Spontaneous Volunteers Across National Borders: An Agent-Based Comparison

Yannic Schulte
Bergische Universität Wuppertal
yschulte@uni-wuppertal.de

Miriam Klein
Karlsruhe Institute of Technology
miriam.klein@kit.edu

Marcus Wiens
Karlsruhe Institute of Technology
marcus.wiens@kit.edu

Frank Fiedrich
Bergische Universität Wuppertal
fiedrich@uni-wuppertal.de

Frank Schultmann
Karlsruhe Institute of Technology
frank.schultmann@kit.edu

ABSTRACT

In today's globalized world and with the extensive use of social media, there is a high connectivity of people across countries, which can be a helpful potential in disaster response. In a coordinated manner, spontaneous volunteers from neighbouring nations can provide high manpower and resources to a disaster affected area. In this article, we discuss why the consideration of spontaneous volunteers is relevant in a cross-border context in order to improve disaster resilience for borderlands. Furthermore, we introduce a baseline agent-based model to simulate cooperation procedures for the involvement of spontaneous volunteers to the official crisis response in a borderland and discuss important issues that need to be addressed in future considerations.

Keywords

Spontaneous Volunteers, Cross-Border, Borderland, Agent-Based Modelling, Disaster Management.

INTRODUCTION

Today's world is shaped by interconnectivity and widespread use of social media resulting in a strong network of people, also across nations. During recent natural disasters, these connections were seen as a useful potential in disaster relief. In a coordinated way, spontaneous volunteers can provide considerable human resources and relief supplies to an area affected by a disaster. Especially in a borderland, it can bring an enormous advantage to have access to resources of the neighbouring country and thus, to think of an efficient inclusion of spontaneous volunteers in the planning phase for disaster response. Although there is no reference in the scientific literature on the deployment of spontaneous volunteers in a cross-border disaster situation so far, this does not mean, however, that this scenario has not yet occurred or should remain unconsidered. By contrast, it is precisely in this setting, in which coping with disasters can be difficult due to different responsibilities, e.g., that volunteers can effectively complement the work of first response agencies and thus provide substantial support. For this reason, we clarify why the consideration of spontaneous volunteers is relevant in a cross-border context in order to improve the resilience of border regions to disasters. The presented article will first outline the basic phenomenon of the emergence of spontaneous volunteers. Furthermore, the following section examines the impact that the crossing of national borders can have on the motivation of volunteers and shows that the management of volunteer groups should also be established across borders. However, this requires a well-functioning integration structure in the individual countries. Based on this argumentation and due to the lack of empirical evidence, four scenarios for cross-border integration and coordination are developed, which are then compared and evaluated using agent-based simulation. Subsequently, the findings generated from these scenarios are merged with the previous assumptions. The conclusion section discusses limitations of the framework and outlines next steps in this ongoing work with regard to improvement of disaster resilience in border regions.

FUNDAMENTALS OF SPONTANEOUS VOLUNTEERS

Spontaneous volunteers or non-affiliated volunteers have received a great deal of attention in research in recent years. There have been some catastrophic events, in which spontaneous volunteers have become active and have made a significant contribution to disaster management. The phenomenon has also become particularly relevant due to the growing importance of social media, in which volunteers have organised themselves. The following section will briefly deal with the individual points addressed here.

As early as 1970, Dynes pointed out that people gather at places of disaster to help after catastrophes (Dynes, 1970). Forrest then investigated this in 1978 in the case of natural disasters and called this phenomenon *Group Emergence* (Forrest, 1978). This means that people join together to form groups that begin to deal with disasters independently of existing structures in order to fill the initial supply gap when a disaster occurs. He concludes that group emergence should be taken into account when civil protection authorities plan for such events. Stallings and Quarantelli (1985) also attribute the formation of emergent citizen groups to the initial absence of authorities after disasters (Stallings & Quarantelli, 1985). Fritz & Mathewson (1957), who identify five groups of people who travel to the scene of an emergency, take an even more differentiated view. There are the returnees, the anxious, the curious, the exploiters and the helpers. Kendra & Wachtendorf (2001) added in 2001 the group of supporters who gather to encourage emergency responders and express their gratitude. (Fritz & Mathewson, 1957; Kendra & Wachtendorf, 2001). The relevant group here, the helpers, is described by Fritz & Mathewon (1957) as unbound, i.e. not in connection with organisations active in disaster control. According to Stallings et al. (1985), the group is formed on the basis of the common goal of helping after the occurrence of a disaster.

Dynes (1970) divides the groups that become active in disaster relief into four categories. On the one hand, he distinguishes on the basis of the group structure (already existing vs. new) and on the other hand, differentiation is made in regard of the tasks (regular vs. not regular). There are established organisations, such as the professional fire brigade (Type I), which already exist before the event and whose inherent task is to become active in the event of disasters. The second group (Type II) includes organisations such as the Red Cross, which consist of a large number of volunteers who can also take on tasks in the field of disaster management. It is expected that there will be an increase in the number of volunteers of this type during the course of a disaster, as the volunteers gradually become active. The third group (Type III) are the organisations, which exist in their structure before the event, but which do not initially have any links with disaster management. These could be, for example, sports clubs or similar organisations, which decide collectively to support the measures to cope with the event. The last group (Type IV), and the forming of spontaneous volunteer groups can be considered as one of them, are organisations that only develop during catastrophes and become active on their own. That could e.g. be spontaneously formed search and rescue groups as seen in the aftermath of Hurricane Katrina. There are no structures in advance and the volunteers usually have little connection with the established structures for disaster management (Dynes, 1970).

Influence of social media

As described, volunteers have always travelled to disasters to help. The reason why the phenomenon has gained in importance in recent years is that the population has increasingly been connected via social media. The digital infrastructure makes it possible for those affected to exchange information with outsiders and potential helpers (Palen & Liu, 2007; Reuter, Marx, & Pipek, 2011). The online tools are used to provide emotional support as well as fast information (Jin et al., 2014). The structures in social media enable rapid networking so that new contacts can be made quickly. In the literature, middle-aged people in particular are described as volunteers who are involved in catastrophes, i.e. also the group that is active in social media (Barraket et al., 2013; Ocak et al., 2013; Rotolo & Berg, 2011 and Stewart et al., 2013). In the event of a disaster, the known technical resources can then be used to establish structures for the assistance of and by volunteers (Reuter et al., 2013).

Past events where this was visible are, e.g., the earthquake in Haiti in 2010, the flooding in Central Europe in 2013 (Schorr et al., 2014 and Versluis, 2014) or the refugee situation in Europe in 2015 (Simsa et al., 2019).

Involving volunteers in emergency response

While initially, for example during the floods in Central Europe in 2013, the emergency forces have been rather critical of spontaneous volunteers and perceived them as an additional burden, as more forces were needed to coordinate them, today the potential of these volunteers is often recognized (Kendra & Wachtendorf, 2003; Schorr et al., 2014; Stallings & Quarantelli, 1985 and Wachtendorf & Kendra, 2004). In addition to taking over simple tasks such as filling sandbags, more complex tasks resulting from the professional skills of the individual volunteers can also be performed. One problem is the verification of the skills (Barsky et al., 2007; Heger & Reuter, 2013 and Kendra & Wachtendorf, 2003). Nevertheless, the opinion exists that the potential should be used

and mechanisms must be created for the integration. Fernandez already developed a basic system for volunteer management in 2007 (Fernandez, 2007). The integration of spontaneous volunteers was also specified in an international standard in 2017 (ISO 22319:2017-04). The standard describes various framework requirements that are necessary for the involvement, such as clarifying responsibility and liability, but also identifying tasks, selecting volunteers, and offering appreciation. In Germany, e.g., this was concretized in the research project KUBAS (Sackmann et al., 2018 and Sackmann & Voßschmidt, 2016) in which an IT-based coordination system for spontaneous volunteers was developed. An essential point is the ad-hoc applicability of the system with the possibility of short-term and simple registration of the volunteers, as well as the coordination of these via different communication channels. A graphical interface is available to the responsible persons, through which they can manage the volunteers and tasks depending on the specified objectives. Different approaches to integration are taken up again in the following section (Sackmann et al., 2018 and Sackmann & Voßschmidt, 2016).

SPONTANEOUS VOLUNTEERS IN A CROSS-BORDER CONTEXT

Motivation of spontaneous volunteers

To best of the authors' knowledge, the topic of spontaneous volunteers in cross-border disaster response is not addressed in scientific literature so far. The authors have also found no evidence in the grey literature dealing with relevant events in which spontaneous volunteers became active across national borders. Thus, this article will bring up this notion and highlight its potential by an agent-based simulation. In this section, the argument will be discussed whether the volunteers' motivation to help is influenced by the factual existence of a national border.

There are studies that examine the motivation of spontaneous volunteers. It should be noted, however, that many sources investigate the motivation to help among people who are attached to organizations, but there are also overlaps. The *Volunteer Functions Inventory* is a recognized and verified tool for investigating the motivation of volunteers who are, however, tied to organizations. In total, the inventory consists of six functions that describe the motivation to help. The most frequently mentioned reason for helping is the general desire to help (value function). (Chacón et al., 2017 and Clary et al., 1998) This need is also stated as a strong reason (but not exclusively) for spontaneous volunteers to become active in disasters and was also recognized early on as a motivation for spontaneous volunteers (Lowe & Fothergill, 2003). Other motivating factors are the personal involvement as well as the relationship towards or identification with the victims (Fritz & Mathewson, 1957, p. 43). A study by Barraket et al. (2013) summarizes the results of various studies and breaks down these motivating factors again in a separate survey. First of all, it is described that volunteering is becoming increasingly "agile" (Volunteering Australia, 2012). People are less and less tied to organizations because the commitments seem to be very high. However, the desire to help is still there, which means that an increase in spontaneous volunteers can be expected. Furthermore, the study confirms that the motivation is mainly based on the need to help and on personal contacts with the individuals affected, other volunteers or the locality. The self-therapeutic effect of helping is also described as a reason to become active. Supporting the response activities helps to cope with a shocking event, such as a catastrophe, and to make people feel 'useful'. These reasons are described as internal factors, while external factors are also mentioned, such as geographical proximity, availability in time (e.g. also by closing the workplace due to the disaster) and constant media coverage, as well as the opportunities to help that are communicated in social media. Also cultural influences and social norms are mentioned, which lead to people becoming active as spontaneous volunteers (Barraket et al., 2013).

Border regions have special characteristics. For instance, some national borders have developed from natural borders such as rivers and mountains (Guo, 2015, pp. 4–12). Border regions can also differ considerably in terms of infrastructure, which has led, e.g., to cooperation in civil protection, if on one side of the border there is little or no emergency response infrastructure (Princen et al., 2016). Furthermore, borders have always served inherently as a separation between states and, e.g., also as a means of identification of the population with their own country, which can lead to a situation where borders are also perceived as obstacles (Dahles & van Hees, 2007). Reasons why spontaneous volunteers may be less active across national borders are therefore, on the one hand, due to the specific context, i.e. that a disaster with cross-border implications must first be present. On the other hand, depending on the border region, the motivating factor of the personal involvement or the relationship to or identification with the victim in a border region may also be lower if this is more 'distant' due to a physical barrier, such as a river. In addition, community and social networks across the affected border regions are less established as people may have fewer relatives or acquaintances on the other side of the border. However, this can only apply to a part of the border regions. As Adrot et al. (2018) showed, it is possible that border regions are highly integrated. In this case, borderlands can develop a unique culture which can be rooted even more deeply than the respective national cultures and thus, borderlands can fulfill a connecting function instead of separating nationalities. In addition, the desire to simply want to help is probably not influenced by the mere existence of borders, so that we consider border crossing of volunteers as a relevant factor in future crisis.

Lack of cross-border coordination mechanisms for spontaneous volunteers

There are a few aspects, which should be considered when thinking about the involvement of spontaneous volunteers in a cross-border area. First of all, the definition of spontaneous volunteers might not always be clear in a cross-border setting. For example, Barraket et al. (2013) describe that even the definition of spontaneous volunteers in Australia differs between organizations. For the purpose here, we distinguish between bound and unbound volunteers, where bound volunteers are already part of an organization, either connected to civil protection or in organizations which are not affiliated with civil protection (e.g. sports clubs). Unbound volunteers are not part of any organization but can be pre-registered volunteers in a specific database or spontaneous volunteers in our understanding (deduced from Dynes (1970), see also section before). In the ISO 22319:2017-04 a spontaneous volunteer is described as an "individual who is not affiliated with an existing incident response organization or voluntary organization but who, without extensive preplanning, offers support to the response to, and recovery from, an incident" (ISO 22319:2017-04, p. 1). This definition from the *International Organization for Standardization* is helpful in a cross-border context because it gives a common ground for discussing this subject. A key requirement of the ISO 22319:2017-04 is that the involvement of spontaneous volunteers must be pre-planned and it provides a framework to do that (note: it is not the first or only framework, see e.g. Fernandez (2007)). Interesting in the context of this article and the cross-border context are the following conceptual thoughts. It is possible that individual organizations on different levels can be responsible for the planning or coordination of spontaneous volunteers. These must be identified before a disaster occurs and, based on this, the responsibilities must also be defined. In addition to the acceptance of responsibility, clarification of insurance cover and liability is also necessary. It is important that contact points are established to which the volunteers can turn. It is also emphasized that the communication with the volunteers is essential. Therefore, the appropriate language should be used and technical terms should be avoided. In this context, possible language barriers due to the cross-border nature of the situation are also relevant (ISO 22319:2017-04).

Looking at how the ISO requirements are implemented, one can see, e.g. in Germany, that there are still large gaps. Some organizations have developed plans and tested them (see e.g. research project ENSURE) (Deutsches Rotes Kreuz, 2016, 2017), but these pre-planned mechanisms did not yet come into action. Furthermore, these strategies are most often made by single organizations and it can differ from organization to organization and also from city to city or state to state, how they are implemented or if they are even implemented at all. E.g., in Germany, a platform has been developed that allows organizations to create tasks that are then assigned to volunteers via an app as described in the section before (Sackmann et al., 2018; Sackmann & Voßschmidt, 2016). However, it is still unclear who will manage this platform in the event of a disaster.

Coordination of volunteers is necessary to avoid self-formed parallel structures and to use their potential, as is also postulated by ISO 22319:2017-4. However, there is no reference in the ISO to cross-border coordination. Nevertheless, it can be deduced that the levels at which spontaneous volunteers are coordinated are sometimes unclear and that the organizations coordinating them need still to be defined, which increases the difficulties in a cross-border context. Cross-border issues such as insurance protection and liability may also be of increased relevance. The example of how spontaneous volunteers in Germany have so far been insufficiently taken into account shows that for cross-border coordination, a general framework need to be established clarifying the responsibilities within the countries including the considerations of appropriate strategies across national borders.

The issues described can lead to different scenarios of how spontaneous volunteers become active in cross-border disaster situations, which will be explained and simulated using agent-based modelling in the following section.

Simulation frameworks

As highlighted above, research about spontaneous volunteers covers empirical studies addressing the volunteers' motivation, optimization approaches dealing with task assignment to volunteers regarding their availability, and pre-disaster registration tools to assess volunteers' qualification. Moreover, there already exist some coordination frameworks. Hashemipour et al. (2017) presented a decision support system to "predict response-operation performance and take necessary steps to improve it. These include choosing appropriate coordination methods and task-allocation approaches and training volunteers based on specific job priorities". In 2019, Lindner et al. came up with a framework for disaster volunteers focusing on scenario based information exchange. However, there is no framework especially studying the coordination of spontaneous volunteers across national borders.

Hence, we propose a scenario-based simulation framework to study international coordination of spontaneous volunteers considering cultural impact factors like language barriers or different organizational structures in professional disaster response. The objective of this formalized framework is to highlight the advantages of volunteer management in a cross-border context, given the lack of empirical studies and reliable empirical data. We use an agent-based modelling approach as it allows to study the dynamics resulting from the interaction of individual behavior. In the context of an agent-based modelling, *agents* are able to perform flexible, autonomous

actions in their environment to achieve their design goals (Jennings, 1999). Moreover, agents are discrete individuals following pre-defined behavior rules. They are heterogeneous, adaptive and can interact with others (Macal, 2009), which makes them appropriate to study disaster situations where people need to interact e.g. for the exchange of current information and resources.

Thus, there already exist various agent-based models, which study disasters, for example evacuation procedures. The model by Joo et al. (2013) compares various evacuation strategies for warehouses in the event of a fire and the model of Mas et al. (2012) studies the 2011 Great East Japan Earthquake and models tsunami evacuation. Additionally, the model by Crooks & Wise (2013) is analyzing the Haiti earthquake of January 2010 by using crowdsourced GIS data. To the best of our knowledge, there is no agent-based model simulating the involvement of spontaneous volunteers in official crisis response procedures with regard to a national border.

AGENT-BASED COORDINATION FRAMEWORK FOR STUDYING SPONTANEOUS VOLUNTEERS ACROSS NATIONAL BORDERS

Design

This study considers a border region between two countries, which is hit by a natural disaster at the simulation starting time decreasing the populations' health. The agents acting in the border region classify as affected population who request for help, professional crisis response actors being active in the affected region and spontaneous volunteers arriving from non-affected areas to provide help. Each of these actors is assigned a health status and a stock of essential goods (e.g. food, water etc.), which both are decreasing over time until care is provided. This allows us to distinguish between "simpler" (e.g. provision of food as prevention from turning to bad health conditions) requests of needs which can be carried out by untrained helpers and serious or sophisticated requests (e.g. medical care for agents that are already in bad health conditions) requiring help from professionals.

The affected population has the possibility to communicate their needs by requesting help either from professional crisis response actors via calling the coordination center or to post the requests in a social media group. Each incoming request either in the coordination center or via social media is assigned to an area depending on the requesting actors' location (the areas' decomposition for professionals resembles a chess field and the areas' decomposition of spontaneous volunteers is given in figure 2). The provision of help is done by picking an area and start a search and rescue procedure. It is checked if elderly or other vulnerable people are living in this area and what help they need as well as to provide essentials to the affected population (i.e. fulfill the "simpler" requests). It is to highlight that those areas, which are not covered by the search and rescue procedure of spontaneous volunteers in a coordinated manner, are left to the professionals increasing their already dense workload due to fulfilling the serious requests. Hence, the presented coordination framework quantifies the potential of spontaneous volunteers: The better the distribution of workload is carried out, the better spontaneous volunteers support the crisis response teams by taking responsibility of minor problems and leaving them more capacities for emergencies. The framework compares cooperation in two dimensions: First, the degree of centralization (i.e. involvement of spontaneous volunteers in professional crisis response coordination) and second, the degree of cross-border coordination as shown in the following table.

Table 1. Overview of the considered coordination scenarios

	Separated coordination per country	Cross-border coordination
Decentralized coordination	1: Volunteers in both countries acting on their own (no coordination at all)	2: Spontaneous volunteers of both countries coordinate themselves without involvement in professional crisis response (rather hypothetical, considered for sake of completeness)
Centralized coordination	3: Both countries include spontaneous volunteers separately in their professional crisis response	4: Common coordination of both countries including spontaneous volunteers to their professional crisis responses (perfect coordination)

It is assumed that all volunteers belonging to one social media group decide to provide their help at one hotspot to not destroy the feeling of group affiliation and common sense that is always reported by spontaneous volunteers. Thus, for this simulation we consider groups as homogenous entities. However, the framework also would allow for variations. Initially, all social media groups have their individual set of information while the professionals have one common set of information. The professional crisis response actors and the social media groups are implemented by different strategies to set priorities of response (as seen in table 1). In scenario 1, the uncoordinated scenario, each group of volunteers ranks the area of needs separately by summing up all requests

they received from an area and choose the area of most requests. Then, each individual from the group moves to the chosen area and provides help by a search and rescue procedure without any coordination of the chosen areas (i.e. the areas chosen by the groups are not aligned and may be similar or overlap). In scenario 2, the group-coordination scenario, all social media groups share their information and prioritize the response by summing up the number of received requests over the whole set of information. They choose areas for each group in a way that one group addresses the first area and the other group addresses the second area and so on, beginning at the area with highest priority. Each group starts their search and rescue procedure in the assigned area. As the volunteers would need some time to get to the area, it may happen that the professionals, who work independently, already fulfilled the need when the volunteers arrive. This is improved in Scenario 3, the countrywide-coordination scenario, where spontaneous volunteers are included in the professional crisis response, but for both countries separately. Here, the prioritization is done by the professionals so that adequate needs are addressed and delays are avoided. Scenario 4, the cross-border-coordination scenario, carries out the prioritization by considering the overall setting of professionals and volunteers including both countries.

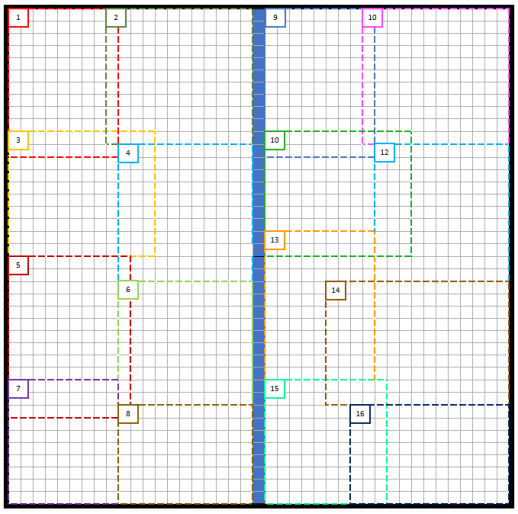

Figure 1. Simulation environment

The agent-based model is implemented using the *Repast Simphony* toolkit. The simulation environment is a matrix modeling a borderland with a river (blue line in figure 2) dividing two neighboring countries. A bridge across the river allows the exchange of resources. A number of 1,000 affected individuals is randomly distributed into this environment so that 500 are in each country. Per country, there exist five groups on social media. Additionally, the number of professionals is chosen for each country, such that they can deal with five areas simultaneously.

The simulation runs in discrete time steps called *ticks* such that 1 tick simulates 15 minutes in real time. The health status of each agent is modelled by an energy variable ranging from 0 to100 and the available resources are given in a stock variable ranging from 0 to 14. Initially, there is a random distribution of energy and each time step it decreases by 1 as long as no care is undertaken. The populations' need of stock is initially modelled by a normal distribution with mean of 2 and variance of 4. This variable is decreasing every 24 ticks by 1. Agents are in good state (do not need any assistance) if their energy level is at least 20 and their stock is at least 3, they need help which can be provided by untrained persons if their energy is at least 20 and their stock is below 3 and help from professionals if their energy falls below 20. In each tick, the affected persons can decide to set up a help request to professionals or a social media group in her or his country. The volunteers associated with the corresponding social media group are receiving the request and decide to provide help along the helping strategies defined in table 1. Similarly, the professionals start their provision of help always in the areas with highest priority. The help is realized by a search and rescue procedure over the chosen area. In detail, a helper (either professional or volunteer) starts in the upper left corner and moves field by field to the lower right corner. If there is an affected person on the current field, the helper supplies it with a fixed amount of essential goods or calls a professional if required by a very low health conditions of the affected person. We assume, that the helpers have enough goods to supply all affected persons in an area. After finishing the search and rescue procedure for one area, the helper takes the next area in their priority queue to provide help. For spontaneous volunteers, this takes some ticks as they need to check their social media accounts and decide for the next area.

Results

The framework *Repast Simphony* allows an integrated parameter tracking over time. Comparing the level of undersupplied persons at simulation duration (i.e. at tick 240), we see that the first scenario leaves a number of 2.1% undersupplied people. This number is reduced by noticeable 57,1% considering the third scenario, where professionals and volunteers cooperate. This highlights the importance of cooperation among professional crisis response actors and spontaneous volunteers in general. Specific in the border area, we see an improvement of 33,3% comparing the first and second scenario. Scenario 4 considers the highest level of coordination and thus, leads – as expected – to the lowest rate of undersupplied persons in the affected region. In this case, 0.8% of affected individuals remain undersupplied, which is a decrease of 11,1% compared to scenario 3 and a decrease of 42,8% compared to scenario 1. Although the improvement from scenario 1 to 2 is smaller than comparing scenario 1 and 3, we see a higher level of resources. If we now consider an asymmetric crisis, i.e. the affected population is not equally distributed in the area, but 90% of affected people concentrate in one country, we see an immense reduction of undersupplied by 56,3% comparing scenario 1 and 2. In addition, the results highlight the importance of self-help capacities in the population. Doubling the initial resources allows for a reduction of 56,3% leaving less than half of the disaster victims undersupplied even in the uncoordinated scenario.

Summarizing, the following table shows the comparison of the four scenarios varying the degree of coordination along the two dimensions: embeddedness in the official crisis response and across the nations. We suspect that the higher variance in scenario 2 results due to a larger set of possible assignments between affected person and helper.

Table 2. Overview of simulation results

	mean of undersupplied persons	standard deviation of undersupplied persons
scenario 1	2,1%	0,2%
Scenario 2	1,4%	0,9%
scenario 3	0,9%	0,3%
scenario 4	0,8%	0,2%

This baseline version focuses on different levels of cooperation. It is characterized by strong assumptions and is therefore not able to take all aspects of borderland coordination procedures into account. However, it yields interesting insights that are worth further considerations and shows the models' potential. In addition to the extensions of the model, the authors also need to address a verification and check of external validity.

Further steps

The ongoing process aims at the implementation of a detailed coordination procedure for professionals involving spontaneous volunteers in case of a natural disaster. Special attention is given to a border context, where several nations need to coordinate their activities. The simulation is based on scenarios (comparison of cooperation in two dimensions: first, between volunteers and professionals aligning their procedures or not; second, between two nations of a borderland working together or separate) without considering data on a specific case study or borderland area. It is supposed to be a general framework studying the impact of varying parameters in a generalized way, but allows to fill data from any disaster situation and borderland. Thus, with an increasing degree of realism, complexity rises so that it is important to up-scale the model simultaneously. For that purpose, a set of refinements and extensions needs to be defined.

- The characteristics of spontaneous volunteers can be captured in a more detailed way by considering individual equipment, skills, abilities, experiences and objectives in order to analyze the resulting dynamics of the complete setting and learning effects for the coordination behavior in reproduced scenarios. Besides the volunteers' abilities, their motivation plays a key role that should be considered, in particular as it may vary over time. The theoretical background is already provided in the section before. However, this is an ongoing work and the implementation is not realized yet.
- As the actors act in a self-determined way according to their assigned characteristics and can be influenced by the actions of other agents, the method of agent-based modelling yields the possibility to distinguish different groups of actors to analyze the intricate interplay between these groups and to

consider learning effects. Thus, in order to detail the coordination procedure, a deeper understanding of the communication and coordination procedures between organizations is also necessary as well as an investigation in the communication processes and information spreading on social media. This simulation is a comparison of collaboration levels and therefore more details about the nature of inter-organizational cooperation and information sharing via social media could improve the findings.

- The diversity and 'real-life'-complexity of the border can be increased with respect to several aspects. On the one hand, the geographical model can be more realistic as *Repast Simphony* allows the integration of maps representing the landscape of a border region. On the other hand, the sociological dimension of the cross-border region as well as legislative and regulatory issues can be addressed in later simulations.

CONCLUSION

Enhancing the understanding of disaster resilience for a cross-border region is a challenging task. In this paper, we gave an overview of spontaneous volunteers in a border region considering their motivation to help as well as regulatory issues and simulated a simplified coordination procedure for the inclusion of spontaneous volunteers in the disaster response process. As there was no consideration of spontaneous volunteers in a border region so far, we started with an outline of problems in several dimensions and set-up a baseline simulation. First insights of coordination procedures with respect to resource improvement hint at a significant potential of cross-border coordination.

The ongoing process aims to establish a coordination framework for spontaneous volunteers in a border region, which is enriched with more coordination-relevant factors such as legislation, organization and practical issues. Following the bottom-up approach, it is quite clear that the baseline version of the model faces a high degree of simplification. This makes the model tractable from the beginning and allows to explain effects in later versions of the model. However, it is an ongoing work, which will be continuously approached to the relevant properties of the cultural and behavioral characteristics of agents as well as the driving factors of the "real" environment. The improvement of model verification and validation will play a key role in future considerations. It is planned to carry out experts' discussion in order to find the most relevant assumptions to be address in later model versions as well as to compare simulation results with experience from the field. Thus, the presented work is embedded in a broader research project called INCA, aiming to establish a decision support framework for improving cross-border area resilience to disasters, which is also complemented by empirical research including surveys, interviews, and experiments.

ACKNOWLEDGMENTS

We gratefully acknowledge funding from the German Research Foundation (DFG-FI 2139/3-1 and DFG-SCHU 1189/13-1) and the French National Agency for Research (ANR-16-CE92-0011-01). We thank the participants of the Upper-Rhine Conference (disaster assistance working group) for their critical reflections on our framework. Many thanks also to Leonhard Möhrle and Philipp Luchner for their programming assistance.

REFERENCES

Adrot A., Fiedrich F., Lotter A., Münzberg T., Rigaud E., Wiens M., Raskob W., Schultmann F. (2018). Challenges in Establishing Cross-Border Resilience. In: Fekete A., Fiedrich A. (eds), Urban Disaster Resilience and Security, Addressing Risks in Societies, Ashgate the urban book series.

Barraket, J., Keast, R., Newton, C. J., Walters, K., & James, E. (2013). Spontaneous Volunteering During Natural Disasters (Working Paper No. No. ACPNS 61). Brisbane, Queensland.

Barsky, L. E., Trainor, J. E., Torres, M. R., & Aguirre, B. E. (2007). Managing volunteers: Fema's Urban Search and Rescue programme and interactions with unaffiliated responders in disaster response. DISASTERS, 31(4), 495–507. https://doi.org/10.1111/j.1467-7717.2007.01021.x

Chacón, F., Gutiérrez, G., Sauto, V., Vecina, M. L., & Pérez, A. (2017). Volunteer Functions Inventory: A systematic review. Psicothema, 29(3), 306–316. https://doi.org/10.7334/psicothema2016.371

Clary, E. G., Snyder, M., Ridge, R. D., Copeland, J., Stukas, A. A., Haugen, J., & Miene, P. (1998). Understanding and assessing the motivations of volunteers: A functional approach. Journal of Personality and Social Psychology, 74(6), 1516–1530. https://doi.org/10.1037/0022-3514.74.6.1516

Crooks A. T., Wise S. (2013). GIS and agent-based models for humanitarian assistance. Computers, Environment and Urban Systems, 41, 100-111.

Dahles, H., & van Hees, E. (2007). Firefighters across frontiers: Two fire brigades cooperating in the Dutch–

German borderland. Culture and Organization, 10(4), 315–328. https://doi.org/10.1080/1475955042000313759

Deutsches Rotes Kreuz (2016). Pilotkonzept für den Einsatz von ungebundenen HelferInnen - Teil 1: Wissenschaftliche Erkenntnisse für eine Fortbildung von Einsatz-, Führungs- und Fachführungskräften (Schriftenreihe der Forschung Band 2). Berlin.

Deutsches Rotes Kreuz (2017). Pilotkonzept für den Einsatz von ungebundenen HelferInnen Teil 2: Wissenschaftliche Erkenntnisse für eine Einweisung ungebundener HelferInnen (Schriftenreihe der Forschung Band 2). Berlin.

Dynes, R. R. (1970). Organized behavior in disaster. The Disaster Research Center Series. Lexington, Massachusetts: Heath Lexington Books.

Fernandez, L. S. (2007). Volunteer management system design and analysis for disaster response and recovery. Ann Arbor: ProQuest, UMI Dissertations Publishing 2007.

Forrest, T. R. (1978). Group Emergence in Disasters. In E. L. Quarantelli (Ed.), Sage studies in international sociology: Vol. 13. Disasters: Theory and research (pp. 105–125). London, Beverly Hills, Calif.: Sage Publications.

Fritz, C. E., & Mathewson, J. H. (1957). Convergence behavior in disasters: A problem in social control. National Research Council (U.S.). Committee on Disaster Studies. Disaster study: Vol. 9. Washington: National Research Council.

Guo, R. (2015). Cross-border management: Theory, method and application. Berlin: Springer. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&AN=935967

Hashemipour, M., Stuban, S. M., & Dever, J. R. (2017). A community-based disaster coordination framework for effective disaster preparedness and response. *Australian Journal of Emergency Management, The*, *32*(2), 41.

Heger, O., & Reuter, C. (2013). IT-basierte Unterstützung virtueller und realer Selbsthilfegemeinschaften in Katastrophenlagen. In R. Alt & B. Franczyk (Eds.), Proceedings of the 11th International Conference on Wirtschaftsinformatik (pp. 1861–1875). Merkur.

ISO 22319:2017-04. Security and resilience - Community resilience - Guidelines for planning the involvement of spontaneous volunteers.

Jennings N. R. (1999). Agent-Oriented Software Engineering. In: Imam I., Kodratoff Y., El-Dessouki A., Ali M. (eds), Multiple Approaches to Intelligent Systems. IEA/AIE 1999. Lecture Notes in Computer Science, vol 1611, Springer.

Jin, Y., Liu, B. F., & Austin, L. L. (2014). Examining the Role of Social Media in Effective Crisis Management: The Effects of Crisis Origin, Information Form, and Source on Publics' Crisis Responses. Communication Research, 41(1), 74–94. https://doi.org/10.1177/0093650211423918

Joo J., Kim N., Wysk R. A., Rothrock L., Son Y. J., Oh Y. G., Lee S. (2013). Agent-based simulation of affordance-based human behaviors in emergency evacuation. *Simulation Modelling Practice and Theory*, 32, 99-115.

Kendra, J. M., & Wachtendorf, T. (2001). Rebel Food … Renegade Supplies. Convergence After The World Trade Center Attack.

Kendra, J. M., & Wachtendorf, T. (2003). RECONSIDERING CONVERGENCE AND CONVERGER LEGITIMACY IN RESPONSE TO THE WORLD TRADE CENTER DISASTER. In L. Clarke (Ed.), Research in Social Problems and Public Policy. Terrorism and Disaster: New Threats, New Ideas (Vol. 11, pp. 97–122). Bingley: Emerald (MCB UP). https://doi.org/10.1016/s0196-1152(03)11007-1

Lindner, S., Sackmann, S., & Betke, H. (2019). Simulating Spontaneous Volunteers: A System Entity Structure for Defining Disaster Scenarios. Proceedings of the Information Systems for Crisis Response and Management (ISCRAM), 516-527.

Lowe, S., & Fothergill, A. (2003). A Need to Help: Emergent Volunteer Behavior after 9/11. Conference Papers - American Sociological Association, 293–314.

Macal C. M., North M. J. (2007) Agent-based modeling and simulation: Desktop ABMS. In: Simulation Conference, 2007 Winter, IEEE, 95-106.

Mas E., Suppasri, A., Imamura, F., & Koshimura, S. (2012) Agent-based simulation of the 2011 great east japan earthquake/tsunami evacuation: An integrated model of tsunami inundation and evacuation. Journal of Natural Disaster Science 34(1), 41-57.

Ocak, T., Duran, A., Özdeş, T., Hocagil, C., & Küçükbayrak, A. (2013). Problems Encountered by Volunteers Assisting the Relief Efforts in Van, Turkey and the Surrounding Earthquake Area. Journal of Academic Emergency Medicine, 12(2), 66–70.

Palen, L., & Liu, S. B. (2007). Citizen Communications in Crisis: Anticipating a Future of ICT-Supported Public Participation. In M. B. Rosson & D. Gilmore (Eds.), CHI'07, Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 727–736). ACM.

Princen, S., Geuijen, K., Candel, J., Folgerts, O., & Hooijer, R. (2016). Establishing cross-border co-operation between professional organizations: Police, fire brigades and emergency health services in Dutch border regions. European Urban and Regional Studies, 23(3), 497–512. https://doi.org/10.1177/0969776414522082

Reuter, C., Heger, O., & Pipek, V. (2013). Combining Real and Virtual Volunteers through Social Media. In T. Comes, F. Fiedrich, Fortier S., Geldermann J., & T. Müller (Chairs), 10th International Conference on Information Systems for Crisis Response and Management, Baden-Baden (Germany).

Reuter, C., Marx, A., & Pipek, V. (2011). Social Software as an Infrastructure for Crisis Management-a Case Study about Current Practice and Potential Usage. In M. A. Santos, L. Sousa, & E. Portela (Chairs), Proceedings of the 8th International Conference on Information Systems for Crisis Response and Management, Lisbon, Portugal.

Rotolo, T., & Berg, J. A. (2011). In Times of Need: An Examination of Emergency Preparedness and Disaster Relief Service Volunteers. Nonprofit and Voluntary Sector Quarterly, 40(4), 740–750. https://doi.org/10.1177/0899764010369179

Sackmann, S., Lindner, S., Gerstmann, S., & Betke, H. (2018). Einbindung ungebundener Helfer in die Bewältigung von Schadensereignissen. In C. Reuter (Ed.), Sicherheitskritische Mensch-Computer-Interaktion: Interaktive Technologien und soziale Medien im Krisen- und Sicherheitsmanagement (pp. 529–549). Wiesbaden: Springer Vieweg.

Sackmann, S., & Voßschmidt, S. (2016). Das Projekt KUBAS: Koordination ungebundener Spontanhelfer. Bevölkerungsschutz. (4), 19–21.

Schorr, C., Biegert, A., Weber, T., Max, M., & Schulze, M. (2014). Die Rolle von ungebundenen HelferInnen bei der Bewältigung von Schadensereignissen - Teil 1: Untersuchung am Beispiel Hochwasser 2013 in Sachsen (Schriften der Sicherheitsforschung). Berlin.

Simsa, R., Rameder, P., Aghamanoukjan, A., & Totter, M. (2019). Spontaneous Volunteering in Social Crises: Self-Organization and Coordination. Nonprofit and Voluntary Sector Quarterly, 48(2_suppl), 103S-122S. https://doi.org/10.1177/0899764018785472

Stallings, R. A., & Quarantelli, E. L. (1985). Emergent citizen groups and emergency management. Public Administration Review, 93–100.

Stewart, K., Glanville, J. L., & Bennett, D. A. (2013). Exploring Spatiotemporal and Social Network Factors in Community Response to a Major Flood Disaster. The Professional Geographer, 66(3), 421–435. https://doi.org/10.1080/00330124.2013.799995

Versluis, A. (2014). Formal and informal material aid following the 2010 Haiti earthquake as reported by camp dwellers. DISASTERS, 38 Suppl 1, S94-109. https://doi.org/10.1111/disa.12050

Volunteering Australia (2012). State of Volunteering in Australia.

Wachtendorf, T., & Kendra, J. M. (2004, November). Considering Convergence, Coordination, and Social Capital in Disasters. Presentation to the Canadian Risk and Hazards Network 1st Annual Symposium, Winnipeg, Manitoba, Canada.