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Katarzyna Sienkiewicz-Małyjurek
Associate Professor, Silesian University of Technology
https://orcid.org/0000-0002-0915-5776

Benefits, challenges, and perspectives of using the blockchain technology in emergency management

Introduction

Blockchain is a decentralized technology based on distributed ledger information in a peer-to-peer network, in which each node includes a copy of a given chain and has access to the complete transaction history without the need for intermediaries.[1] As a result, this technology facilitates the acquisition, storage and transmission of information and ensures its transparency and integrity. It creates new opportunities for joint activities and sharing resources, increasing the possibility of providing public services. For this reason, it is considered one of the most significant technological trends, a global revolution and innovation changing organizational structures and methods of implementing activities.[2] It is not a new technology but a new way of using other advanced technologies.

1 S. Ølnes, J. Ubacht, M. Janssen, "Blockchain in government: Benefits and implications of distributed ledger technology for information sharing", *Government Information Quarterly*, vol. 34, no. 3, 2017, p. 356; C. L'Hermitte, N.-K.C. Nair, "A blockchain-enabled framework for sharing logistics resources during emergency operations", *Disasters*, vol. 45, no. 3, 2021, p. 534.

2 M. Janssen, V. Weerakkody, E. Ismagilova, U. Sivarajah, Z. Irani, "A framework for analysing blockchain technology adoption: Integrating institutional, market and technical factors", *International Journal of Information Management*, vol. 50, 2020, p. 303; F. Lumineau, W. Wang, O. Schilke, "Blockchain governance – A new way of organizing collaborations?", *Organization Science*, vol. 32, no. 2, 2021, p. 500.

Nowadays, blockchain is gaining more and more followers. Researchers and practitioners point to the potential of this technology not only in banking and finance but also in trade, healthcare, insurance, transport, supply chain management, data management, education, voting, public procurement, social assistance, administrative processes and energy market.[3] Increasingly, researchers claim that blockchain can transform public policy and public service activities.[4] However, research on the subject is limited, and blockchain's usefulness is still debatable.[5] The current research on the blockchain is primarily conceptual, focusing on the technical aspects of using this technology.

As a result, more and more attention is being paid to the disadvantages and limitations of blockchain technology. Possible problems result from, among others, the lack of legal regulations defining the scope and manner of using this technology, the lack of specialist knowledge, and limited scalability and compatibility with other systems.[6] Ølnes et al.[7] and Jansen et al.[8] also noted that – as with any other technology – blockchain, in terms of technology, is insufficient to guarantee an increase in the efficiency of operations. Because blockchain is an emerging technology in public governance, there are extensive research needs both in terms of the possibilities and principles of its implementation, as well as its positive and negative effects.

Considering the potential benefits of blockchain implementation, researchers in the field of emergency management are calling for more research on this topic.[9] This technology could have particular importance in this area due to the complex and dispersed nature of emergency management and the growing scale of contemporary threats.[10] It could facilitate decentralized management of activities and thus improve

3 F. Lumineau, W. Wang, O. Schilke, "Blockchain governance ..., *op. cit.,* pp. 501–502; E. Tan, S. Mahula, J. Crompvoets, "Blockchain governance in the public sector: A conceptual framework for public management", *Government Information Quarterly*, vol. 39, no. 1, 2022, 101625, p. 1.

4 D. Tapscott, A. Tapscott, *Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money Business and the World*, New York: Portfolio-Penguin, 2016; D. Cagigas, J. Clifton, D. Diaz-Fuentes, M. Fernández-Gutiérrez, "Blockchain for Public Services: A systematic literature review", *IEEE Access*, vol. 9, 2021, p. 13904.

5 M. Janssen, V. Weerakkody, E. Ismagilova, U. Sivarajah, Z. Irani, *op. cit.*, p. 303; E. Tan, S. Mahula, J. Crompvoets, *op. cit.*, p. 9.

6 D. Cagigas, J. Clifton, D. Diaz-Fuentes, M. Fernández-Gutiérrez, *op. cit.*, p. 13912; E. Toufaily, T. Zalan, S. Ben Dhaou, "A framework of blockchain technology adoption: An investigation of challenges and expected value", *Information and Management*, vol. 58, no. 3, 2021, 103444, pp. 10–11.

7 S. Ølnes, J. Ubacht, M. Janssen, *op. cit.*, p. 356.

8 M. Janssen, V. Weerakkody, E. Ismagilova, U. Sivarajah, Z. Irani, *op. cit.*, p. 308.

9 Y. Wang, H. Chen, "Blockchain: A potential technology to improve the performance of collaborative emergency management with multi-agent participation", *International Journal of Disaster Risk Reduction*, vol. 72, 2022, 102867, pp. 3–5.

10 D. Marciniak, "The supportive role of non-governmental organisations in sustainable emergency management: The case of Poland", *International Journal of Emergency Management* [forthcom-

direct response to threats. However, there is still a lack of conceptual research and results from the practical implementations of this technology.[11] Therefore, this article aim is to understand blockchain technology's benefits, challenges, and usefulness in emergency management based on previous research and experience in this field.

Research methodology

Although there are examples of blockchain's use in public governance, they are limited, and they were implemented in a short period. Primarily, it is not a well-established research area in emergency management. For this reason, it was decided to use the critical review method in this article.

Generally, "literature reviews are essential to advance the knowledge and understand the breadth of the research on a topic of interest, synthesize the empirical evidence, develop theories or provide a conceptual background for subsequent research, and identify the topics or research domains that require more investigation".[12] Critical reviews are beneficial for analyzing emerging research areas. Although they are interpretative and the selection of sources is often discretionary, their role is to inform and initially outline specific initial research problems.[13] Moreover, critical reviews are not only a synthesis of the existing knowledge, but they analyze it leading to the establishment of propositions or models, which are the starting point for further research.[14]

In the case of this article, the research problem is the question: What are the benefits, challenges, and usefulness of blockchain technology in emergency management processes? Searching for an answer to this research question, a critical review of the characteristics of blockchain technology in emergency management was conducted (Figure 1).

The first step of the research process involves identifying the reasons for implementing blockchain technology in emergency management. Next, analyses of the benefits and challenges of this technology based on the critical review of emergency management theory and blockchain characteristics are conducted. In line with the adopted methodology, propositions and recommendations for theory and practice are established from the conducted critical review.

ing]; K. Sienkiewicz-Małyjurek, "Specyfika łańcucha dostaw w procesie zarządzania kryzysowego", *Zeszyty Naukowe Politechniki Śląskiej. Organizacja i Zarządzanie*, vol. 70, 2014, p. 427.

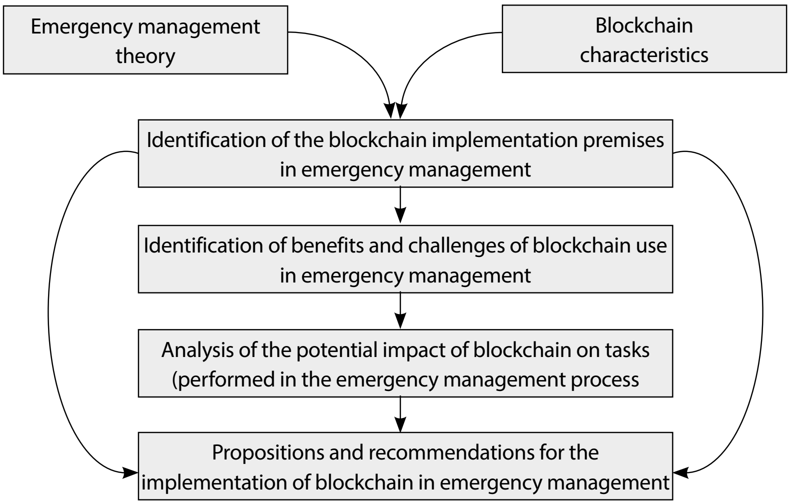
11 C. L'Hermitte, N.-K.C. Nair, *op. cit*., p. 546; Y. Wang, H. Chen, *op. cit.*, p. 3.

12 G. Paré, M.-C. Trudel, M. Jaana, S. Kitsiou, "Synthesizing information systems knowledge: A typology of literature reviews" *Information and Management*, vol. 52, no. 2, 2015, p. 183.

13 M.J. Grant, A. Booth, "A typology of reviews: An analysis of 14 review types and associated methodologies", *Health Information and Libraries Journal*, vol. 26, no. 2, 2009, p. 93; H.M. Cooper, "Organizing knowledge syntheses: A taxonomy of literature reviews", *Knowledge in Society*, vol. 1 no. 1, 1988, pp. 120–121.

14 G. Paré, M.-C. Trudel, M. Jaana, S. Kitsiou, *op. cit*., p. 189; M.J. Grant, A. Booth, *op. cit.*, p. 93.

Figure 1. Research framework



Source: author's own elaboration.

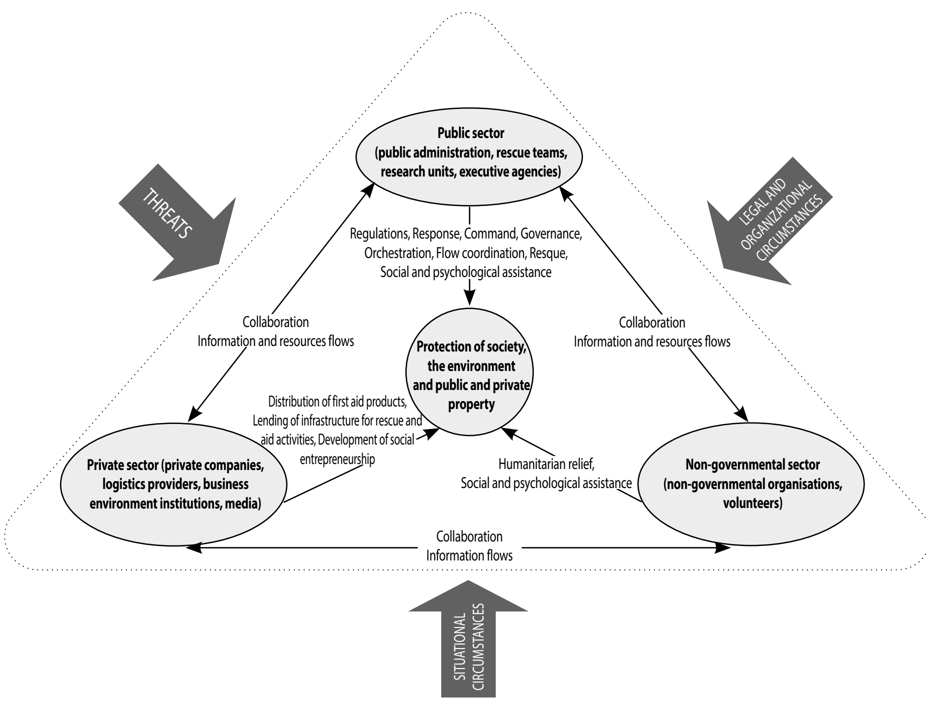
Complexity of emergency management

The nature of emergency management is complex. Activities in this field are implemented by many autonomous actors from all sectors and take place at all state levels. Tasks between public units have been divided according to the statutory competencies of individual organizations in order to ensure collaboration and complementarity of activities.[15] The orchestrators are the relevant public administration bodies, but blue light organizations (police, fire brigade, emergency medical services) play a key role in direct response. Their activities are complemented by other organizations, crucial in a given situation, such as the Building Supervision Inspection, Border Guard, Epidemiological Station, and Gas Emergency. Although public administration bodies are responsible for the entirety of emergency management activities, the participation of organizations from other sectors is also necessary, e.g. to provide a fleet of vehicles for evacuation purposes and other infrastructure to provide temporary accommodation for victims, inform the public about threats and interventions taken, or to obtain additional necessities, e.g. food, clothing, hygiene products. For this reason, actors such as private companies, the media or Red Cross

[15] A. Chodyński, "Sieciowość w zarządzaniu bezpieczeństwem na poziomie regionalnym i lokalnym", *Bezpieczeństwo. Teoria i Praktyka*, vol. 14, no. 1, 2014, p. 19; B. Kożuch, K. Sienkiewicz-Małyjurek, "Mapowanie procesów współpracy międzyorganizacyjnej na przykładzie działań realizowanych w bezpieczeństwie publicznym", *Zarządzanie Publiczne*, no. (3) 31, 2015, pp. 242–243.

and Caritas play an essential role.[16] Therefore, emergency management is collaboration-based, depending on the type of emergency. In each case, even when the same threat occurs, the actions are different because a given emergency occurs in a different place and time, and other people and entities are at risk. As a result, each emergency requires an individual approach. Additionally, threats can accumulate and cascade. The complexity of emergency management is illustrated in Figure 2.

Figure 2. The complexity of emergency management



Source: author's own elaboration.

The structure and flows in emergency management, presented in Figure 2, illustrate its interoperable nature. Protection of society, environment and property requires combining the competencies of organizations from various sectors, reliable and up-to-date information and effective flow of resources. Moreover, emergency management covers both activities before, during and after an emergency. During stabilization, even before the symptoms of an emergency appear, it is possible to plan and prepare activities and resources appropriately. At this time, it is possible to conclude partnership agreements and contracts with private organizations. Actions taken at

16 D. Marciniak, "Podstawowe problemy wpływające na logistyczne uwarunkowania zarządzania kryzysowego", *Bezpieczeństwo. Teoria i Praktyka*, no. 4, 2020, pp. 111–112; K. Sienkiewicz-Małyjurek, "Specyfika łańcucha dostaw...", *op. cit.*, p. 428.

this time aim to mitigate and prepare for possible threats. The entities participating in actions must mobilize quickly and flexibly react to changes. After the end of an emergency, in the reconstruction phase, there is a gathering of resources to bounce back and even obtain a higher level of resilience and preparation for future threats. This complexity pushes researchers to search for ways to increase the effectiveness of emergency management, and many researchers have high hopes for blockchain.[17]

Benefits and challenges of blockchain technology in emergency management

Blockchain is a "secure public ledger platform shared by all parties through the Internet or an alternative distributed network of computers".[18] It consists of a series of encrypted blocks based on distributed ledger technology, in which data is stored along with the date and links to related blocks.[19] New data, after being entered into the distributed ledger, and all modifications are subject to verification and approval by the entities in the chain. Unconfirmed data is blocked, thus minimizing the risk of introducing false data, unwanted changes, hacking or phishing. All activities in blockchain are also easy to trace for its participants. In addition, the verification and approval of transactions that meet the requirements occur through smart contracts, which are self-executing computer codes that force blockchain users to behave according to the arrangements because different behaviours are not confirmed and accepted.[20] Key blockchain-specific features relevant to emergency management include:[21]

– data security resulting from immutability or verified modification of stored data and transaction sharing; only authorized participants can add, modify, and approve data; in emergency management, this feature replaces the need for inter-organizational trust with data verification and interaction mechanisms;
– transparency on the ability to store and share information with all authorized parties on an open-access basis, where each participant is responsible for their actions and all transactions are digitally signed; this is beneficial for joint decision-making and setting up operational procedures in emergency management;
– decentralization equalizing rights and obligations in the chain and eliminating domination in decision-making processes and central coordination; this

[17] Y. Wang, H. Chen, *op. cit.*, p. 4.

[18] M. Pilkington, Blockchain technology: Principles and applications, [in:] *Research handbook on digital transformations*, eds. F.X. Olleros, M. Zhegu, Cheltenham: Edward Elgar Publishing, 2016, p. 231.

[19] Y. Wang, H. Chen, *op. cit.*, p. 3; E. Tan, S. Mahula, J. Crompvoets, *op. cit.*, p. 2; E. Toufaily, T. Zalan, S. Ben Dhaou, *op. cit.*, pp. 1–2.

[20] F. Lumineau, W. Wang, O. Schilke, *op. cit.*, p. 2.

[21] E. Toufaily, T. Zalan, S. Ben Dhaou, *op. cit.*, p. 3; Y. Wang, H. Chen, *op. cit.*, pp. 7–8; F. Lumineau, W. Wang, O. Schilke, *op. cit.*, p. 2.

possibility builds the adaptability of the emergency management network thanks to the spontaneous and quick reaction of individual blocks to threats.

In addition, there are three types of blockchain: public, alliance, and private.[22] The entire society has access to the public blockchain and only a narrow group of participants to the private. By contrast, the alliance blockchain is mixed and seems to be the best solution for multi-agent, joint emergency management from an interoperability perspective. In the case of focusing strictly on communication with the public and co-creation of public value, public blockchain should be more applicable. As a result, the choice of the type of blockchain depends on the purpose of its implementation. Nevertheless, each type is assumed to create conditions for effective inter-organizational and intersectoral collaboration. The main benefits of blockchain and their potential impact on emergency management contains:[23]

1. Collaboration reliability: reducing opportunities for opportunistic behaviour and limited rationality in elections and decision-making, leading to the implementation of actions as agreed; activities are carried out after approval by authorized participants;
2. Facilitating coordination: improving the division of rights, tasks and roles thanks to standard administrative documents and the direct possibility of implementing processes; using blockchain means accepting the established rules and automating them;
3. Communication improvement: equal access to transparent and verified information in real-time thanks to decentralization, openness and collective supervision of this information; the consensus mechanism improves credibility and reduces the dissemination of false information;
4. Ensuring trust: limiting the traditional approach to inter-organizational trust thanks to consensus and sequential recording of information; in blockchain, each participant has equal access to information that is located in secure, shared transaction records, where changes cannot be made without the approval of other authorized participants;
5. Safety of data: the need to verify new data and the changes introduced in it reduces the risk of manipulation of this data; decentralization, the use of multiple databases and authorization of access to them guarantee the integrity of information, reducing the likelihood of security breaches;

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22 Y. Wang, H. Chen, *op. cit.*, p. 9.

23 D. Cagigas, J. Clifton, D. Diaz-Fuentes, M. Fernández-Gutiérrez, *op. cit.*, pp. 13912–13914; V. Chamola, V. Hassija, V. Gupta, M. Guizani, "A comprehensive review of the COVID-19 pandemic and the role of IoT, drones, AI, blockchain, and 5G in managing its impact", *IEEE Access*, vol. 8, 2020, p. 90245; C. L'Hermitte, N.-K.C. Nair, *op. cit*., p. 536; Y. Wang, H. Chen, *op. cit.*, p. 9*;* F. Lumineau, W. Wang, O. Schilke, *op. cit*., p. 508; S. Ølnes, J. Ubacht, M. Janssen, *op. cit.*, pp. 359–360*;* E. Tan, S. Mahula, J. Crompvoets, *op. cit*., pp. 4–8.

6. Task automation: automated contract execution as agreed simplifies processes and reduces bureaucracy and flaws;
7. Transaction transparency: access to data and transaction history tracking open to participants allows for identification of all necessary information for participants at a given moment and creates responsibility for tasks.

Blockchain can affect the effectiveness of collaborative emergency management by facilitating the management of joint activities and optimizing the technical aspects of collaboration. The possibilities offered by this technology may be of significant importance in emergency management, as they may allow to improve the division of tasks, ensure equal access to current information, and simplify ongoing processes. However, blockchain is new technology if we consider its use in emergency management. The experience with the use of this technology shows that thanks to decentralization, operational transparency and data security, it has the potential to effectively manage complex situations in which many independent entities from various sectors are involved. For this reason, it is assumed that using blockchain on a large scale will be a breakthrough in collaboration. However, this assumption is still not fully empirically verified, and it has not been verified whether the expectations for blockchain are overstated.[24] It is also not recognized what the nature of the changes caused by blockchain implementation will be. However, it was noted that trust depends on the institutional solutions used and not on the blockchain technology itself, which only supports the proper course of processes and their control but does not guarantee the reliability of the information entered.[25] As a result, implementing and adequately using blockchain will be easier for countries with higher-quality institutional and legal solutions and highly qualified staff. Such challenges mean that more and more researchers pay attention to the problems and limitations related to the use of this technology. They include:[26]

1. No legal regulations: Problems may be related to the scope of blockchain use in emergency management and the information that can be made available as part of this technology. Without appropriate policies and procedures, participants of collaborative emergency management will not know the transparent rules of using blockchain and will not fully use it, or vice versa – they may exceed applicable regulations.
2. The potential concentration of power in the hands of a small group of people: Specialized knowledge is required to manage blockchain processes, and people supervising this technology can dictate how it is used and modify codes and rules.

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24 F. Lumineau, W. Wang, O. Schilke, *op. cit*., p. 514; Y. Wang, H. Chen, *op. cit.*, p. 11.

25 S. Ølnes, J. Ubacht, M. Janssen, *op. cit.*, p. 362*;* D. Cagigas, J. Clifton, D. Diaz-Fuentes, M. Fernández-Gutiérrez, *op. cit.*, p. 13915.

26 D. Cagigas, J. Clifton, D. Diaz-Fuentes, M. Fernández-Gutiérrez, *op. cit.*, pp. 13912–13915; M. Janssen, V. Weerakkody, E. Ismagilova, U. Sivarajah, Z. Irani, *op. cit.*, p. 306*;*. F. Lumineau, W. Wang, O. Schilke*, op. cit*., pp. 509–511; E. Tan, S. Mahula, J. Crompvoets, *op. cit*., pp. 4–8.

Therefore, there is a risk of limiting decentralization in operations and decision-making, which may result in top-down control.

3. Lack of awareness and knowledge: Many people still associate blockchain with only Bitcoin and criminal activities. In addition, few people know how to use it. In emergency management, implementing blockchain would require the involvement of decision-makers and users and their appropriate training; it is related to economic and social limitations.
4. Economic and social costs: Like any technology, blockchain requires investment in technical measures and the integration of distributed systems, as well as training the people who will use it. In emergency management, collaboration is not only inter-institutional, as private sector organizations and non-governmental organizations, the media, and the public also participate in the activities. The solution could be to implement blockchain in the first place in order to facilitate inter-institutional collaboration (private chain) and then its gradual extension to other sectors (alliance chain). Another solution could be to implement a public chain for communicating with the public and building social responsibility in emergency management in the first place.
5. Replacing people's work with automated processes: There is a view that easy and repetitive work will be automated thanks to blockchain implementation. However, the specificity of emergency management makes each situation unique and requires an individual approach. Moreover, actions taken in this area require continuous, ongoing decision-making, adequate to the situation. Therefore, at present, this threat does not seem to be significant. It is possible that after integrating blockchain with artificial intelligence, there will be prospects of replacing human work with machines, which in dangerous conditions may have a positive meaning.
6. It is not possible to verify the authenticity of the entered information: The quality of the data entered into the blockchain depends on the participants of that chain. The technology itself only facilitates the flow of processes based on existing information. If the entered data is inaccurate, incomplete or false, it will have a critical impact on the course of emergency management activities. This threat also makes people realize that it is impossible to replace trust with blockchain technology completely. Parties must trust the information entered into the chain, its nodes, and those who manage this technology.
7. Inability to codify tacit knowledge: Along with the increase in the tacitness of data, the possibility of its codification decreases. This limitation is a significant challenge in emergency management because a large part of the activities in this area is based on experience and is tacit knowledge. The situational uniqueness of emergency management also limits the possibility of codifying knowledge because there are many factors influencing decision-making in a given situation, and not all of them can be codified.

8. Not fully resilience to attacks: It is not possible to eliminate the vulnerability to attacks completely. In addition, decentralization may lead to additional weak links in the chain. In emergency management, such problems can limit the interoperability between participants in a private blockchain. In a public blockchain, attacks can cause information chaos.
9. Scalability limitation: Blockchain is limited by the scale and speed at which it can process transactions. It takes time to place data and verify it between nodes, which increases as the number of validating links increases. Additionally, their propagation speed decreases as the blocks' size increases. In the response phase of emergency management, units need to process a huge amount of information per second.
10. Limited possibilities of blockchain integration with legacy technologies: An interoperable infrastructure is needed for blockchain functionality. Technologies implemented in an earlier period may not be compatible and may need to be adjusted accordingly to ensure their interoperability. In emergency management, each unit uses its own operating system, and not all of these systems are always compatible. However, it is also possible to implement blockchain with incomplete functionality, to perform specific functions, e.g. communication with the society and co-creation of public value in the form of a public chain or in the form of an alliance or private chain for joint decision-making, communication and information transfer.

Although blockchain can significantly improve inter-organizational activities in emergency management, the problems that may arise during its use force units to think about its effectiveness. The benefits listed earlier indicate that blockchain can improve operations and reduce problems resulting from the complexity of emergency management. On the other hand, many challenges may limit potential benefits. For this reason, it is worth noting that blockchain requires appropriate management by competent people and institutional and social embedding.[27]

Blockchain in the emergency management process

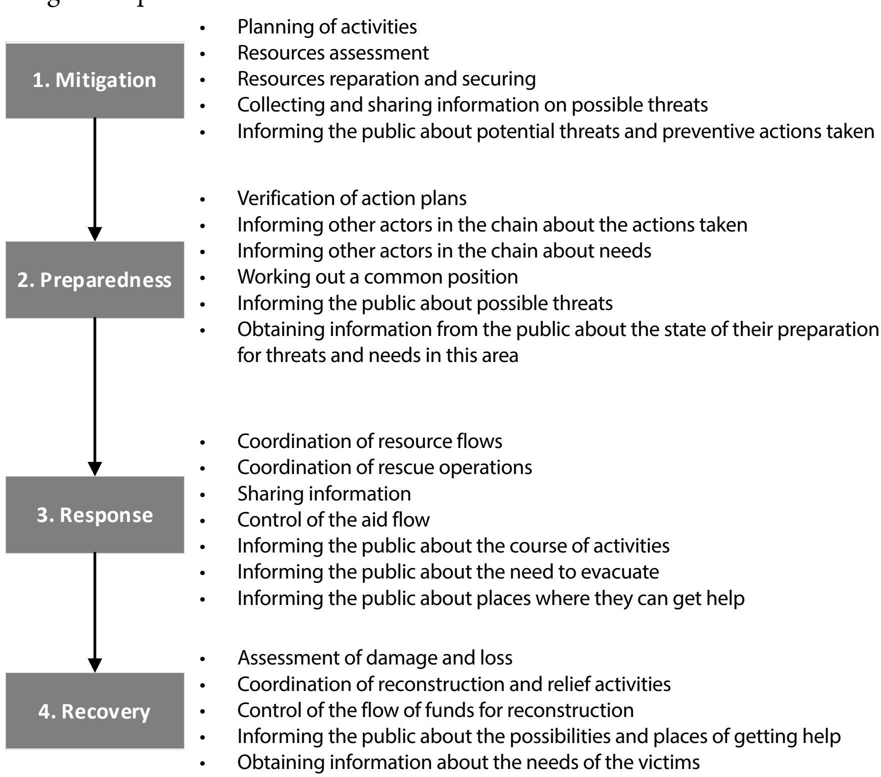
The possibilities of using blockchain in emergency management are broad, ranging from sharing information to planning and supporting the implementation of complex projects. Wang and Chen[28] believe this system can be helpful in communication and emergency resource management. For example, the World Food Program (WFP) used blockchain to deliver coupons to Syrian refugees.[29] The technology has also found application in tracking and obtaining reliable real-time informa-

[27] S. Ølnes, J. Ubacht, M. Janssen, *op. cit.*, p. 360.
[28] Wang, H. Chen, *op. cit.*, p. 10.
[29] F. Lumineau, W. Wang, O. Schilke, *op. cit.*, p. 515.

tion on the spread of the COVID-19 virus, coordinating clinical trials for vaccines and drugs, and raising funds for research and the fight against the virus.[30] Ølnes et al.[31] also indicate the usefulness of blockchain in managing mass events that require the cooperation of event organizers with city authorities, blue light organizations, private security companies, building managers, etc. Due to the significant utility of blockchain in managing distributed data, this technology can also be used to manage critical infrastructure. It can help track changes in protecting this infrastructure and spread information about emerging threats.

As seen from the above examples, there are many possibilities for using blockchain, but they depend on the phase of emergency management and the specificity of a given threat. Examples of blockchain technology's usefulness in the emergency management process are presented in Figure 3.

Figure 3. Examples of blockchain technology's usefulness in the emergency management process



Source: author's own elaboration.

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[30] H. Wang, "Public health emergency decision-making and management system sound research using rough set attribute reduction and blockchain", *Scientific Reports*, vol. 12, no. 1, 2022, 3600, p. 10.

[31] S. Ølnes, J. Ubacht, M. Janssen, *op. cit.*, p. 357.

In the mitigation phase, thanks to obtaining reliable data from many dispersed sources, blockchain can facilitate the preparation of actions adequate to real threats. It can also favour the creation of decentralized working teams enabling direct and immediate reaction to emerging threats. Blockchain is also significant in the preparedness phase in improving communication, mobilizing resources, and alerting society. Thanks to its use, local societies can not only prepare for threats but also mobilize to participate, e.g. in the form of volunteering. In the response phase, thanks to the automation and simplification of procedures, blockchain can create opportunities to eliminate duplication of activities and allow access to information about currently performed tasks, thus facilitating their coordination. However, due to the dynamics of changes and time pressure, blockchain limitations related to scalability must also be considered. This bottleneck may be important because lack of time is the norm in the response phase. Waiting for data to be sent and verified may further delay decision-making and action implementation processes. In the recovery phase, blockchain can facilitate coordination and control of resource flows. It is the longest phase of emergency management, carried out under less time pressure than the response phase. For this reason, the limitation of scalability will not have such a significant impact on the actions taken. The key utility of blockchain in the recovery phase may include gathering and managing information and resources from multiple dispersed sources to ensure adequate recovery, as well as helping the society to obtain aid.

Conclusion

Blockchain still requires intensive research. It offers great benefits in emergency management but also brings challenges that need to be solved. Moreover, the readiness of the government to reduce its role and decentralize emergency management has great importance. The technical ability to guarantee safe transactions cannot be overestimated either. These parameters are essential because, after deciding to implement blockchain, the government should choose the type of blockchain and to what extent it should be implemented. This technology will not have the expected functionality if central control is maintained. Analyses conducted in this article lead to three main propositions requiring empirical verification:

1. Blockchain can significantly improve communication processes in emergency management, both between organizations involved in conducting activities and with the society, if its full functionality is ensured.
2. By ensuring transparency and decentralization of decision-making processes, blockchain can increase the efficiency of operational processes, including managing mass events and critical infrastructure, as well as conducting rescue, evacuation and humanitarian aid activities.

3. In the longer term, public blockchain may also contribute to increasing the effectiveness of the process of co-creating public value in emergency management by increasing the level of public involvement in activities in this area.

In addition, the analysis carried out allows the following recommendations to be formulated:

1. There is a need to create a legal basis enabling the use and governance of blockchain in emergency management.
2. It is advisable to carry out an analysis of case studies of the use of blockchain in emergency management in order to identify good practices.
3. It is necessary to develop human resources in the use and management of blockchain.
4. It is advisable to prepare projects for the implementation and use of blockchain in individual phases of emergency management and even in the entire process.
5. It is necessary to develop reliable technical solutions to minimize the risk of introducing false information and data loss and increase the scalability and the possibility of blockchain integration with other systems.

The above recommendations result from the fact that blockchain needs appropriate management, adapted to the context in which it will be used. Adequate knowledge about the functionality of this technology and how to use it is necessary to ensure this requirement. Otherwise, the blockchain may not be used at all. The threats are also related to using the blockchain, including the possibility of failure occurrence, management of sensitive data, and technological alienation. For this reason, it is necessary to ensure appropriate legal regulations and organizational framework allowing full and transparent implementation of processes. Blockchain is a very prospective technology that can significantly improve emergency management processes; however, in the first place, it requires appropriate organization and embedding in the existing conditions.

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Benefits, challenges, and perspectives of using the blockchain technology in emergency management
Abstract

The potential of blockchain causes more researchers to postulate this technology's use in public governance. Due to the specificity and complexity of emergency management, blockchain may have particular importance in this area. On the other hand, there are many challenges related to the implementation and use of this technology. Therefore, this article aim is to understand blockchain technology's benefits, challenges, and usefulness in emergency management based on previous research and experience in this field. The perspectives and challenges of using blockchain were analyzed based on the complexity of emergency management. As a result, this article presents how blockchain can contribute to the improvement of emergency management processes.

Key words: blockchain, emergency management, complexity, threats, technology