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Case Study: Analysis of The Largest Tornado in The Czech Republic from The Perspective of Humanitarian Logistics*

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Abstract

Humanitarian organisations and Integrated Rescue Services in the Czech Republic are well prepared to face certain types of disasters. These organizations are facing a typical crisis events, in Czech Republic especially floods. However, in the years of 2019 – 2021 there have been a number of shocks - crisis events - that as it was the tornado at the South Moravia region in 2021. The purpose of this paper is to conduct a research of public information on this disaster, consolidate and analyse the information. The available information is analyzed based on a literature search in the Web of Science and Scopus databases and other relevant sources. From these data, the crisis event is described, mapped and the interventions of the Czech government and the Integrated Rescue Services are synthesized. At the same time, the research gap is identified and recommendation for further research are set out.
Keywords: Humanitarian logistics, crisis management, humanitarian supply chain

Introduction

In terms of humanitarian disasters, the Czech Republic (CR) is characterised by floods. Floods are also something for which humanitarian organisations and the Integrated Rescue Service (IRS) are very well prepared. However, the logistics of these entities had exposed to significant shocks in the last period of 2019-2021. In 2020 the CR was hamstrung by the COVID-19 pandemic, in 2021 the country was hit by the strongest tornado in history and in 2022 a massive refugee crisis came as part of the armed conflict in Ukraine. These are all significant shocks to the established state of affairs in the CR. In response to these events, the leadership of humanitarian organisations and state emergency services are beginning to realise that significant changes are needed to meet the new challenges in these dynamic times.

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Regardless of the origin, adverse events are associated with the aftercare of the damaged population and territory. Humanitarian supply chain (HSC) is an important part of this process, distributing materials, people and money to and from the affected regions. By optimizing logistics processes within humanitarian crises, it is possible to save financial resources, save lives more effectively and improve overall performance of humanitarian organizations.

This paper is part of a large-scale study that aims to improve the state of humanitarian logistics in the CR in collaboration between academics and practitioners. The aim of this paper is to conduct the first phase of the research, which focuses on a case study of humanitarian logistics during a tornado in South Moravia Region (SMR) in 2021, to discuss the interim results and set the next steps of the research. In this first phase of the research, an analysis of the situation in South Moravia in 2021 will be made, an analysis of natural disasters in the CR will be conducted with a focus on tornadoes. The aim of the whole research will be to describe the state of humanitarian logistics in the CR before this event, to map and analyse this event and to suggest solutions that will improve the current situation.

State of the art

Natural disasters destroy infrastructure and property, displace families, and disrupt our daily lives. The objective of disaster relief operations is to provide humanitarian assistance in the forms of water, food, shelter, and supplies to areas affected by large-scale emergencies (Kovács, 2018). Humanitarian operations are different due to the varying severity of disasters and diverse recipients' needs. The Orissa super cyclone in India in 1999, the Gujarat earthquake in India in 2001, the Bam earthquake in Iran in 2003, Hurricane Ivan in 2004, the Indian Ocean tsunami in 2004, Hurricane Katrina in 2005, the Muzaffarabad earthquake in Pakistan in 2005, Cyclone Sidr in Bangladesh in 2007, Cyclone Nargis in Myanmar in 2008, the Sichuan earthquake in China in 2008, the Haiti earthquake in 2010, the Pakistan floods in 2010, and the triple disaster triggered by the earthquake, followed by a tsunami and ultimately the Fukushima nuclear emergency in Japan in 2011, the Pakistan floods in 2011, the Uttarakhand floods in 2013, Cyclone Phailin in Odisha and Andhra Pradesh in India in 2013, and the Typhoon Haiyan in the Philippines in 2013 were a few of the most devastating disasters in the recent past (Sahai, 2016).

Significant issues in planning and execution of humanitarian relief logistics that are discussed include the following (Zeimpekis, 2013):

- Approaches that tackle realistic relief distribution networks. In addition to largescale computing issues, heuristics may handle the complexity and particularities of humanitarian supply chains accurately. A key element to the success of these efforts is to account for uncertainty while integrating long-term and tactical decisions.
- Solution approaches that integrate real-time information while effectively coping with time pressure and uncertainty which are inherent to a disaster scene.
- Judicious recourse strategies that allow a quick and effective restoration of preplanned solutions whenever an unpredictable event occurs. Examples of these events include sudden changes in travel times due to severe damages in the transportation network, etc.
- Coordination of multiple parties that are often involved in managing a disaster. These parties typically include NGOs, local, state and federal agencies. In this multiparty setting, a successful disaster response depends on the judicious management of the flow of real-time information that unfolds. Issues related to effectively communicating and sharing information as well as rapidly integrating and processing the shared information need to be addressed carefully.

Goal and Research Methods

Research questions and goals

The aim of this paper is to conduct the first phase of the research, which focuses on a case study of humanitarian logistics during a tornado in South Moravia Region in the CR in 2021, to discuss the interim results and set the next steps of the research. In this first phase of the research, an analysis of natural disasters in

the CR will be conducted with a focus on tornadoes, and an analysis of the situation in South Moravia in 2021 will be made. That said, from a methodological point of view, the paper is a case study.

The research questions for this phase of research are:

- Are there relevant sources available from which information can be obtained regarding tornado in South Moravia Region in the CR that can be used as a basis for extensive research?
- Is tornado event in 2021 suitable for study of the crisis response and study the resilience capabilities to react on the tornadoes and similar crisis situations?

Research Methods

First, the sources are searched, synthesized and analyzed. Analysis of current knowledge from relevant sources will be used to fulfil the objectives of the thesis and answer the research questions. The relevant sources in this research are the government of the CR and governmental organisations, the IRS of the CR, the Czech Statistical Office, the Czech Hydrometeorological Institute and institutions of a similar nature, and articles and conference proceedings in the Web of Science or Scopus databases. The analysis will be carried out using the snowball method, where after the basic research, additional sources will be gradually added to complete the picture. Research of the Web of Science and Scopus databases was based on keyword searches. The keyword combinations 'tornado', 'moravia', and 'czechia' were used. An abstract analysis was performed on the outputs.

Given that the event took place in 2021 and the CR is a relatively small country, it is expected that the lack of resources could be a limiting factor for this research. As part of the ongoing research, the authors of this thesis have already contacted Czech humanitarian organisations and the Directorate General of Fire Rescue Services of the Czech Republic (DG FRS) who have promised to assist in gathering knowledge about this event. Guided interviews with senior personnel in the logistics of this event will be conducted in the following research. This part of the research aims to conduct a literature search of publicly available information.

Analysis of tornadoes in the Czech Republic

An analysis of natural and anthropogenic risks for the CR was carried out in 2020 by the DG FRS based on data and information from ministries and other experts at central and regional level. The risks that are relevant for the Czech Republic at national and regional level based on an assessment of potential loss of life, environmental, economic and social impacts were revealed, see Fig. 1. (DG FRS 2020). The results form the basis for regional crisis plans. Some risks are excluded from the report for the regional level, as they are only relevant at the central level (e.g. disruption of the state's financial and foreign exchange management) or are managed by other entities, e.g. armed conflict, which is the responsibility of the Ministry of Defence (DG FRS 2020).

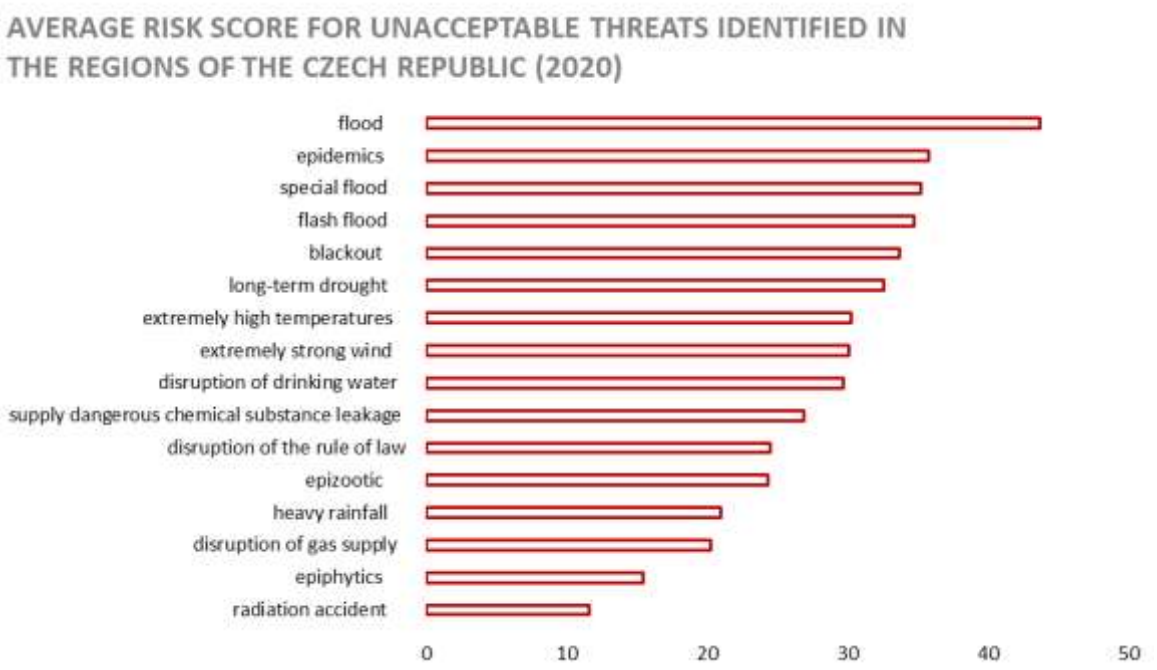


FIG. 1: AVERAGE RISK SCORE FOR UNACCEPTABLE THREATS IDENTIFIED IN THE REGIONS OF THE CZECH REPUBLIC (DG FRS 2020)

Based on this analysis, the average risk score was ranked highest for flooding with a value of 43.67 % of all responses (DG FRS 2020). In previous research, the authors found that floods are the most common disaster the CR faces (Repík, Foltin 2022). Statistics on floods in the CR can be seen in the

Fig. 2. The epidemic ranked second with a value of 35.74 % of all responses (DG FRS 2020), which is fully understandable given that the first wave of COVID-19 arrived in the CR in March 2020. It would be scientifically interesting to compare what this study would have looked like if it had been conducted a year earlier.

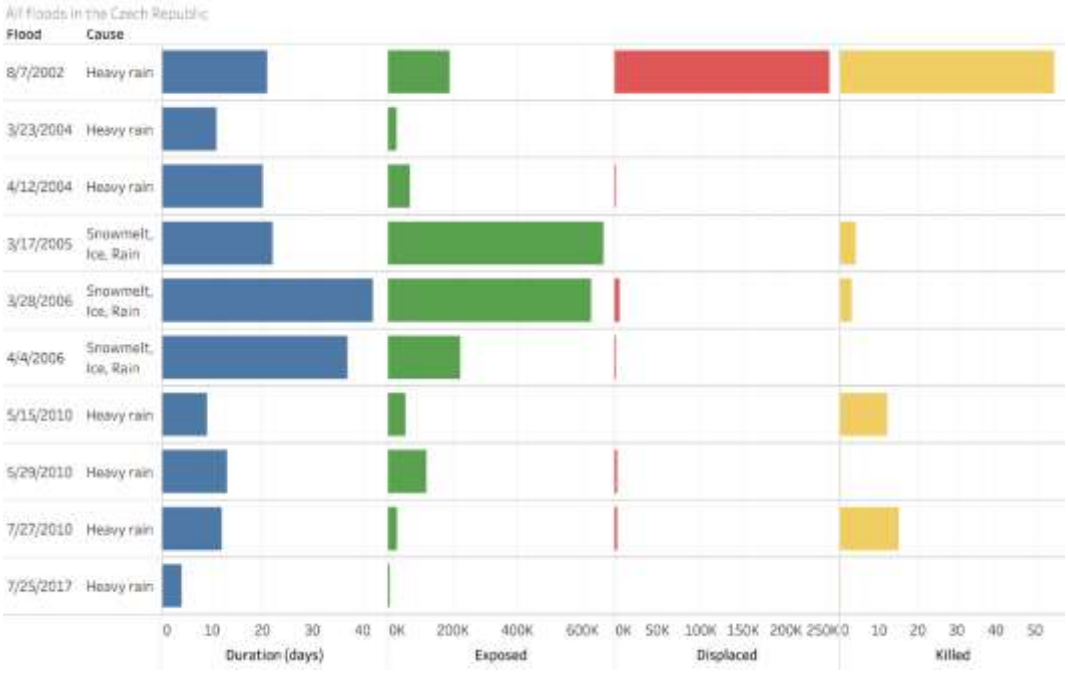


FIG. 2: ALL FLOODS IN THE CZECH REPUBLIC (GLOBAL FLOOD DATABASE 2022)

What is significant for our study, however, is the fact that the tornado did not appear in this ranking at all. It is important to show statistics that prove that tornadoes are not new to the CR, see Fig. 3 and

Fig. 4. Fig. 3 visualizes all tornadoes that have occurred in the CR since 1993.

Fig. 4 then graphically displays the data on the distribution of tornadoes between the regions of the CR. Such data seems to be something that the CR should consider for its crisis management and humanitarian logistics. The twist comes when looking at

Fig. 6. Tornadoes occur relatively frequently in the CR, on average 3.7 times per year between 1993 and 2022 (see Fig. 3). However, their strength and resulting damage are most often F0 or F1 according to Fuji's scale (National Weather Service 2022). The F2 scale is rare in the CR and the chances of F3 are minimal. In fact, until the South Moravia tornado of 2021, there had never been an F4 tornado in the CR (ESWD 2022). At the same time, it should be noted that there are also tornadoes in the database that do not have a numerical classification, but even for these it can be stated that they were not of F4 strength.

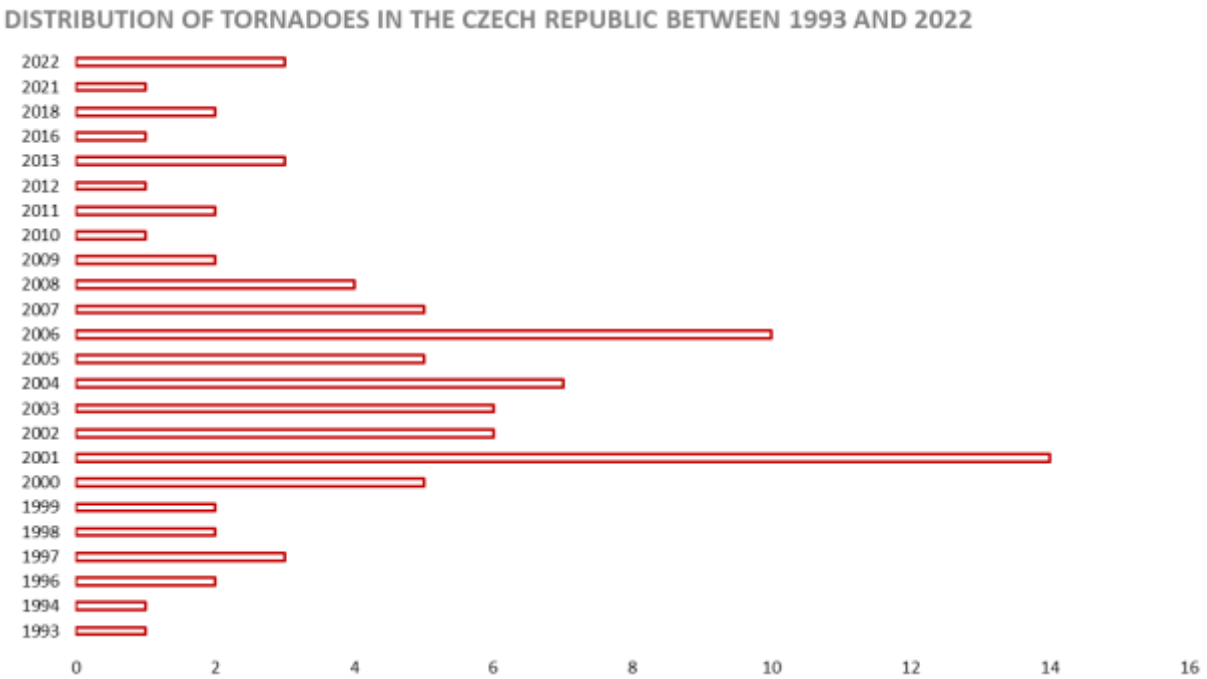


FIG. 3: DISTRIBUTION OF TORNADOES IN THE CZECH REPUBLIC BETWEEN 1993 AND 2022

Statistics show that tornadoes are not entirely uncommon in the CR. They regularly appear throughout the country during the summer months. However, their impact is usually very low, these phenomena do not cause damage to life or property and so do not receive media attention. It is therefore not surprising that even emergency plans do not take this phenomenon into account and that the tornado in the SMR in 2021 caused a huge shock to the disaster response phase. The event was a wake-up call for humanitarian logistics in the CR. There were identified significant gaps in preparation for a disaster of this nature and magnitude. In the first minutes after the tornado struck, temporary warehouses began to be set up to store and distribute humanitarian aid. First, 3 smaller temporary warehouses were set up in Hodonín. Subsequently, they moved to the premises of the Tabačka factory, which offered a huge and sufficient space to store a large overflow of in-kind donations. The response phase was long and exhausting. Humanitarian organisations operating on a voluntary basis began to realise that volunteering was not enough. The media played a key role in terms of promoting funding for aid. Humanitarian aid started to become known to the wider public.



FIG. 4: LOCATIONS OF TORNADOES IN THE CZECH REPUBLIC (ESWD 2022)

Fig. 5 and

Fig. 6 visualizes that the SMR (Jihomoravský) and the Central Bohemian Region (Středočeský) are the most prone to tornadoes. Both regions have values >= 15, while the other regions are below values <= 10. For this reason, it may be advisable to plan for at least these counties with the understanding that a similar situation may arise. In doing so, it may not even be a targeted preparation for a single type of disaster. Up to this point, a tornado has never been determined to be a risk to the SMR (Pochylá 2021). Pre-contracted warehouses, teams of paid emergency workers, or a warning system are things that are useful for multiple types of larger scale disasters.

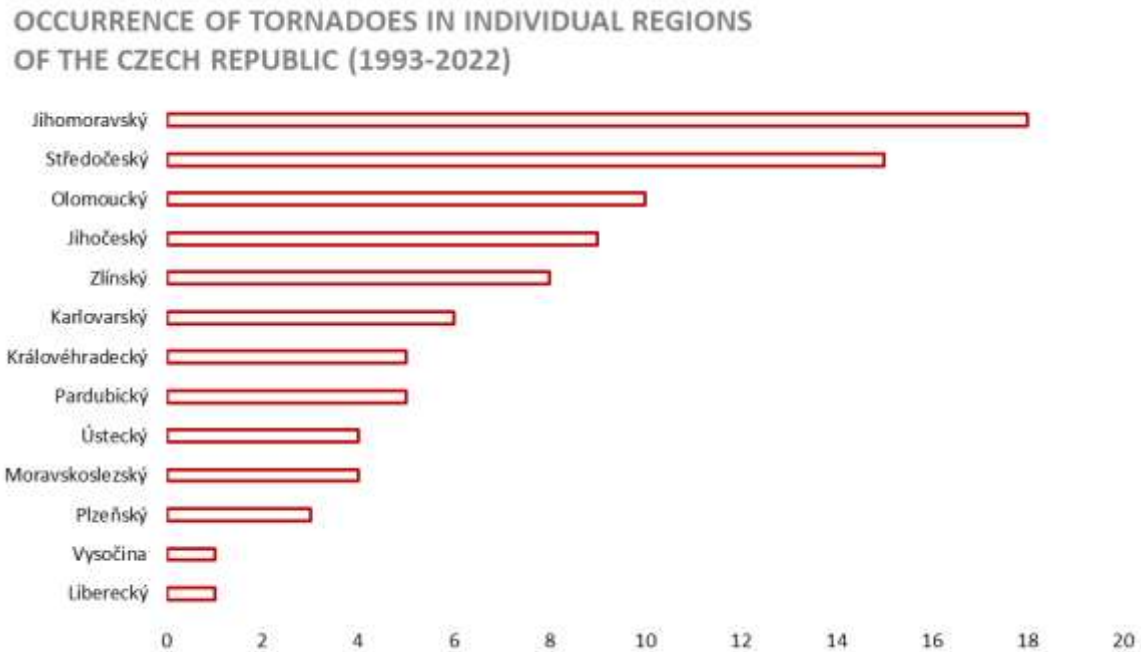
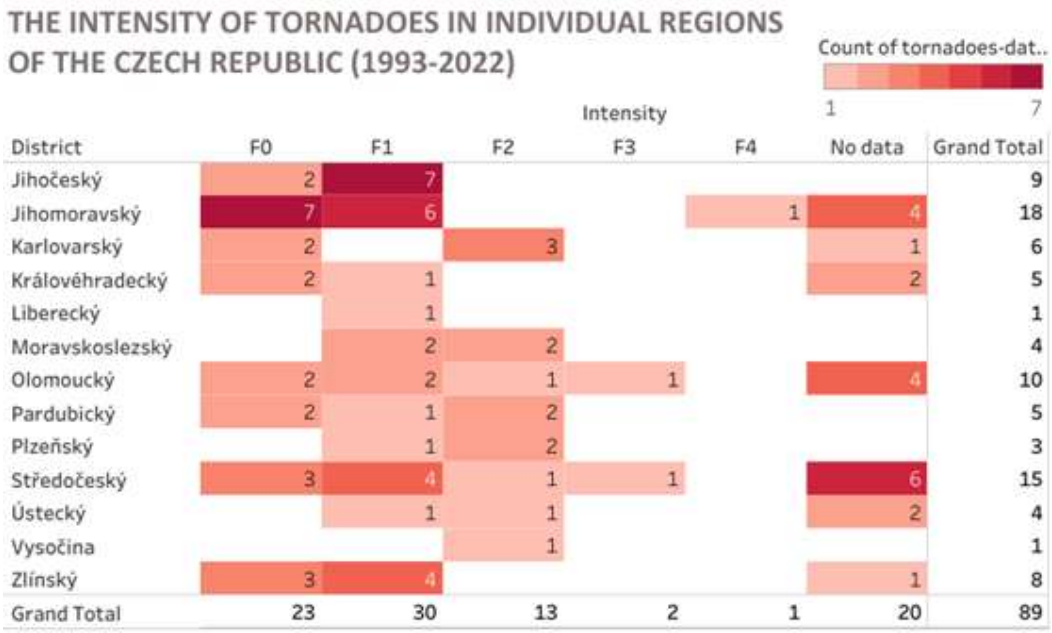


FIG. 5: OCCURRENCE OF TORNADOES IN INDIVIDUAL REGIONS OF THE CZECH REPUBLIC (ESWD 2022)



District	F0	F1	F2	F3	F4	No data	Grand Total
Jihočeský	2	7					9
Jihomoravský	7	6			1	4	18
Karlovarský	2		3			1	6
Královéhradecký	2	1				2	5
Liberecký		1					1
Moravskoslezský		2	2				4
Olomoucký	2	2	1	1		4	10
Pardubický	2	1	2				5
Plzeňský		1	2				3
Středočeský	3	4	1	1		6	15
Ústecký		1	1			2	4
Vysočina			1				1
Zlínský	3	4				1	8
Grand Total	23	30	13	2	1	20	89

FIG. 6: THE INTENSITY OF TORNADOES IN INDIVIDUAL REGIONS OF THE CZECH REPUBLIC (ESWD 2022)

Analysis of the crisis situation caused by a tornado in South Moravia in 2021

Description of the event

On 24 June 2021 between 19:14 and 19:53 CEST, strong thunderstorms occurred in the early evening in South Moravian Region (CHMI 2021). The tornado, along with other dangerous phenomena, was part of a very strong convective storms on a cold front over Austria, the CR, Poland and Slovakia (CHMI 2021). One of these storms moved from Austria through the districts of Břeclav and Hodonín further into the Zlín region and was accompanied by a strong tornado which caused significant damage (DG FRS 2021a). This zone was 26 km long and up to 700 m wide, passing from the town of Břeclav to the town of Hodonín. Specifically, the tornado hardly hit the villages of Hrušky, Moravská Nová Ves, Mikulčice, Lužice, the northern part of Hodonín and Pánov (see Fig. *7*). In these municipalities a large part of the buildings were often damaged or completely destroyed, less frequent damages or damages outside the built-up areas concerned the municipalities of Břeclav, Kostice, Tvrdonice, Týnec and Ratíškovice (CHMI 2021). According to the Czech Hydrometeorological Institute (CHMI), based on ground surveys, this is the strongest tornado ever recorded on Czech territory (CHMI 2021). GD FRS states that it was one of the strongest recorded tornadoes in Europe in the last 20 years (DG FRS 2021a). Basic information about the tornado is summarized in Table 1.

TABLE 1: BASIC INFORMATION ABOUT THE SMR TORNADO (PÚČIK ET AL. 2022)

Tornado formation	**~19:14 CEST, 1 km east of Břeclav**
Tornado decay	**19:53 CEST, 1 km south of Ratíškovice**
Maximum intensity	**IF4**
Path length	**27.1 km**
Maximum continuous path of IF2 or stronger winds	**15.3 km**
Maximum path width	**~ 2800 m, east of Břeclav**
Maximum width of IF2 or stronger winds	**590 m, in Hrušky**
Minimum path width	**~ 250 m, in Hodonín**
The area impacted by the tornado (IF0 damage or stronger)	**21.9 km²**
The area impacted by the strong tornado (IF2 damage or stronger)	**6.1 km²**

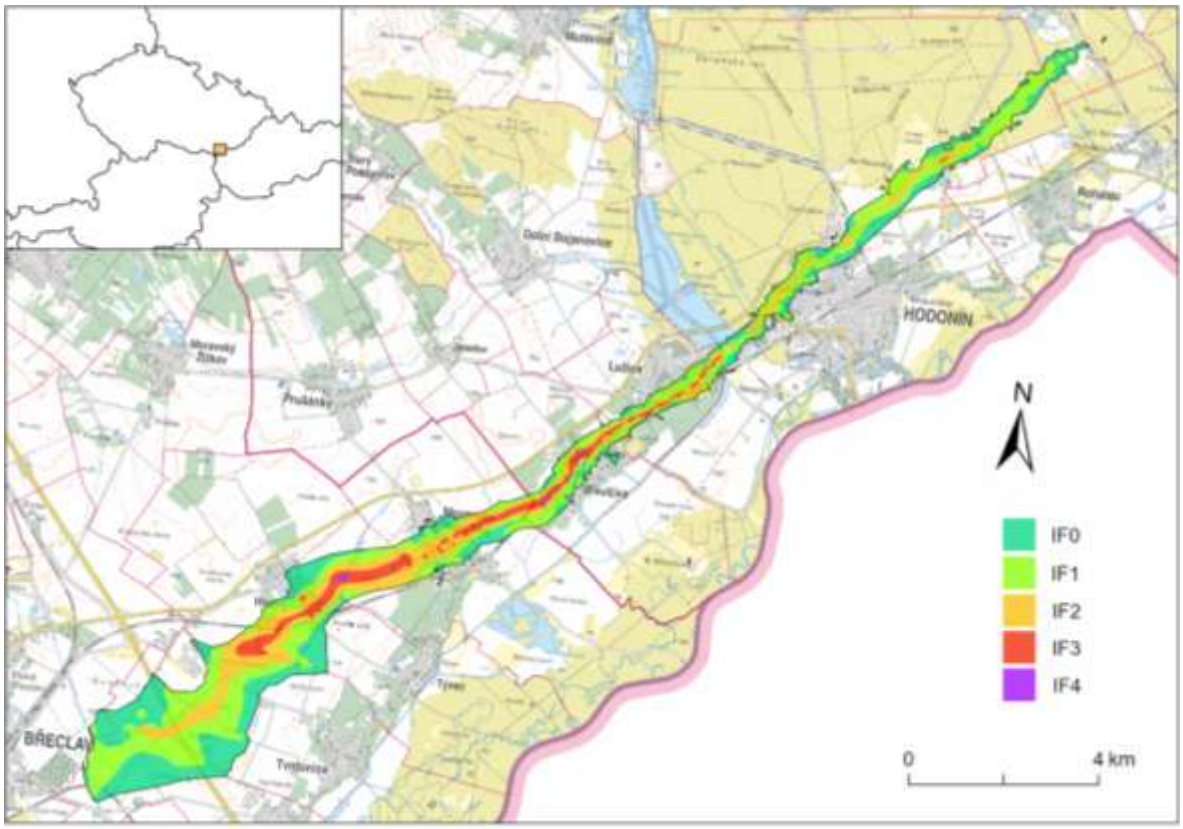


FIG. 7: THE TRAIL OF THE TORNADO IN SMR (PÚČIK ET AL. 2022)

Intervention of the Fire Rescue Services

The first emergency call in connection with the tornado was made at 7:19 p.m., and the first fire unit was dispatched at 7:20 p.m (DG FRS 2021a). This was followed by overwhelming emergency calls. During the first four hours, the Regional Operations and Information Centre of the South Moravian Fire Brigade handled over 600 calls to the emergency line (DG FRS 2021b). There were many duplicate calls, and the communications software was operating at its technical limits (DG FRS 2021a). A total of 168 firefighting units responded on the first day (DG FRS 2021a). A few minutes after the tornado struck, crisis staffs were activated at the level of the region, municipalities with extended jurisdiction and individual IRS units (DG FRS 2021a). Specialized teams were dispatched to the site to search for persons buried in the rubble, as well as three engineer detachments (DG FRS 2021b). The crisis staffs ensured the conditions for the work of the rescuers and cooperated in coordinating volunteers and meeting the needs of the affected people. In the first phase, firefighting units, IRS units, crisis teams of humanitarian organisations, as well as other people rushing to help, struggled with the poor accessibility of the affected area. The affected area was gradually divided into 5 intervention sectors (Hrušky, Moravská Nová Ves, Mikulčice, Lužice, Hodonín, including the locality of Pánov) for better coordination of rescue and liquidation work (DG FRS 2021b). During the second day, the nature of the work in the individual sectors gradually changed and the rescue work turned into liquidation work. These included the removal of damaged roofs and structures, stabilisation of buildings that were in danger of collapse, removal of debris and wrecked vehicles, and road clearance. In natural disasters such as tornadoes, the typical problem is the immediate overwhelming of infrastructure, which creates logistical problems with distribution and accessibility of the area (Repík, Foltin 2022). Gradually, however, the debris is cleared away and the infrastructure is put into increasingly better conditions.

On 25 June, teams of regional FRS units and other firefighting units were dispatched to the relief work, which proved crucial (DG FRS 2021a). The relief work required a large deployment of forces and resources. The Governor of the SMR decided to declare a state of danger for the municipalities of Břeclav and Hodonín, thus contributing significantly to the managing this unprecedented event (SMR 2021). It allowed, for example, to set up landfills in places that were not designated for this purpose, which made it possible to quickly remove the mess from the infrastructure. In the context of the declaration of a state of emergency, the government issued a

regulation on the provision of state material reserves, which allowed the activation of the tools of the State Material Reserve Administration, such as fuel, machinery, power stations or equipment etc. (ASMR 2021).

Due to the huge amount of aid offered, the organisation of in-kind humanitarian aid was logistically complex, i.e. selecting parking lots and setting up shuttles for volunteers to the affected villages, selecting storage facilities, receiving and expedition in warehouses, and distributing materials according to the needs of the affected people. In addition to this, a number of social media groups were created where logistical requirements were duplicated and not updated. Logistics were also complicated by the fact that waste dumps began to spontaneously form in the affected areas. The FRS SMR in cooperation with the regional authority was behind the creation of 3 landfill sites, namely the site in Moravská Nová Ves, the site of the Mír mine in Mikulčice and the Ploma site in Hodonín (DG FRS 2021a). The landfills were positioned to cover the entire 27 km long area (see Fig. *8*). The total volume of waste taken to landfill sites as of 22 July is estimated at more than 300 000 tonnes (DG FRS 2021a).

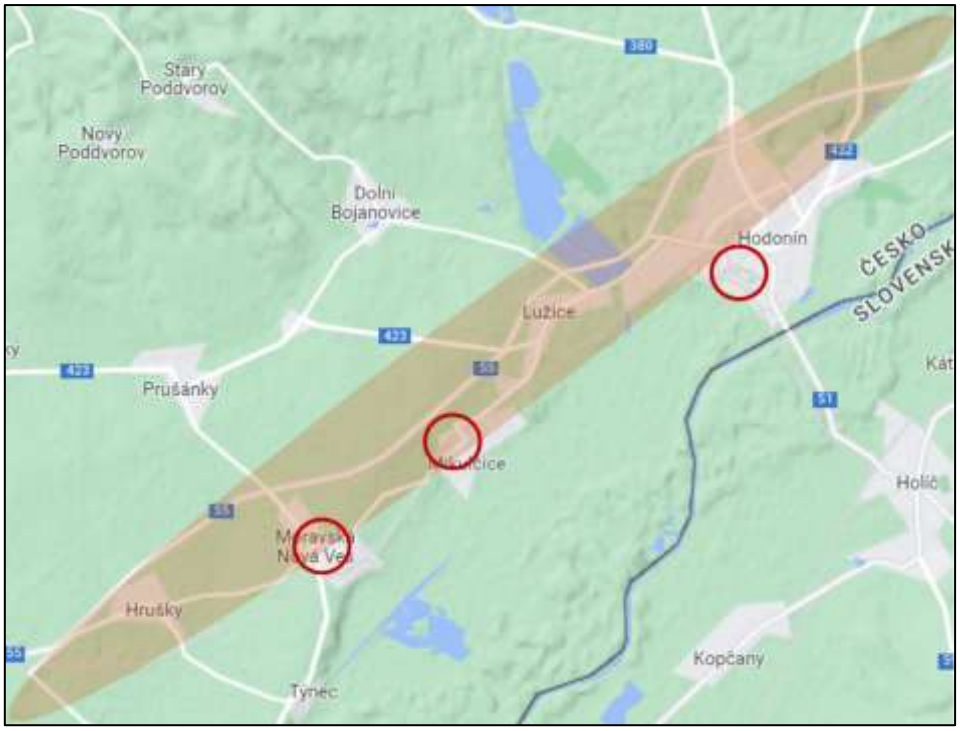


FIG. 8: LANDFILL SITES (OWN)

Intervention of the Medical Rescue Services

The first call, in connection with a passing weather phenomenon, prior to the tornado occurring, was a head injury from large hail at 7:03 p.m, events related to falling objects were reported from 7:22 p.m (ZZSJMK 2022). Also, the termination was gradual, with dispatch resources left on site until the debris was fully inspected, with the last dispatch groups leaving the scene at 5:00 p.m. the following day (ZZSJMK 2022). The number of patients taken away by the ambulance service was a total of 83 persons (ZZSJMK 2022). For the Medical Rescue Service South Moravian Region 43 rescue vehicles were deployed (were occupied by 2 - 5 employees), also rescuers from other regions, Slovakia, Austria came to help (ZZSJMK 2022). From 19:05 to 21:00, 819 calls were made to the 155 line (emergency line in the Czech Republic), from 19:05 to 05:00 there were 1191 calls to the 155 line.

This was the largest and longest deployment for all the units in the history of their existence, this event confirmed the importance of the IRS and the need for close cooperation of its basic components (ZZSJMK 2022). On the basis of the experience gained, all components are planning to further deepen their cooperation, both in the operational centres and in the coordination of common procedures and rescue work in the field (ZZSJMK 2022). The handling of the tornado situation also had an impact on the change in the set procedures for dealing with the emergencies (ZZSJMK 2022). Another important aspect of the tornado response from an

emergency management perspective was that in 2021, due to the coronavirus epidemic, only 1 exercise of the IRS SMR components took place out of a planned 15 (ZZSJMK 2022).

Intervention of the Czech Army

The use of the army for rescue work is legislatively anchored in Act No. 219/1999 Coll. The Act provides for the use of the army for rescue work and for the liquidation of the consequences of a disaster, which is a temporary organised deployment of military units and military equipment with the necessary military material under the command of the relevant commander or chief, which occurs when the relevant administrative authorities, local government authorities or fire protection authorities cannot ensure rescue work or the liquidation of the consequences of a disaster with their own forces (Czech Republic 1999). The Czech Armed Forces (CAF) started to carry out tasks in the affected area on 25 June at 8:00 a.m. (Ministry of Defence & Armed Forces 2022). At this time, the 1st Engineer Detachment of the 15th Engineer Regiment (10 soldiers, 8 pieces of equipment), 15 members of the Castle Guard and 150 professional soldiers took part in the action (Ministry of Defence & Armed Forces 2022). On 27 June, in the evening hours, the II Engineer Detachment (18 soldiers, 16 pieces of engineer equipment) also started its tasks (Ministry of Defence & Armed Forces 2022). The operation was completed on 23 August 2021, with a total of 1,194 soldiers and 104 pieces of equipment deployed, including 62 pieces of heavy equipment (Ministry of Defence & Armed Forces 2022).

Based on the requirements of the crisis staff of the SMR, it was gradually deployed (Ministry of Defence & Armed Forces 2022):

- 50 soldiers to secure the warehouses for the distribution of humanitarian aid;
- a temporary command post was established in Rohatec (8 soldiers);
- a group of Military Police to guard the gathered equipment, to secure the movements and to patrol the affected areas;
- 3 psychologists to coordinate psychosocial assistance;
- one doctor and 7 non-medical staff to provide emergency operation of general practitioner's offices in Moravská Nová Ves

Government Intervention

The government has adopted several measures to help people, municipalities and companies affected by the tornado (see Table 2). People affected by the natural disaster could also receive psychological assistance. A number of financial programmes were logistically very important for the reconstruction of the area after the disaster. People could finance their housing, companies could finance their damaged property and the SMR in general could finance its recovery. The government played an important role in the humanitarian aid and reconstruction of the affected area. At the same time, the Ministry of the Interior of the CR summarized on its website the collections organized by humanitarian organizations, which was an important part of the central management in terms of logistics. With uniform information, fragmentation of resources and fraud are reduced.

TABLE 2: OVERVIEW OF GOVERNMENT SUPPORT (GOVERNMENT OF THE CZECH REPUBLIC 2021)

Support	Value	Provider
Changing the conditions for granting support by the State Fund for Investment Support so that the fund can provide affected citizens with a subsidy for housing renovation in addition to low-interest loans.	-	Government
Subsidies for the reconstruction of damaged or construction of a new dwelling under the Živel programme.	Up to CZK 2 million	Government
A subsidy programme for the reconstruction of damaged municipal property.	Up to 50 % (90 %) of the costs for municipalities (regions) CZK 420 million is available	Government
Affected citizens could obtain a benefit of extraordinary immediate assistance to provide basic necessities of life and first aid to eliminate the consequences of the disaster until assistance can be provided from other sources.	Up to 15 times the amount of the individual's subsistence minimum, i.e. up to CZK 57 900	Labour Office of the Czech Republic
Freeing up money from the land improvement budget to quickly help people and communities damaged by the tornado.	CZK 100 million is available	State Land Office
Each owner of a destroyed house was offered logs or a financial donation.	50 cubic meters of logs CZK 100 000 20 cubic meters of firewood	State Enterprise Forests of the Czech Republic
Financial support for the rehabilitation of damaged water supply and sewerage systems and related facilities.	Up to CZK 100 million	Ministry of Agriculture
Programme Help after a Tornado to entrepreneurs whose property was damaged: a) subsidy for the purchase of new assets b) an interest-free loan from the Czech-Moravian Guarantee and Development Bank	a) Up to CZK 1 million (+ CZK 50 000 for clean-up work) b) Up to CZK 45 million Approved the use of up to CZK 200 million	Ministry of Industry and Trade
Forgiveness of employers and self-employed persons who had a place of residence or place of business on 24 June 2021 for late payment of compulsory social security contributions for June to November 2021.	-	Social Security Administration
Remission of tax, tax accessories and advance payment of tax to taxpayers in the territory of the municipalities with extended competence Břeclav and Hodonín. Certain fines will be waived if the specified conditions are met.	-	Ministry of Finance
The targeted Tornado programme for employers and employees. Through the Tornado programme, the Labour Office will contribute to wage compensation and wages themselves.	A contribution of 100 % of wage costs incurred for the period 25 June to 31 July	Ministry of Labour and Social Affairs
Affected agricultural businesses can receive compensation through the Agricultural Risk and Crisis Framework Programme.	Up to 100 % of the proven damage Approved the use of up to CZK 1.5 billion	Ministry of Agriculture
The government released funds from the government budget reserve provided in the form of a subsidy to the SMR on the basis of its previous request. The money will be used to cover the initial costs of the emergency within the framework of the region's crisis management.	Up to CZK 20 million	Government

Summary of the analysis

The entire analysis is synthesized into a single table and timeline. The results of the synthesis can be seen in Table 3, which summarizes the basic exact numerical data on the 2021 tornado crisis event in South Moravia. These data concern damage to people and property and are directed to the IRS. The data for humanitarian NGOs is not as well publicly available and will be the subject of further research through guided interviews with logistics staff of the largest Czech humanitarian organizations.

TABLE 3: SUMMARY STATISTICS ON DAMAGE AND IRS INTERVENTIONS (ZZSJMK 2022; DG FRS 2021B; 2021A; 2020; MINISTRY OF DEFENCE & ARMED FORCES 2022; POCHYLÁ 2021; ASMR 2021)

Deaths	**6**	**persons**
Injured people who went to hospital on their own	**hundreds**	**persons**
Number of ambulance patients transported	**83**	**persons**
- Moravská Nová Ves	21	persons
- Mikulčice	18	persons
- Hrušky	14	persons
- Lužice	16	persons
- Hodonín + Pánov	14	persons
Buildings damaged	**1 200**	**buildings**
Buildings designated for demolition	**191**	**buildings**
Property damage	**tens of millions**	**EUR**
The total volume of waste sent to landfill as of 22 July	**300 000**	**tonnes**
All IRS units participated in providing interventions in the initial acute phase	**2 880**	**interventions**
Firefighters intervened	**7 541**	**firefighters**
Pieces of equipment firefighters used	**2 963**	**pieces**
Firefighters spent there	**61 386**	**hours**
Patients transported by the ambulance service	**83**	**persons**
Number of soldiers involved	**1 194**	**soldiers**
Pieces of equipment soldiers used	**104**	**pieces**
- of which heavy machinery	62	pieces
The cost of deploying the army	**209 042**	**EUR**

The entire emergency event is also mapped onto a single timeline (see Fig. *9*). The timeline maps the situation from the first minutes before the tornado occurred to the end of the emergency. This map was compiled based on analysis of publicly available IRS, CHMI, and Armed Forces resources. Thus, it can be expected that it may not be exhaustive, however, key moments of the event are included. This event timeline maps the crisis situation at the onset, response, and recovery phases of an emergency. The subject of the next research, according to Coppola's model, should be mitigation and preparation (Coppola 2015). The presented timeline ends with the end of the state of danger two months after the tornado. However, the recovery phase is still ongoing. At the same time, initiatives corresponding to the mitigation and preparation phases are underway and emerging.

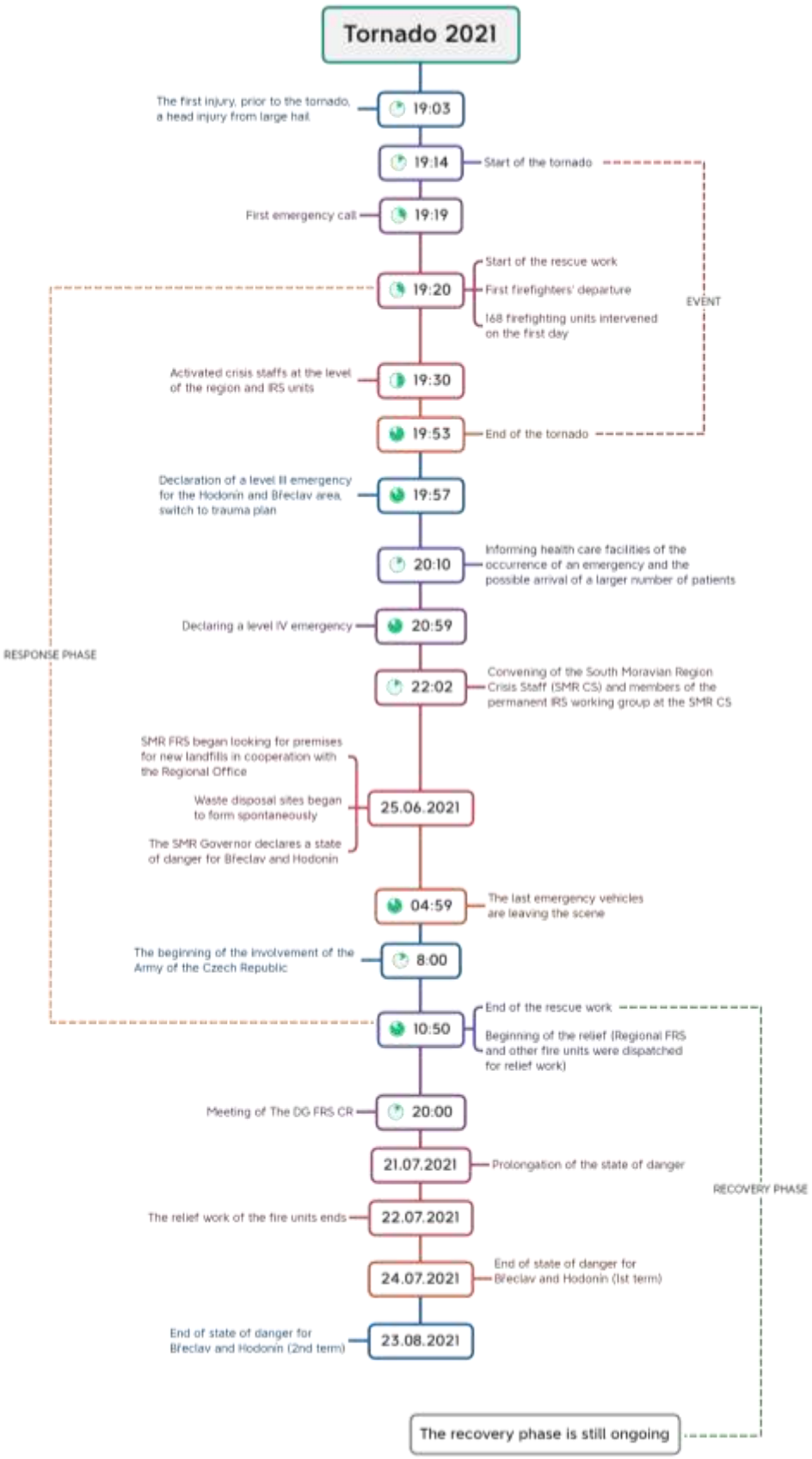


FIG. 9: TIMELINE OF THE EVENT (DG FRS 2021B; 2021A; ZZSJMK 2022; CHMI 2021; MINISTRY OF DEFENCE & ARMED FORCES 2022; POCHYLÁ 2021; DG FRS 2020; ASMR 2021)

Concluding Discussion

In this study, the authors attempted to collect and analyse data related to the 2021 tornado crisis in SMR. The paper analyses publicly available sources describing the situation in CR during the tornado events in the years or 2019-2021. The outputs present a summary description of the interventions of the IRS, the military and the government of the CR. The synthesis of information tells about the actions of one part of the crisis preparedness and humanitarian logistics components of the CR. We have partly touched upon legislation in the context of justifying why the military intervened in a crisis event. There is a legislative framework for crisis and emergency preparedness in the CR. Even within the European Union there are documents that could be relevant in the context of our research e.g. documents of the DG ECHO movement (DG ECHO 2022). Further research should examine in detail the legislative framework of crisis preparedness and humanitarian aid in the CR or in the field of the European Union.

On the basis of data from the European Severe Weather Database we have analysed the occurrence of tornadoes on the territory of the CR and their distribution according to the Fuji scale, in individual regions of the CR and in years. This data could be analysed in more detail in future research. For example, the Fuji scale distribution is flawed in that some tornadoes are not assigned a category in the database. At the same time, further research could filter by tornadoes of a more significant nature and examine them in more detail.

Presented event timeline maps the crisis situation at the onset, response, and recovery phases of an emergency. The subject of the next research, according to Coppola's model, should be mitigation and preparation (Coppola 2015). Such initiatives are already emerging in the CR at the level of practitioners. The initiatives are partly supported by the fact that less than a year after the SMR tornado came the Russian invasion of Ukraine, which was associated with a massive refugee crisis and material and financial aid to Ukraine. This put additional pressure on already tired crisis actors and humanitarian organisations, but on the other hand it also put pressure for further improvement and cooperation.

We asked two research questions that we attempted to answer in this study.

First research question:

- Are there relevant sources available from which information can be obtained regarding tornado in South Moravia Region that can be used as a basis for extensive research?

It was found that scientific publications dealing with this event have so far been published only in the context of research on the physical characteristics and impacts of tornado, not in the field of crisis management and humanitarian logistics. No relevant articles on the topic were found in the Web of Science and Scopus databases based on keyword searches. Our search of the Web of Science and Scopus databases was based on keyword searches. The keyword combinations 'tornado', 'moravia', and 'czechia' were used. An abstract analysis was performed for all outputs. On the other hand, publications and materials from other relevant sources were found. These include, for example, CHMI, GR FRS, IRS or the Czech Government. Thus, we can say that the data are already available, but no scientific publications that meet our context have yet been found.

Second research question:

- Is tornado event in 2021 suitable for study of the crisis response and study the resilience capabilities to react on the tornadoes and similar crisis situations?

Based on these findings, we consider the topic to be highly topical and important to address in further research. During the time this publication was being written, we also contacted DG FRS and representatives of the five largest Czech humanitarian organisations (Czech Red Cross, People in Need, ADRA, Diakonie, Caritas Czech Republic), with whom we tried to establish cooperation for the development of research on this event within the framework of crisis management and humanitarian logistics. All the responses we received agreed that the topic is important and relevant for research. Experts in the field agree that the tornado was a significant shock to Czech humanitarian logistics and a driver for further improvement and cooperation. At the same time, there is a consensus that interesting examples of good and bad practice can be extracted from this event. Thus, by answering the second research question, we consider that the topic is suitable for further research.

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