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Research Article

Functional evaluation of civil protection mobile applications in the context of decision support for public alerts

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Abstract: Providing the public with fast, accurate and reliable information is a key element of civil protection in the prevention and management of emergencies. This study presents an international overview of civil protection mobile applications used in different countries, analyses their main functional characteristics and evaluates their role in alerting and informing the public. The study proposes a functional evaluation framework for civil protection mobile applications based on a weighted, multi-criteria evaluation approach. The framework evaluates localised alerts, monitoring integration, preparedness support, offline accessibility and communication depth. Civil protection applications used internationally are analysed and compared using a standardised scoring method. Based on the comparative analysis, decision-making implications are derived for the development of a civil protection mobile application tailored to the national civil protection organisation. The results confirm the role of mobile applications as complementary elements to traditional alerting infrastructures and provide practical guidance for system-level integration and future developments.

Keywords: mobile applications; civil protection; functional evaluation; decision-making support framework; preparedness-alert-information

I. INTRODUCTION

The security landscape of the 21st century presents professionals with increasingly complex challenges. The growing frequency of natural disasters (NaTech events) and industrial accidents caused by civilisation justifies the continuous development and modernisation of civil protection tools.

A key element in managing emergency situations is providing the population with rapid, accurate and reliable information, because the timely delivery of appropriate information has a direct impact on protecting the lives of the population, preventing panic [1] and reducing the extent of damage. Traditional warning methods, such as siren systems [2] and information broadcasts, continue to play an important role, but they are not always able to meet the expectations of the population.

Digitalization now offers a wide range of opportunities [3], and in recent years [3], smart devices and mobile applications [5] enable the population to access emergency information directly and in a personalised manner. As a result, mobile applications specifically designed to alert, inform and prepare the population are already available in many countries. Civil protection applications have an alert function, while the more advanced ones also contain civil preparedness guidelines, behavioural advice, behavioural norms and real-time monitoring data, thus complementing traditional civil protection systems.

This study provides an overview of civil protection mobile applications and their practical use through international examples. The study focuses on civil protection functions that serve to prepare, alert and inform the population, as well as experiences that can be used to further develop the Hungarian civil protection system.

1. The theoretical approach to digital civil protection

The emergence of civil protection mobile applications can be interpreted not only as a technological innovation, but also as a reflection of the transformation of the approach to civil

protection. In contrast to traditional, one-way alert models, digital platforms fit into the theoretical framework of risk communication, resilience and collaborative crisis management. Modern civil protection is increasingly moving towards proactive risk management, in which the population is not merely a passive recipient of alerts, but an active participant in the recognition, interpretation and management of emergency situations. In this context, mobile applications function as the "digital interface" of the civil protection system, linking monitoring systems, decision-making processes and public behaviour.

This approach is consistent with the resilience-based disaster management models appearing in international literature, according to which effective defence is not solely a question of technical capacity, but also has informational, social and communicational dimensions.

2. Scientific value of the study

- Definition of a standardised functional evaluation system for public warning mobile applications.
- Application of a weighted, multi-criteria evaluation method to compare solutions introduced at the international level.
- Identifying the most important system-level design factors that influence the effectiveness and resilience of alerts, and
- Deriving decision-making implications for the development of an integrated international public warning mobile application.

II. THE IMPORTANCE OF PREPARING, ALERTING AND INFORMING THE POPULATION

Preparing, alerting and informing the population are civil protection activities in their own right, each of which plays a different role in managing emergency situations. Alerting serves to signal the existence of an emergency, informing provides information related to the current situation and communication of rules of conduct, while preparing serves to transfer prior knowledge, i.e., it prepares people in advance for the alert, the correct application of the expected rules of conduct and the information related to the emergency.

The alarm fulfils its purpose adequately and plays its role in managing uncertainty [6] if it is clear to the population what action the signal requires. If there is no framework for interpretation, the alert remains mere information, which does not result in a coordinated response from the population. The timing of the alert is also a decisive factor, as a delayed signal reduces the time available for decision-making and response, thereby limiting the range of defence options [7].

The effectiveness of information is based on the accuracy, consistency and reliability of the information communicated. In light of this, incomplete, inaccurate or contradictory information can cause uncertainty and delayed reactions among the population. In such cases, information no longer provides guidance but creates uncertainty in decision-making [10].

Without preparing the public, alerts and information alone cannot create uniform public behaviour. Preparation provides a framework for interpretation in which the meaning of the alert and the content of the information can be transformed into conscious action [11].

The above elements are functional on their own, but their coordinated application will enable the population to act in accordance with the objectives.

1. Methodology and limitations of the study

The study uses a qualitative-comparative method to analyse international civil protection mobile applications. The assessment is based on publicly available official documents, application descriptions, literature sources and a structured comparison of functional characteristics.

The functional comparison focused on criteria relevant to civil protection, with particular emphasis on the localizability of alerts, connection to monitoring systems, the availability of civil protection content, offline accessibility and the depth of communication. The weighted evaluation system is based on expert judgement, which focuses on practical applicability.

The limitations of the study include the fact that empirical research into the actual use of the applications by the population (user statistics, efficiency measurements) was not part of the research, and that the different legal and institutional environments of the individual national systems may affect comparability.

III. PRESENTATION OF INTERNATIONAL CIVIL PROTECTION MOBILE APPLICATIONS

The use of civil protection mobile applications has become widespread in recent years around the world, but mainly in countries where [12] natural disasters or industrial hazards pose a challenge to public safety. Decision-making is often challenging for professionals, therefore, the use of an integrated criteria assessment method is recommended [14]. Civil protection mobile applications operate under state supervision (integrated into the state system, certified by the authorities or connected to a central

alert infrastructure) and their purpose varies from country to country depending on local conditions.

In the *United States*, the development and application of civil protection applications is closely linked to the federal disaster management structure. The FEMA App, operated by the Federal Emergency Management Agency (FEMA) [15], aims to support preparedness for emergencies, relay official alerts, and make emergency plans and guidelines available to the public [16]. The content of the app is linked to the Ready.gov programme, but there is no official app called "Ready" operating independently. The FEMA App accesses information through the federal alerting frameworks Integrated Public Alert and Warning System (IPAWS) [17] and the Emergency Alert System (EAS) [18]. In this structure, the Computer Aided Management of Emergency Operations (CAMEO) system does not function as a public application, but as an industrial safety decision support tool [19].

In Australia, the Emergency AUS [20] application is an important tool for protecting the population in the event of extreme weather events and bushfires [22]. It provides real-time alerts, map displays, and easy-to-understand advice and situation updates to the public, with a strong focus on weather and natural hazards. The strength of the system lies in its rapid alerting and simple, easy-to-understand information. In contrast, Emergency Alert Australia is a nationwide (telephone) SMS and cell broadcast-based alerting system [23] which complements mobile applications. One of the system's greatest strengths is its rapid area-specific alerting and simple, easy-to-understand communication [25].

In Canada, Alert Ready [26] is a national alert system that delivers critical alerts to the public via television, radio and compatible mobile devices [27]. In addition, the public primarily receives these alerts via the Alertable [28] platform, which also allows for individual settings. The applications are primarily used to convey warnings related to natural disasters – floods, storms and forest fires – which fit well with the country's multi-level federal emergency system.

Several countries in *Europe* operate advanced civil protection mobile applications. *In Germany*, the Notfall Informations und Nachrichten App (NINA) [29] application provides alerts in the event of natural disasters, industrial accidents and terrorist threats, based on data from federal and state authorities. The app is integrated into the German civil protection system and is widely accepted by the population. *In Sweden*, the Krisinformation [30] app plays a similar role, with a strong emphasis on providing the population with reliable information and presenting official information in a uniform manner. Its functions are more information-oriented than technical alerts, but it maintains the trust of the population. *In France*, the SAIP [31] (discontinued) app supports public alerts in the event of terrorist acts and other dangerous events, but its effectiveness has been criticised on several occasions. In recent years, the focus has shifted to the cell broadcast-based FR Alert [32] system, thus limiting the role of SAIP. *In Spain*, the My112 [33] mobile application and *in Italy*, the Alertmap [34] mobile application support access to emergency information and emergency call functions. Italy also has a cell broadcast-based IT-Alert system [35], but its public preparedness content is limited.

In Asia, *Japan* is a prime example of the integration of mobile applications and monitoring systems for civil protection. The Safety Tips app provides notifications in multiple languages, including "*English, Japanese, Chinese, Vietnamese, Spanish, Portuguese, Thai, Indonesian, Tagalog, Hangul, Nepali, Khmer, Burmese and Mongolian, providing notifications in the event of earthquakes and tsunami warnings"* [36], closely linked to the J-ALERT [37], national alert system and nuclear monitoring networks. *In Singapore*, the SGSecure [39] application focuses primarily on terrorist threats and raising security awareness, and although it includes elements of public preparedness, it plays a more complementary role compared to traditional disaster management systems.

In India, the MyGate [40] application represents a unique approach, as it is not a state civil protection system, but a community-based platform requiring registration for access, which primarily provides alerts and additional information to local communities.

In Russia, mobile applications supported by EMERCOM of Russia and Rostec SOS [41] provide access to civil protection and emergency services, functioning as complementary elements to the state alert system, but their international adaptation, and thus their application in Hungary, is limited.

IV. ANALYSIS OF INTERNATIONAL CIVIL PROTECTION MOBILE APPLICATIONS

Mobile applications for civil protection can be divided into several major functional groups in **Table 1.** in the appendix.

The first group includes applications that focus primarily on emergency alerts and the communication of current information. They typically send real-time notifications in the event of natural disasters, extreme weather conditions and industrial accidents. In these cases, area-specific alerts can be implemented, which supports the effective management of localised events [42].

The second group includes applications that, in addition to alert functions, also support the

Table 1. *Analysis of International civil protection mobile applications*

Country	Application	Main functions	Monitoring integration	Civil protection preparedness	Hungarian adaptation
USA	FEMA App	Alerting, preparedness, guidance	Indirect (IPAWS/EAS)	High	Partially recommended
Australia	Emergency AUS	Weather, bush fires, alerts	Yes	Moderate	Recommended
Canada	Alertable	Natural disaster alerts	Yes	Moderate	Recommended
Sweden	Krisinformation	Uniform information	Partial	Moderate	Recommended
Germany	NINA	Alarm, terror, industrial accident	Yes	Moderate	Highly recommended
France	SAIP/FR Alert	Terror and danger alert	Partial	Low	Limited
Spain	My112	Emergency calls, alarms	Partial	Low	Limited
Italy	AlertMApp	Alerts, notifications	Partial	Low	Limited
Japan	Safety Tips	Earthquakes, tsunamis, nuclear hazards	Strong (J-ALERT)	High	Partially recommended
Singapore	SGSecure	Terrorism, security	Partly	Moderate	Not primary
India	MyGate	Community alert	No	Low	Not recommended
Russia	EMERCOM /Rostec SOS	Civil defence, emergency call	Yes	Moderate	Not adaptable

preparation of the population. In addition to alert functions, these extended applications also include guidelines, rules of conduct and preparedness protocols.

In many countries, mobile applications for civil protection are closely integrated with existing disaster management monitoring systems, with the result that the applications function as digital extensions of complex civil protection systems. With integrated solutions, hazards detected by monitoring systems that may affect the population are immediately displayed on an interface accessible to the public.

Internationally, we are seeing more and more examples of two-way communication, through which the public can send feedback to the authorities or, also via the app, report dangerous events affecting the public – even their own situations in distress – to the authorities.

A common feature of the apps examined is that they all convey information from reliable sources. Maintaining public trust is essential to ensure that alerts and information actually achieve their purpose. The most effective applications are those that are clearly identifiable as coming from a state professional organisation and whose communication is consistent with other news channels. Civil protection mobile applications are an important complementary element of civil protection systems. They do not replace traditional monitoring and public alert systems, but when used in an integrated manner with them, they can create real added value in the field of civil protection.

1. Risks and dilemmas of civil protection mobile applications

Although civil protection mobile applications offer many advantages, their use is not without risks and dilemmas. One of the most significant problems

is the phenomenon of "alert fatigue" resulting from excessive alerts, which can reduce the responsiveness and trust of the population in the long term.

Data protection and the handling of personal data pose a further challenge, particularly in the case of location-based services and two-way communication. Civil protection applications can only function effectively if data processing is transparent, lawful and comprehensible; otherwise, trust can quickly be undermined.

It is also important to note that digital solutions cannot fully cover all groups in society. Traditional methods of alerting and informing the public must continue to be maintained for older people, those who are less digitally literate and areas that are cut off from the technological infrastructure.

Therefore, mobile applications should function as complementary elements of a multi-channel alert system, which also includes sirens, indoor alert units, mobile network alerts and traditional media communications. This redundancy ensures that alerts reach the public even in the event of a partial failure of the communication system.

Special attention should also be paid to socially vulnerable groups, including the elderly, people with disabilities and those with limited access to digital technologies. Digital alert solutions should therefore always be complementary and not replace traditional alert methods.

V. FUNCTIONAL EVALUATION OF CIVIL PROTECTION MOBILE APPLICATIONS

1. Methodological background of functional evaluation

The functional evaluation framework used in the study is based on the criteria-based evaluation approach used in decision support systems. The selected criteria represent the system-level functions that directly influence the effectiveness of public warning systems and the response of the population.

The weighting of the criteria was determined of criterion i. Based on expert opinion, assessing the relative impact of each function on the timeliness of alerts, situational awareness and system resilience. Furthermore, monitoring integration and public preparedness are of great importance for early detection and response awareness. It should also be noted that offline availability and communication depth are supporting functions but play a critical role in emergency situations involving network outages.

A discrete scoring scale (0 / 0.5 / 1) was used to ensure the transparency and reproducibility of the assessment.

2. Determination of weights

The weights in **Table 2** were determined based on expert opinion, with a focus on the effectiveness of alerts, the timeliness of information flow, and community resilience. The greatest weight was given to localised alerts, as they directly influence the response time of the population and the effectiveness of risk reduction. Monitoring integration and public preparedness are also given high priority, while offline accessibility plays a smaller but critical complementary role.

The total Score (1) to (3) is the sum of the weighted values of the individual functional criteria, which expresses the functional performance of the given application in terms of civil protection.

$$Score_i = w_i \times v_i \tag{1}$$

$$Total\ Score = \sum_{i=1}^{n} (w_i \times v_i) \tag{2}$$

$$Total\ Score = (\mathrm{C1} \times w_1) + (\mathrm{C2} \times w_2) + (\mathrm{C3} \times w_3) + (\mathrm{C4} \times w_4) + (\mathrm{C5} \times w_5) \tag{3}$$

where

- w_i represents the weight of criterion *i,*
- v_i represents the assigned value criterion *i.*

Table 2. *Determination of weights*

Code	Criterion	Weight	Explanation
C1	Localised alert	0.25	Area-based, targeted notification
C2	Monitoring integration	0.20	Connection to monitoring and alarm systems
C3	Preparing the population	0.20	Guidelines, rules of conduct
C4	Offline availability	0.15	Content that can be used without the Internet
C5	Depth of communication	0.2	One-way or two-way communication
Total		1.00	

3. Weighted functional assessment

NINA (German) in **Table 3**.

$$0.25 \times 1 + 0.20 \times 1 + 0.20 \times 1 + 0.15 \times 1 + 0.20 \times 0 = 0.25 + 0.20 + 0.20 + 0.15 + 0 = 0.80$$

The NINA app's high overall score is primarily due to its close integration with monitoring systems, offline public preparedness content, and consistent, credible communication.

FEMA App (USA) in **Table 4.**

$$0.25 \times 1 + 0.20 \times 0.5 + 0.20 \times 1 + 0.15 \times 1 + 0.20 \times 0 = 0.25 + 0.10 + 0.20 + 0.15 + 0 = 0.70$$

The strengths of the FEMA App lie in its public preparedness features and offline accessibility, while the lack of two-way communication lowers its overall score.

Emergency AUS (Australia) in **Table 5.**

$$0.25 \times 1 + 0.20 \times 1 + 0.20 \times 0.5 + 0.15 \times 0 + 0.20 \times 0{,}5 = 0.25 + 0.20 + 0.10 + 0 + 0.10 = 0.65$$

The Emergency AUS application excels in terms of its alert and monitoring functions related to natural hazards, but the lack of offline content reduces its ability to support resilience.

VÉSZ (Hungary) in **Table 6.**

Table 3. *NINA (Germany) weighted functional assessment*

Criterion	Weight	Value	Subscore
C1	0.25	1	0.25
C2	0.20	1	0.20
C3	0.20	1	0.20
C4	0.15	1	0.15
C5	0.20	0	0.00
Total			0.80

Table 4. *FEMA App (USA) weighted functional assessment*

Criterion	Weight	Value	Subscore
C1	0.25	1	0.25
C2	0.20	0.5	0.10
C3	0.20	1	0.20
C4	0.15	1	0.15
C5	0.20	0	0.00
Total			0.70

Table 5. *Emergency AUS (Australia) weighted functional assessment*

Criterion	Weight	Value	Subscore
C1	0.25	1	0.25
C2	0.20	1	0.20
C3	0.20	0.5	0.10
C4	0.15	0	0.00
C5	0.20	0.5	0.10
Total			0.65

$$0.25 \times 0.5 + 0.20 \times 0 + 0.20 \times 0.5 + 0.15 \times 0 + 0.20 \times 0 = 0.125 + 0 + 0.10 + 0 + 0 = 0.225 \approx 0.23$$

Table 6. *VÉSZ (Hungary) weighted functional assessment*

Criterion	Weight	Value	Partial score
C1	0.25	0.5	0.125
C2	0.20	0	0.00
C3	0.20	0.5	0.10
C4	0.15	0	0.00
C5	0.20	0	0.00
Total			0.225≈ 0.23

Table 7. *Overall functional comparison of the analysed applications*

Criterion	Weight	FEMA App	NINA	Emergency AUS	EMERGENCY
C1	0.25	1	1	1	0.5
C2	0.20	0.5	1	1	0
C3	0.20	1	1	0.5	0.5
C4	0.15	1	1	0	0
C5	0.20	0	0	0.5	0
Total score	1.00	0.7	0.8	0.65	0.23

The lower score of the VÉSZ application is primarily due to the lack of automated, localised alerts and monitoring integration, but its information functions provide an important basis for a system that will be further developed in the future.

4. Overall weighted functional assessment

In **Table 7.** based on the overall weighted functional assessment, there is a clear difference between the civil protection mobile applications examined. The German NINA app has the most balanced content and structure, providing a high level of support for the management of different types of hazards, monitoring integration and public preparedness. The FEMA App and Emergency AUS apps have specific strengths, primarily in the areas of preparedness and natural hazard alerts. The functional coverage of the Hungarian VÉSZ app is currently more limited, but due to its institutional embeddedness and official communication role, it could serve as the basis for an integrated, enhanced mobile app for civil protection.

VI. Evaluation of adaptable international models for Hungary

Based on a comparative analysis of international civil protection mobile applications, it can be concluded that not all foreign solutions can be directly adapted to the Hungarian civil protection system. The adaptation process must take into account Hungary's geographical characteristics, vulnerability features, administrative structure, and existing monitoring and public alert systems. As a result of the study, three international models may be suitable for adaptation to varying degrees and in different ways.

1. Adaptability of the German model (NINA)

The German NINA application model can be considered the most adaptable for Hungary, primarily because the civil protection systems of Germany and Hungary have many similarities. In both countries, risk management for plants handling hazardous materials and their surroundings plays a significant role, and in both cases, the alerting of the population is coordinated centrally. One of the biggest advantages of the NINA app is that it handles multiple types of hazards on a single unified platform. The application is capable of sending alerts in the event of natural disasters, industrial accidents, transport incidents and terrorist threats, in close cooperation with the authorities' information systems. Multi-source data management fits well with the logic of the Hungarian MoLaRi system and environmental monitoring networks. Hungary could benefit from the German model's approach, which sees the mobile app not as a standalone tool but as a digital extension of existing technical systems. During adaptation, it will be possible for alerts generated by MoLaRi to also appear on digital channels, supplementing siren warnings with detailed information and rules of conduct.

2. Adaptability of the Canadian and Australian models

The Canadian and Australian applications primarily provide examples to follow in the management of natural and weather-related hazards. They already have significant experience in dealing with floods, storms, forest fires and extreme weather events, which is becoming increasingly relevant for Hungary as the effects of climate change intensify. One of the biggest advantages of this model is its targeted, area-based warning system and simple, easy-to-understand communication. The applications emphasise conveying messages that are understandable and action-oriented to the population in order to avoid panic. In Hungary's case, these solutions could also be well suited to flood protection, inland water risks and the management of extreme weather events. At the same time, the functions of these models relating to industrial and nuclear hazards are more limited, so their full adaptation would not be appropriate on its own. Rather, they can be recommended as a complementary element, as a model for communication and public information.

3. Partial adaptability of the Japanese model

The Japanese civil protection system has one of the most advanced technological integrations in the world. The Safety Tips application is closely linked to the national J-ALERT system and the nuclear and radiation monitoring networks, which have been further developed based on the lessons learned from the Fukushima disaster. For Hungary, the Japanese model is most adaptable at the conceptual and technical level. Japanese practice offers valuable experience in strengthening the link between real-time monitoring and direct public information. The system is very good, but it is not considered justified for us to adopt the Japanese model **Fig. 1** in its entirety, as the Hungarian region is not prone to large-scale earthquakes and tsunamis. Japanese solutions can serve as a model primarily in the areas of system integration, automated alarms and data processing.

Functional comparison of relevant mobile applications for civil protection in **Table 8.**

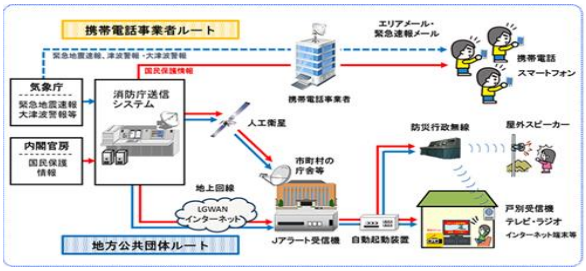


Figure 1. *Japanese model [38]*

The common denominator of the applications examined above is that civil protection has started to move towards digitalisation, but there are significant differences between countries in terms of solutions. One of the most important common points is the use of *location-based services*, while the old sirens can be heard by everyone in the best-case scenario – if they sound, if the noise is favourable, if the weather permits – mobile applications alert those who are actually in danger based on GPS data [43]. Targeted alerts prevent the "boy who cried wolf" scenario, meaning that the population does not become accustomed to unnecessary alerts and takes the alerts seriously.

At the same time, it is interesting to note that *two-way communication* is lacking. Most official systems still function like a digital loudspeaker, with the authorities speaking and the public listening. In contrast, the future clearly calls for public involvement. If the public could send photos from the scene or quick status reports to the authorities, experts would be able to see what is really happening much more quickly and accurately.

Table 8. *Functional comparison of relevant mobile applications for civil protection*

Country	Application name	GPS-based (location-based alerting)	Two-way communication (feedback)	Preparation materials available offline	Multimedia content (maps, photos)
USA	FEMA APP	Yes	No	Yes	Yes
Germany	NINA	Yes	No	Yes	Yes
Australia	Emergency AUS	Yes	Yes (Community report)	No	Yes
Canada	Alertable	Yes	Partially	No	Yes
Hungary	LifeSaver*/EMERGENCY	Yes	Partially	No	Yes

*Note: The LifeSaver application is primarily an emergency call service, while VÉSZ is informational in nature.

It is also worth paying attention to *offline availability*, because in the event of a major storm, the internet may be the first thing to go down. However, the FEMA and NINA apps have developed very good solutions to this problem. Life-saving guidelines and important rules of conduct can be downloaded to your phone in advance, so they are available even in the most difficult moments without an internet connection.

VII. Recommended Hungarian civil protection digital model

The Hungarian VÉSZ app can be considered an official, institutionally embedded solution for public information and emergency communication. The organisational background behind the app and its reliable sources of information provides a stable foundation for further system-level development. Although the app's current functions focus primarily on providing information, its existing design and national coverage make it suitable as a reference base for a future system expanded with automated, localised alert and monitoring functions.

Based on the analysis, it can be concluded that the most expedient approach for Hungary would be to develop a hybrid adaptation model based on the structural and organisational solutions of the German model, supplemented by Canadian and Australian practices and the Japanese approach to integration and monitoring.

The proposed hybrid model does not imply the direct technical transfer of foreign systems. Instead, it focuses on the adaptation of functional and organisational solutions that can be integrated into the existing Hungarian civil protection infrastructure, such as monitoring networks and public alert systems.

In the domestic environment, there is already a civil protection initiative in the form of the VÉSZ [44] mobile application, which provides users with official information. The application is not currently directly connected to the national monitoring and civil alert systems, nor does it provide automatic, localised alerts. Accordingly, the VÉSZ app cannot be considered a comprehensive civil protection alert app, but rather a precursor and partial solution, whose experience and institutional embeddedness could provide a useful basis for the development of a future integrated civil protection mobile app. In terms of its functions, its main strengths are emergency news and announcements, weather information and post-event information. The public preparedness elements are limited, contain general behavioural advice, and the content is informative, not yet personalised. Currently, there is no hazard-specific protocol system and interactivity is lacking.

A hybrid approach would enable the creation of a unified, nationwide civil protection mobile application that:

- fits in with existing Hungarian monitoring and public alert systems,
- is capable of handling natural, industrial and civilisation hazards,
- supports the preparation and awareness of the population,
- and strengthens trust between the public and the authorities.

1. SWOT analysis for the introduction of the Hungarian civil protection app

Strengths

- Existing monitoring and public warning systems (MoLaRi, environmental monitoring).
- Well-organised disaster management structure.
- High smartphone penetration.
- Availability of international best practices**.**

Weaknesses

- Uneven digital literacy among the population.
- Limited reach among older age groups.
- Initial development and operating costs.
- Complexity of inter-institutional data connections.

Opportunities

- Increased public awareness and preparedness.
- Better management of the risks posed by climate change.
- Strengthening trust between the public and the authorities.
- Involving EU development and research funds.

Threats

- Data protection concerns and loss of trust.
- "Alarm fatigue" due to excessive alerts.
- Technical failures in emergency situations.
- Appearance of parallel, uncoordinated communication channels.

2. Functional requirements list for the Hungarian civil protection mobile application

The existence of the VÉSZ app is an important precedent, but due to its functional limitations, it cannot replace the integrated civil protection model proposed here.

In order to implement the recommended model, the following functional requirements should be defined:

Basic functions

- Display of official emergency alerts from government sources.
- Sending area-based (localised) notifications.
- Handling multiple types of hazards (natural, industrial, technological hazards).
- Differentiation of alerts by priority.
- Prioritised controlled alerting logic (MoLaRi compatible).

Information and preparedness functions

- Display of detailed rules of conduct in the event of an alarm.
- Preparation guides and checklists for each type of hazard.
- Frequently asked questions and easy-to-understand information.
- Visual elements (maps, pictograms).

Monitoring integration

- Connection to existing monitoring systems (MoLaRi, environmental measurement networks).
- Display of real-time or near real-time data.
- Temporal tracking of alarm events.

Communication feedback

- Priority given to one-way communication (authority→ population).
- Optional two-way public feedback options (event detection).
- Access to emergency call functions within the application [45].

Security and data protection requirements

- Transparent data management regulations.
- Minimal personal data processing.
- Compliance with information security and operational security requirements.
- Regular testing and maintenance.

In order to prevent misinformation or false alerts, the system should rely exclusively on authenticated governmental data sources and secure communication channels. Multi-level authorization procedures and regular cybersecurity audits are necessary to ensure system integrity.

3. The future role of civil protection mobile applications

The development of civil protection mobile applications is expected to continue in the direction of system integration and automation in the coming years. Artificial intelligence-supported data processing, real-time sensor data analysis and predictive risk analysis may open up new opportunities for targeted and timely alerts to the population.

In Hungary, future developments should not be implemented as standalone applications, but as part of a unified civil protection information ecosystem. This could include the coordinated operation of mobile applications, cell broadcast systems, siren alerts and traditional media channels.

When adapting civil protection mobile applications, it is important to consider that users are often in dynamic traffic environments. Research indicates that infrastructure and traffic signals influence safety [46], while inadequate street lighting increases the risk of pedestrian accidents. [47] Technology adoption depends on user perception [48], while transportation systems are evaluated from both social and environmental perspectives [49]. Simulations, in turn, help model behavior and hazardous situations. [50] All of this justifies the need for mobile alert systems to provide fast, understandable and context specific information.

The key to the long-term success of civil protection mobile applications is not primarily a technological issue but rather gaining and maintaining the trust of the population, which can only be achieved through consistent, credible and understandable communication.

VIII. CONCLUSIONS

The aim of the study was to present the role of civil protection mobile applications in modern alert and information systems from an international perspective and to assess their adaptability to the Hungarian civil protection system. The analysis clearly confirmed that civil protection mobile applications have become an indispensable part of emergency communication, but they cannot replace traditional monitoring and alert systems on their own.

Based on the international examples examined, it can be concluded that the most effective applications are those that are closely aligned with the institutional and technical civil protection structure of the country concerned and operate as part of a unified communication chain. Localised alerts, real-time monitoring integration and offline civil protection content together represent the greatest added value of digital civil protection.

The analysis also pointed out that preparing, alerting and informing the public can only be effective as an integrated system. Without preparation, alerts remain mere information, while inconsistent or unreliable information reduces public cooperation and increases the risk of panic. In this context, mobile applications are not merely technical tools, but important instruments for shaping civil protection behaviour.

With regard to Hungary, the study confirmed that the current VÉSZ application is important but can be considered a functionally limited precursor. Its institutional embeddedness and official communication role can provide a suitable basis for the development of an improved, integrated civil protection mobile application, but international comparisons clearly identify shortcomings – particularly in the areas of automated, localised alerts, monitoring integration and interactive public feedback – which, without improvement, will prevent the application from fulfilling its full civil protection function.

Based on the results of the study, it can be concluded that the hybrid adaptation model offers the most favourable solution for Hungary, combining the structural and organisational solutions of the German model, the communication experiences of Canadian and Australian practices, and the Japanese approach to system integration. Such an approach allows the digital civil protection to appear not as a parallel system, but as an element that strengthens existing systems.

The development of civil protection mobile applications is not primarily a technological issue, but a complex professional, organisational and social task. The key to long-term effectiveness is maintaining public trust, which can only be achieved through consistent, credible and understandable communication and the gradual involvement of the public. The results of the study can contribute to the strategic development of the domestic civil protection system and provide a basis for future research and development.

Based on the results of the study, several practical recommendations can be formulated for the development of the Hungarian civil protection mobile application:

- integration of mobile applications with existing monitoring systems (e.g. MoLaRi),
- connection to indoor alarm units,
- introduction of automated location-based alerting,
- development of offline preparedness content for emergency situations,
- strengthening public trust through consistent official communication.

AUTHOR CONTRIBUTIONS

Viktória Bene: Conceptualization, Experiments, Theoretical analysis, Writing and editing.

Iván Devosa: Writing, Review and editing.

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Barbara Elek: Supervision.

DISCLOSURE STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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