
Minimizing the Time Access of Emergency Services as a Prerequisite for Sustainable Regional Development

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Abstract:

Purpose: The aim of this article is to develop an optimal model for the operation of water safety services leading to a reduction in the number of drownings in Poland. Rest by the water is one of the most popular forms of spending free time. The safety of bathers in water areas has been treated for years as a strategic aspect of developing countries.

Design/Methodology/Approach: On the basis of the literature, 3 regimes have been established for the time when rescue units reach drowning people and those in need of help in water areas: <8 minutes - low risk of death, 8-15 minutes medium, > 15 minutes - high. The data obtained comes from the event reports for 2019 conducted by the Water Rescue Coordination Center in Szczecin. The analyzed region includes water areas of the West Pomeranian region. The following research tools were used, critical data analysis, Generate Service Areas (GSA), The Hot Spot Analysis and Heat map symbology.

Findings: There were 351 incidents in total. In the < 8min group there were 219 accidents if assistance was provided by land and 161 in the case of providing assistance by water, group 8-15 min: 158 (land), 210 (water), > 15 minutes 275 (land), 377 (water) and 88 incidents where, due to its location, assistance was provided after 30 minutes. Thanks to the application of Hot Spot Analysis, the most vulnerable places were identified.

Practical Implications: In Poland, the high rate of people who drown should mobilize the governing bodies and emergency services to adjust the functionality of the safety system to socio-economic needs in order to improve its effectiveness. In the era of developing technologies, changes in the information and communication needs of people using water areas are observed.

Originality/Value: The current spatial distribution of rescue unit services does not take into account their areas of operation, areas and times of intervention, and operational capabilities. Too many accidents in water areas occur over a time span of more than 8 minutes. This indicates the occurrence of a large number of life-threatening incidents.

Keywords: Water rescue, rescue organizations, regional development, spatial management, drowning, risk, GIS.

Paper type: Research article.

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1. Introduction

It is the duty of state governing bodies to ensure conditions for development, protection against threats and security, including in particular protection against threats to the life and health of its inhabitants (Telak, 2018). In the literature on the subject, the concept of development is understood as a process of positive changes causing qualitative progress, defined as the transformation of socio-economic structures, as a result of which new features are created (Klóska *et al.*, 2020). The Organization for Economic Co-operation and Development (OECD) defines regional development as an effort to reduce regional disparities by supporting economic activity in these regions, with the aim of ensuring a high standard of living for people living in a given region (OECD, 2016). The implementation of the regional policy has a significant impact on the development of regions (Korenik, 2006).

In Poland, the tasks of regional policy of communes include, *inter alia*, ensuring safety in water areas. The statutory obligation imposed on the managers of a given area is to ensure constant control by rescue entities authorized by law. Due to the high tourist popularity of water areas, especially in the summer season, ensuring safety is a strategic point of local governments for regional development (Ustawa, 2011). Changes in the security potential of the described area make it possible to equate regional development with an increase in the living standards of people living in a given region.

Ensuring the safety of bathers is a key task of regional policy around the world, because water accidents are one of the most common causes of accidental damage to health or loss of life (Zalewski *et al.*, 2014). Comparisons provided by the World Health Organization (WHO) indicate that drowning causes the death of as many as 372,000 people around the world each year, which accounts for as much as 7% of all deaths (WHO, 2019). Survival after a drowning incident depends on two factors, time in which person got out of the water, and in the event of the victim suffering from shortness of breath, also the speed of effective resuscitation (WHO, 2020). Therefore, the key task limiting the occurrence of tragic water accidents is to reach the scene of the accident in the shortest possible time.

Poland has a diverse spectrum of tourist attractions. One of them is water tourism, due to the presence of numerous water areas, including surface and groundwater. A particularly important region in this respect is the West Pomeranian region, where surface waters cover about 5.2% of the region's area, apart from the Zalew Szczeciński, there are 179 lakes with an area of over 50 ha. The total area of lakes (Maps of the Hydrographic Division of Poland (MPHP) is 65,991 ha, which is nearly 2.9% of the region's area. The total length of watercourses within its borders is 30.2 thousand km.

The average density of the river network is 1.32 km / km² (Raport 2018). In the summer season (July 1 - August 31) in the West Pomeranian region, 108 designated water areas protected by lifeguards were in operation in 2019 (Ustawa, 2011; WHO, 2020; Zalewski *et al.*, 2019) and marine areas at a distance of 1MM from the shore, along with designated bathing areas (BA). Such a diversity of the described area may constitute a regional potential for the development of given areas, especially in terms of security.

Even though Poland is a country that has security in its strategic tasks, the rate is 2.1 drownings per 100,000 inhabitants (Utonięcia), which places it among highly developed countries - ensuring safety on the water, and in low-developed countries. One of the factors of this group of accidents may be easy access to unguarded waters along the Baltic Sea coast and in inland waters (Zalewski *et al.*, 2018). Every minute counts when events occur in water areas. Current analyzes show that too small an area is protected by services within 8 minutes, taking into account the occurrence of direct life-threatening events. Contemporary solutions for safety in Polish water areas contribute to the occurrence of development disproportions, which may result in the occurrence of tragic water accidents.

The article analyzes the locations of accidents in water areas in detail and compares them with the operational capabilities of rescue units (Ustawa, 2011). The aim of the presented article is to assess the risk of tragic events based on the range of services (Lotnicze, 2019; Rejestr, 2019; Zasady, 2019; Ustawa, 2006). In order to correctly assess the risk in a specific area, it was decided to examine the spatial distribution of the occurring accidents in the context of the time of reaching the injured and to the place where there is the highest risk of an event.

Inventory of high-risk areas can be an important feedback when creating an auxiliary tool for disposing rescue units for events in accordance with their mobilization capabilities. The article is a continuation of research on the operability of services cooperating within the framework of the water safety system in Poland.

2. Materials and Methods

Securing water incidents belongs to the tasks of rescue services coordinated by the Water Rescue Coordination Centers (CKRW). The following state services are appointed to cooperate in the implementation of this task: water rescue, the Police, the State Fire Service, the Sea Search and Rescue SAR Service, the Helicopter Emergency Medical Service, supported by teams of rescuers-volunteers from Water Voluntary Ambulance Service (WOPR) and Volunteers Volunteer Fire Brigades (Ustawa, 2006; Adamczyk *et al.*, 2020).

Alerts about the occurrence of an incident are reported to CKRW dispatchers directly by witnesses of the incident using the water emergency number 601 100 100 or the Rescue mobile application. The mobile application is a tool that uses GPS,

with the help of which the victim or witness of an incident sends a call for help, taking into account the exact geolocation. Thanks to intra-system communication, emergency calls reported to the operator of the Emergency Notification Center (emergency number 112) or dispatchers of other emergency numbers of services operating in the country are forwarded to CKRW dispatchers. When receiving a report, be it from a witness of the event or from another operator / dispatcher, the task of the CKRW dispatcher is to determine the most precise location of the accident. In the interview, in addition to location data, the dispatcher collects information about the number of casualties, their health condition and the situation.

If a patient is reported to have short of breath, the dispatcher instructs the witnesses to perform resuscitation (CPR) until the arrival of (Kitamura *et al.*, 2010). The purpose of collecting such a detailed interview is to arrange a rescue unit in the vicinity of the accident site, appropriate to the characteristics of the event. When selecting a unit, dispatchers should follow the reach ranges in terms of three time regimes developed on the basis of the statutory time of arrival.

Data on accidents occurring in 2019 come from the CKRW incident reports based in Szczecin. For the purpose of this article, a database was created based on the obtained information, taking into account the following features. Location - operational city / region, district, description of the event, type of water body. Type of event - technical action, prevention, search, environmental protection, saving lives, other - unconfirmed report (false alarm, dead body-animal, drifting object). Characteristics of the event - the number of injured, the number of survivors, the number of deaths. Accidents taking place in the West Pomeranian region were analyzed spatially using the ArcGIS Pro tool.

Generate Service Areas (GSA) creates network service areas around facilities. Specified service area network analysis layer allows to set the analysis properties and solves the analysis. A network service area is a region that includes all streets that can be accessed within arrival time from one or more rescue units. Service areas are commonly used to visualize and measure accessibility.

The Hot Spot Analysis tool calculates the Getis-Ord G_i^* statistic (pronounced G-i-star) for each feature in a dataset. The resultant z-scores and p-values tell you where features with either high or low values cluster spatially. This tool works by looking at each feature within the context of neighboring features. A feature with a high value is interesting but may not be a statistically significant hot spot. To be a statistically significant hot spot, a feature will have a high value and be surrounded by other features with high values as well.

The local sum for a feature and its neighbors is compared proportionally to the sum of all features; when the local sum is very different from the expected local sum, and when that difference is too large to be the result of random chance, a statistically

significant z-score results. When the FDR correction is applied, statistical significance is adjusted to account for multiple testing and spatial dependency.





Heat map symbology draws point features as a dynamic, representative surface of relative density. Use heat map symbology when you have many points that are close together and cannot be easily distinguished. Since heat mapping is a representation of point distribution, it works best when there is a large number of point features, especially if their symbols overlap.

When you have sparse distributions of points, consider drawing them with a different symbology option instead. Heat map symbology displays the relative density of points as a dynamic raster visualization using a color scheme to indicate density values. Ideally, the color scheme is a smoothly varying set of colors, ranging from cool (sparse density of points) to hot (high density of points).

The density definition, and therefore the color values, change as you zoom in and out. The density is calculated using the kernel density method, the same algorithm used by the Kernel Density geoprocessing tool. Each cell in the raster visualization has a value that represents relative density. This density is based on the feature count, but you can optionally choose a Weight field to weight the density by an attribute. For example, the heat map symbology of point features representing accidents can be weighted by the number of accidents at a given location, so that more accidents at one location have a greater impact on the density calculation.

The specificity of the operation of services on water reservoirs did not allow the use of only the above-mentioned tools. The theoretical model described and tested in an earlier study was used to calculate the water reach. For the purpose of this article, the hitherto applied methodology was modified with the tools described above. The drowning risk minimization model developed in the previous publication was used, containing three risk areas of a fatal event (Table 1).

Table 1. *Drowning risk minimization model*

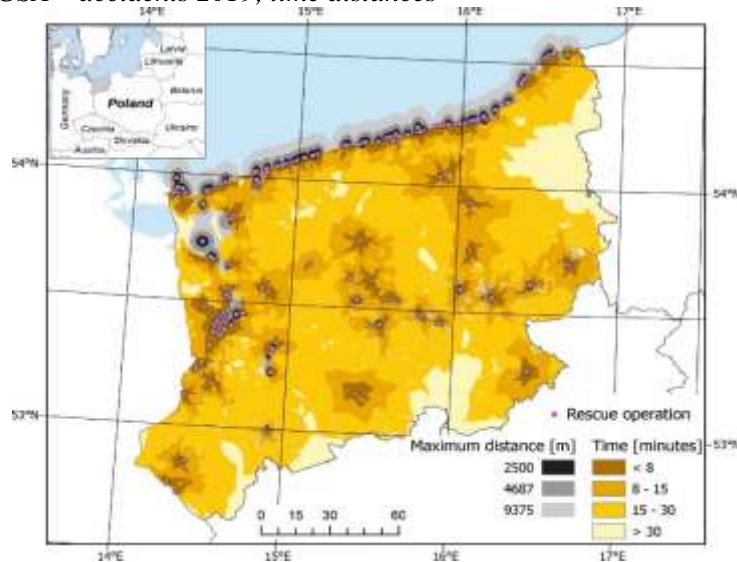
No.	Type of risk	Area of services operation in time	Access by	Color of the area
1.	Low	Less than 8 min	Land Water	
2.	Medium	8 to 15 min	Land Water	
3.	High	More than 15 min	Land Water	
				

Source: *Own compilation.*

3. Results

The total number of rescue operations in 2019 was 351. Accidents occurred both in the summer season, when guarded bathing areas were in operation, and in the off-season, when water areas were left without constant supervision by lifeguards. In the off-season, the incidents were secured by lifeguards on duty in cooperation with state services and volunteer rescue units. The obtained results allowed for the creation of a collective map for all actions in 2019 and the calculation of time distances for them (Figure 1).

Figure 1. GSA – accidents 2019, time distances



Source: Own study.

Analyses of the research results show that rescue units cooperating in the task of ensuring safety in water areas are able to reach 219 incidents by land within 8 minutes. Using the waterway at a distance of 2500m appropriate for the theoretical model they reach 161 events. This means that for the accidents described above, the risk of a fatal event is low. The described risk areas are based on the operational capabilities of the services. For the remaining shares, assuming an immediate threat to life, the risk of death is moderate or high.

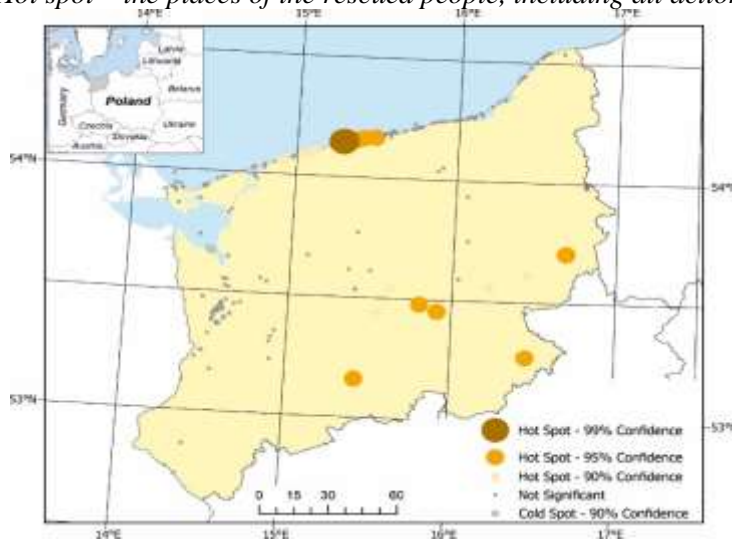
The moderate risk was shown by 158 accidents, which the services are able to cover by reaching by land within 8-15 minutes. In the same risk area, there are 210 events that can be reached by water rescue entities with appropriate equipment, i.e. a distance of 4,687m. Most of the incidents can be reached by rescue units within 15-30 minutes - by land (275), within 9,375 m - by water (317). Another 88 accidents reported to dispatchers will be secured in more than 30 minutes. The described cases are at high risk of a fatal event. The obtained results are presented in Table 2.

Table 2. SBW Water Safety Services

Time	Count	Distance	Count
<8 min	219	2500	161
8 – 15	158	4687	210
15 – 30	275	9375	317
>30	88		

Source: Own compilation.

Figure 2. Hot spot – the places of the rescued people, including all actions



Source: Own compilation.

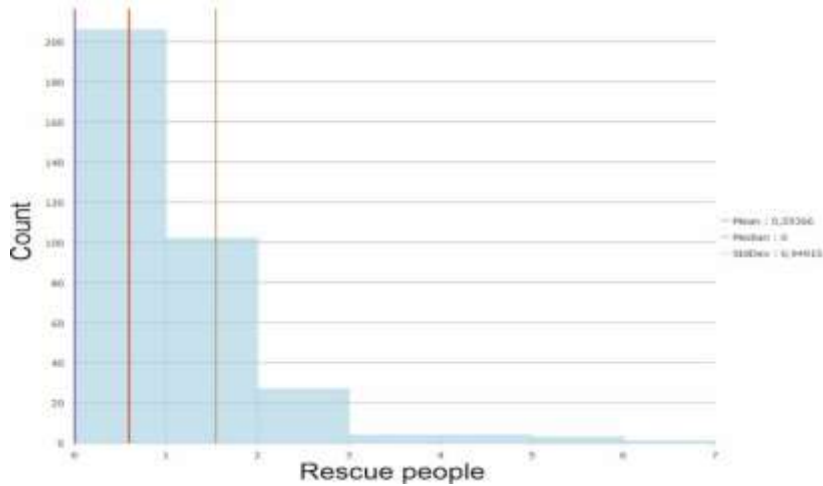
The developed materials allowed for the creation of a hot spot map (Figure 2), which shows the actions carried out in 2019, including people rescued during one event. Most of the events examined show a negligible risk in terms of a fatal event. This means that in 208 cases, rescue units were available to one casualty. Thus, the probability of such an event is the highest. The described actions were called cold spot.

One incident is worth noting - the hot spot 99% confidence. The de-scribed rescue action took place on the coast of the West Pomeranian region in the town of Trzęsacz, where as many as seven victims needed help. The risk of death is high for such events. Especially if the accident occurs in an area with more than 8 minutes waiting time for the rescue team. At the same time, the probability of such a high-risk event is low. The obtained results are presented in the diagram (Figure 3).

The results obtained in this publication made it possible to create Heat maps (Figure 4) for the events taking place in the summer and off-season for 2019. The map shows the clusters of accidents with the highest and the lowest intensity of their occurrence. Due to the fact that the considerations take into account the whole year,

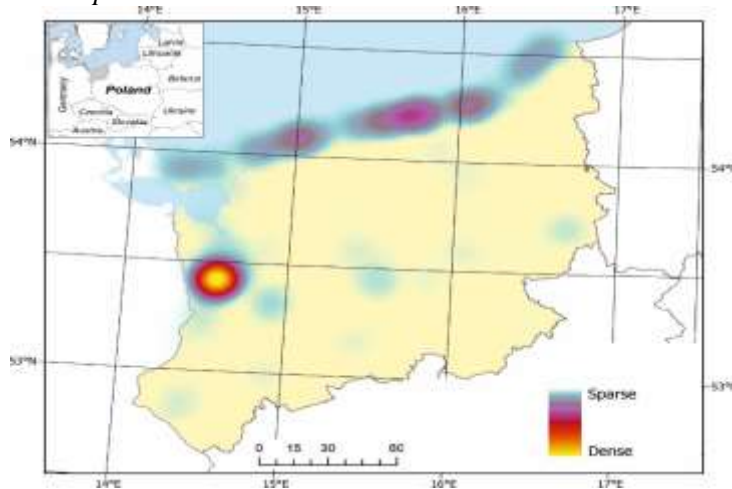
there is a concentration of accidents in the region of the voivodeship city - Szczecin and in the region of the entire coast of the West Pomeranian region.

Figure 3. The probability of an event occurring



Source: Own compilation.

Figure 4. Heat map – accidents 2019



Source: Own compilation.

4. Discussion

According to the provisions of the Constitution, “the Republic of Poland [...] ensures [...] the security of citizens” (Constitution, 1997). The National Security Strategy of the Republic of Poland indicates national interests with an emphasis on ensuring the safety of the state's in-habitants, including individual and collective protection against threats to their life and health (Strategia, 2014). The strategic development

goals in the field of security include: ensuring public safety while optimizing the national rescue and firefighting system, as well as the system of monitoring, notifying, warning about threats and eliminating the effects of natural disasters and catastrophes; improvement and development of the national crisis management system as well as the civil protection and civil defense system; increasing the social awareness of security and increasing the competences of the inhabitants of the state to react to crisis situations (Strategia, 2014; Perkins *et al.*, 2015).

The research conducted in the West Pomeranian region illustrated the coverage of protected areas in three risk groups presented in the model of minimizing the risk of drowning. Basically, it can be concluded that the existing system solutions in terms of disposing of services are optimal for handling incidents in water areas. However, every minute counts when accidents occur in water areas. Drowning is a serious problem in Poland and if it occurs it often ends in death.

Survival after a drowning incident depends on the speed of the victim's recovery from the water and the speed of effective resuscitation (WHO, 2019). In the event of a sudden cardiac arrest, early, conscious initiation of basic life support is essential (3-5 minutes). This action may increase the survival rate of people suffering from SCA even by 50-70% (Perkins, 2015). Taking into account the occurrence of incidents of a direct threat to life, the area protected by services is too small when reaching 8 minutes.

The alarm and unit dispatch systems operating so far do not allow for indicating the fastest possible location of the emergency team based on the location. The provision of a rescue team appropriate to the characteristics of the event and the time distance is key in the context of the survival of people involved in accidents in water areas.

5. Conclusions

The implementation of regional policy has a significant impact on the development of regions, however, modern solutions concerning security solutions in Poland contribute to deepening development disproportions. The system operating so far does not have a statutory Water Safety System that takes care of the protection of water areas.

The current spatial distribution of rescue unit services does not take into account their areas of operation, areas and times of intervention, and operational capabilities. Too many accidents in water areas occur over a time span of more than 8 minutes. This indicates the occurrence of a large number of life-threatening events. Thus, there is a high probability of an event with a high risk of drowning. Adapting the stationing of rescue units to hot spots and the continuous evaluation of the operating system would be of particular importance.

The research should be expanded by analyzing the operational capabilities of rescue services and entities in correlation with the events that occurred in previous years. There is a need to modify the currently operating rescue and search system in Poland. For the sustainable development of the safety system, there is a need to create an Integrated Water Safety System, which could coordinate and supply incidents in water areas in a way that is optimal for the services and effective for the injured.

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