://wody.isok.gov.pl/imap_kzgw/?gpmap=gpPDF, [access: 04.12.2020].

Fig. 7. Darłówko-Darłowo. Sea flood risk map, including internal sea water, 1% probability of flooding – once every 100 years



Source: https://wody.isok.gov.pl/imap_kzgw/?gpmap=gpPDF, [access: 04.12.2020].

Fig. 8. Rowy. Sea flood risk map, including internal sea water, 1% probability of flooding – once every 100 years



Source: https://wody.isok.gov.pl/imap_kzgw/?gpmap=gpPDF, [access: 04.12.2020].

By treating the data obtained from the geoportal adequately, as in the case of data obtained from PGO 2014, an analysis is developed as a result of which we obtain information on the threats to objects located in the flood zone. The analysis identified 726 objects exposed to flooding, Fig. 9.

Fig. 9. Darłowo. Isolated objects in the flood zone resulting from the so-called storm retreat

Source: own study based on Arc GIS.

In the considerations made so far, it can be noted that the services involved in the crisis management system suffer from an information deficit. Each crisis is characterized by certain parameters, including a shortage of time and information. Not having

complete and up-to-date data, or lacking data on the size of an event, can be a factor in the success or failure of decision-makers and services.

Conclusions

The presented issues were focused on meeting the needs in the field of knowledge:

- what factors influence the use of GIS applications in the area of crisis management and
- understanding and using the acquired knowledge to improve the functionality of the Geographical Information System, understood as a multi-component tool (methods, technical means, hardware, software, database, procedures and people interested in its functioning) for obtaining, publishing, processing and analysing spatial information.

In order for GIS to function effectively, it is necessary to have a harmonious and proportionate balance of the above-mentioned components, as each of them plays an important role in the construction of a reliable information flow system.

Through extensive analytical and program capabilities, GIS contributes to the improvement of decision-making and faster access to information, which makes this system an indispensable tool in the work of emergency services and emergency decision-making bodies in crisis events.

The geospatial tool has many advantages and development perspectives. In addition to improving the safety assurance process, it enables: precise orientation in the field, quick access to up-to-date data and maps in digital form, and analysis of multiple situations simultaneously. However, attention should be paid to the dangers that may be encountered in using said system.

One of the threats to the functioning of the system is access to out-of-date data,which usually escalates anxiety. Other risks relate to hacking groups and terrorist groups stealing data and using it for illegal purposes.

It should also be noted that the use of digital maps may affect the ability to use maps in analogue (paper) form.

The users of GIS applications face big challenges in improving their functions and accuracy of data presentation. This requires increasing system self-sufficiency and forgetting the fact that GIS systems are an auxiliary tool rather than a decision-making tool. The system cannot be held responsible for decisions that save lives or property.

Users of the map tool should be aware of its objective, the purposes of environmental threat analysis, as well as the fact that the system is designed to assist with decision-making, not to take over the role of decision maker.

However, it should be remembered that in order to be able to consistently and safely use the Geographic Information System, a number of actions are needed to improve the efficiency of the system, which include:

- the creation of extensive databases that will be kept up-to-date;
- analysing the quality of information obtained by officials;
- building data security systems and creating bodies that ensure access to secure information;
- facilitating access to published data and computer maps;
- the establishment of legal standards related to access to spatial information;
- making the public aware of the high impact of GIS systems on the development of all sectors of the state economy;
- conducting training for users to use devices equipped with spatial technology.

GIS technology enriches our lives and improves security and supports the functioning of many systems: preventive, crisis management, security, health and military services. The Geographical Information System is constantly being improved and its development capabilities are unlimited, therefore activities related to ensuring security depend on its conscious use.

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Summary

As a result of climate change, ocean levels are rising at an alarming rate. Unfortunately, this will continue to worsen and, if not addressed on a global scale, could result in the migration of people from coastal areas that may soon be flooded. One of the main systems used for data storage and analysis has become Geographic Information System (GIS). This system allows the tracking of unfolding events and processes in the environment and at the same time influences key decision making when a threat occurs.