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How spatial data is used for informed decision making in mountain rescuing? Case study of Polish mountain rescuing organizations

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Abstract:

Mountain rescue operations are one of the cases when spatial data play important input for crucial decisions, with many of them being life-saving decisions (Niedzielski et al. 2021). Like in other time-pressure situations (Korporaal et al. 2020, Lienert 2025), proper data selection, management and visualization plays an important role in effective and efficient actions. The use of spatial data enables a better understanding of the situation and allows appropriate action to be taken intuitively, which increases the efficiency and capabilities of the rescue operations (Yao et al. 2011) and can considerably simplify and shorten the decision-making process regarding in emergency situation planning and crisis management (Brumarová et al. 2021). Their use supports actions taken within the broader context of crisis management in various fields such as fire service (Camaro et al. 2013) or in healthcare and medical service related activities (Świtała, Sikorski 2021; Carbajales-Dale et al. 2023). Mountain rescue actions are especially challenging due to high elevation changes, with many locations being dangerous, and of limited or no access (Almer et al. 2013). Even though it is necessary to use spatial data in mountain rescue actions, there is limited information published.

The reported ongoing study focuses on gathering information on use of spatial data by Polish mountain rescue organizations directly from the rescuers. The insight has been conducted through semi-structured interviews with active rescuers. Polish mountain rescuers are organized in three major operational services: TOPR operating in Tatra Mountains, SOPR operating in Świętokrzyskie Mountains and GOPR covering the rest of main mountain terrains in the country. GOPR within the organization itself is divided into 7 regional groups that covers delimited areas (fig.1).

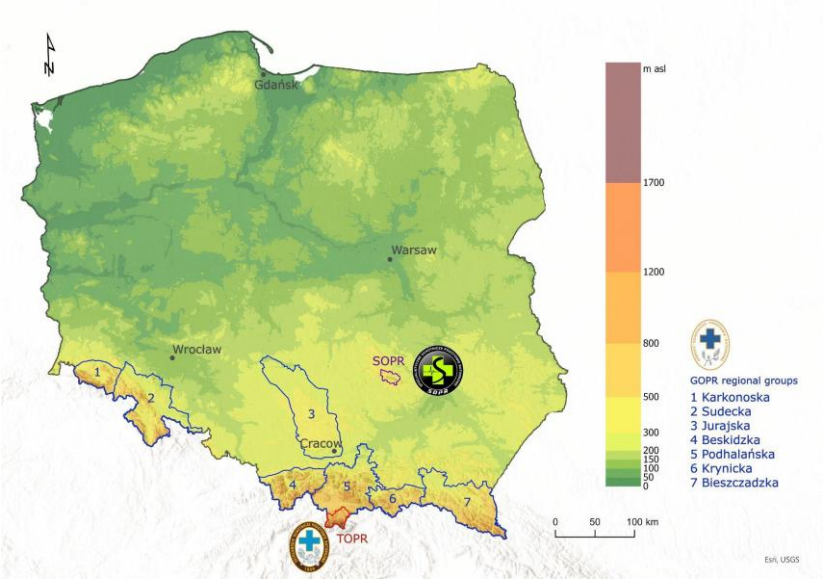

Figure 1. The area of operation of Polish mountain rescue organizations.

Interviews were conducted with 20 rescuers. 35 % interviews were conducted in person and 65 % - online. All of the interviewed rescuers are males working in Polish mountain rescue organizations as volunteers (30%), seasonal workers (10%) and full time employees (60%). The respondents aged 45 years old on average (30 yo minimum, 61 yo maximum age). The average length of service among them is 21 years. Eight of the respondents hold the rank of rescuer, six hold

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the rank of senior rescuer, one the rank of instructor, two the rank of senior instructor, and three hold managerial positions as chief or deputy chief.

The interviews aimed at collecting information on the scope of the spatial data types and sources used in action by mountain rescuers, spatial data management, visualizations, and tools applied on various stages of resource operations. The data from interviews were recorded and then transcribed. The transcripts were analysed using QualCoder software (Cruz et al. 2025) in a qualitative and quantitative approach. The collected data indicate that the scope of spatial data sources is wide and it covers: images from UAV, governmental data bases, real-time GPS data, terrain elevation models, satellite imagery and different types of thematic data (e.g. hiking trails and meteorological data). However, its use differs depending on the stage of the rescue operations. Namely, in the stage of planning an rescue action the general info about the area is needed (e.g. terrain relief, tourist trails). Next, during the rescue operation itself more data useful at the moment is added (e.g. detailed weather information, location of other rescuers in the terrain).

The conducted interviews outline how spatial data is used in mountain rescue operations and the type of data employed. They also enabled the collection of information on the functioning of rescue organisations directly from their members, as, due to the nature of these associations, such information is not available in the literature or online. Data collected from interviews revealed a wide range of data used in rescue operations. This includes GPS data – both the coordinates of the victim location obtained at the time the incident was reported and the real-time location of rescuers and equipment; as well as satellite and drone imagery to get the most up-to-date picture of the operational area. Topographical data and digital terrain models (often with shading) are also utilized to determine the relief of the rescue operation area and its land use. Terrain relief is one of the most widely used geographical data in mountain rescuing for determining the route to reach a victim, particularly in conditions of limited visibility, in winter conditions or on very steep terrain. Thematic data, such as the route and type of hiking trails, are frequently used as well. Thematic data are incorporated as required for a specific rescue operation.

The collected data enable us to identify the types of spatial data used in rescue operations in Poland. Their suitability for specific purposes within the context of these operations stages was also determined. In the next stages of the ongoing project, the collected information will be used for a preparation of maps and spatial visualisations to be included in the survey in the next stages of the study. The overarching goal is to determine the usefulness of spatial data visualization solutions in various stages of rescue operations.

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