

Strengthening Organisational Resilience Through Knowledge Management: The Santa Catarina's Civil Defence Case

Carlos Eduardo de Lima¹, Denilson Sell¹ and Regina Panceri²

¹State University of Santa Catarina, Florianopolis, Brazil

²Santa Catarina's Civil Defence, Florianopolis, Brazil

cadulima@gmail.com

denilsonsell@gmail.com

reginapanceri@gmail.com

Abstract: The constant changes in the political, social, and economic scenarios, as well as recent major crises and natural disasters that have affected Santa Catarina, Brazil, and the world, have increased the demand for organisations to provide more resilient responses. Civil Defence organisations are no exception, and they must prioritise the identification and management of critical knowledge to enhance their organisational resilience. In light of this, a case study was carried out in Santa Catarina's Civil Defence (SCCD), a public government organisation that plays a critical role in the territorial resilience of SC state. The study aimed to evaluate SCCD's organisational resilience and develop a continuous improvement plan based on critical knowledge. To achieve this, the Resilience Analysis Grid (RAG) was used as a tool to characterise the SCCD's resilience potential. The analysis showed that the organisation has an appropriate level of resilience potential. However, to identify ways to enhance this potential, it was necessary to analyse critical knowledge for monitoring, anticipating and responding to unexpected events, as well as exploring how SCCD promotes learning in the face of new situations. To do so, a framework was used to analyse critical knowledge to organisational resilience capabilities. This framework was used to present an improvement plan for the organisation's resilience potential, based on the use of techniques and methods for knowledge management. The plan recommended several practical steps that could be taken to enhance the resilience of the SCCD, including the creation of a knowledge management system, the development of training programmes, and the identification and management of critical knowledge. In conclusion, the study highlighted the importance of critical knowledge in enhancing organisational resilience and demonstrated that a continuous improvement plan based on critical knowledge could lead to significant improvements in the resilience of organisations like the SCCD. By following the study's recommendations, organisations can become better equipped to respond to future challenges and maintain their resilience in the face of change and uncertainty.

Keywords: Organisational resilience, Critical knowledge, Knowledge management, Risk and disaster management, Civil defence

1. Introduction

Climate change and the increasing frequency of natural disasters have highlighted the need for organisations, particularly those involved in disaster management, to enhance their resilience capabilities. This is especially crucial for public defence organisations like the Santa Catarina Civil Defence (SCCD) in Brazil, which play a critical role in ensuring the safety and resilience of communities in the face of various risks and disasters.

Santa Catarina, being the second most affected state in Brazil by natural disasters, has experienced significant financial losses amounting to billions of reais. In light of these challenges, it is imperative for SCCD to strengthen its resilience potential and improve its capacity to respond swiftly and effectively to unexpected events. However, traditional approaches and methods are no longer sufficient to address the complex and unpredictable nature of disasters.

In response to this need, this study aims to investigate how knowledge management can contribute to strengthening the organisational resilience of SCCD. By focusing on the identification and management of critical knowledge, the study seeks to enhance SCCD's ability to anticipate, monitor, respond to, and learn from unexpected events. To achieve this, a case study approach was employed, with SCCD serving as the research subject due to its significant role in the territorial resilience of Santa Catarina.

The research objectives include evaluating SCCD's current organisational resilience and developing a comprehensive improvement plan based on critical knowledge management techniques. The study employs the Resilience Analysis Grid (RAG), a tool developed by Hollnagel (2010), to assess SCCD's resilience potential across four core dimensions: response, anticipation, monitoring, and learning. Additionally, Fraga's (2019) framework for analyzing critical knowledge resources is used to identify areas where knowledge management practices can be implemented to enhance SCCD's resilience capabilities.

The findings of this research have practical implications for public defence organisations like SCCD, as well as for the broader field of disaster management. By adopting effective knowledge management strategies,

organisations can improve their resilience potential, enhance their ability to protect communities, and respond more effectively to future challenges and uncertainties. Furthermore, this study contributes to the scientific understanding of how knowledge management can be leveraged to strengthen organisational resilience in the context of risk and disaster management.

To further validate and expand upon the findings of this study, future research could apply the proposed framework and methodologies to other public defence organisations. This would allow for a more comprehensive evaluation and comparison of resilience potential across different contexts, leading to the development of tailored knowledge management strategies to enhance organisational resilience in diverse risk and disaster management scenarios.

2. Theoretical Foundation

2.1 Fundamentals of Organisational Resilience

According to Fraga, Varvakis and Sell (2019), given the complexity of organisations and their intensive knowledge processes, research in multidisciplinary areas that seek to understand better these environments, such as the area of organisational resilience, is necessary.

Lee, Vargo and Seville (2013) state that the ability of organisations to continue to operate and provide goods, services, and jobs is fundamental to the ability of communities to be resilient. "However, the task of building more resilient organisations is complicated by the inability to translate the concept of resilience into tangible work constructions for organisations" (McManus et al., 2007).

When resilience became part of safety discussions, it was defined as "the intrinsic capacity of an organisation (system) to maintain or recover a dynamically stable state that allows it to continue operations after a major accident and/or in the presence of continuous stress" (Hollnagel, 2006). However, Beauchamp et al (2019) highlight that like the concept of human well-being, resilience is complex and multidimensional, often linked to desirable impacts on development.

Resilience is a multifaceted concept with overlapping dimensions, including robustness, fault tolerance, flexibility, survivability, and agility. Definitions and interpretations vary across fields, but all agree that resilience is critical for thriving in the face of adversity. (Hosseini, Barker and Ramirez-Marquez, 2016). Currently, several disciplinary perspectives operate in many domains of application of the resilience concept. These different perspectives have led to the construction of numerous organisational resilience models.

McManus et al. (2007) states that organisational resilience requires three main qualities: self-awareness, effective vulnerability management, and adaptability to new and unforeseen circumstances. The concept of resilience as a measurable property of a system or organisation is emphasized by Hollnagel and Nemeth (2021). According to Hollnagel (2010), resilience is something that an organisation does, rather than something that it possesses. In this sense, Hollnagel (2010) proposes the RAG tool for assessing the degree of resilience of an organisation based on four main abilities, including the ability to respond, anticipate, monitor, and learn (Figure 1).

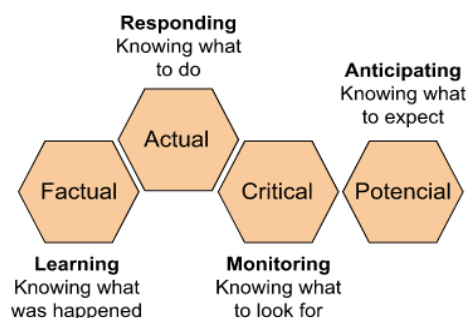


Figure 1: The four Core Capabilities of Organisational Resilience. Source: Hollnagel (2010).

Fraga (2019) states that, to be resilient, an organisation needs to be capable of working on these four basic and essential practical abilities and highlight that an organisation's ability to recover and adapt to unexpected events is a measurable quality of resilience (Hollnagel, 2010; Fraga, 2019; Hollnagel and Nemeth, 2021).

2.2 Knowledge as a Critical Factor for Resilience Potential

Knowledge is the combination of information with experience, context, interpretation, and reflection, which is applied in relevant decisions and actions. In this sense, Choo (2003) emphasizes the integration of meaning creation, knowledge construction and decision-making processes in organisations with a knowledge focus.

Fraga (2019) highlights that organisations need to be aware of their knowledge assets to achieve precise and objective management. However, the growing volume of raw data makes managing these assets an even greater challenge. Therefore, the use of tools to transform them into useful information is essential.

As emphasized by Nonaka and Takeuchi (1998), Hollnagel (2006), and Fraga (2019), knowledge is a critical factor in increasing organisational resilience. To achieve this, Neaga (2010) proposes the use of knowledge accelerators to develop resilience in uncertain and complex environments, while Albuquerque (2020) highlights the importance of a tool for all phases of organisational resilience.

Van de Walle (2014) observes that public sector organisations tend to rely on traditional recipes of organisational reform that result in new types of formalism. However, making knowledge accessible is essential to ensure sustainability and transfer of knowledge to all. Knowledge management is therefore fundamental for organisations working with risk and disaster management, as demonstrated by CEPED/UFSC (2016), which presented a systemic approach to civil protection and defence actions, represented in the operation cycle (Figure 2).



Figure 2: Cycle of civil defence's operation. Source: CEPED/UFSC (2016) translated by authors.

Hollnagel and Woods (2006) argue that to achieve resilient performance, constant updates of knowledge, skills and resources must be available to all members of an organisation. Thus, Fraga (2019) proposes a framework for analysing critical knowledge resources related to resilience capabilities, adapting the Critical Knowledge Factors (CKF) model developed by the Paris Knowledge Management Club in 2000 to include knowledge criticality factors (Figure 3).

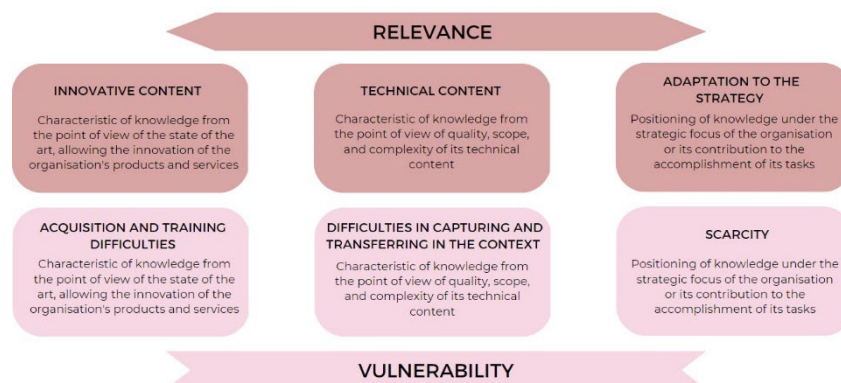


Figure 3: Factors of Knowledge Criticality. Source: Fraga (2019) Adapted by Authors

Therefore, based on the literature review, the theoretical analysis units were adapted and complemented with RDM elements (prevention and mitigation, preparedness, response, and recovery) in order to highlight the importance of knowledge as a catalyst for organisational resilience. Organisations must understand knowledge as something critical to monitor, anticipate, respond to, and learn from (Fraga, 2019) and overcome the challenge of identifying tacit or complex knowledge to apply it in their strategies and tasks.

3. Method

This research used the concept of resilience of Hollnagel (2010) as the ability of an organisation to recover and adapt to unexpected events through its capacities to respond, to monitor, to anticipate, and to learn. Furthermore, the study assumed, following Fraga (2019) and Nemeth and Hollnagel (2022), that the quality of resilience can be measured and improved.

In that regard, Fraga's (2019) framework (Figure 4) is positioned as a practical tool for identifying and analysing critical knowledge from the perspective of resilience capabilities, with the objective of enabling specific actions related to knowledge management that can contribute to organisational learning and performance. Consequently, the framework was selected as a tool for this research, with adaptations made to suit the phases of RDM. The framework of Fraga (2019) consists of four phases, each of which includes further subdivided stages that may be adapted to account for differences in the studied organisation and researcher position.

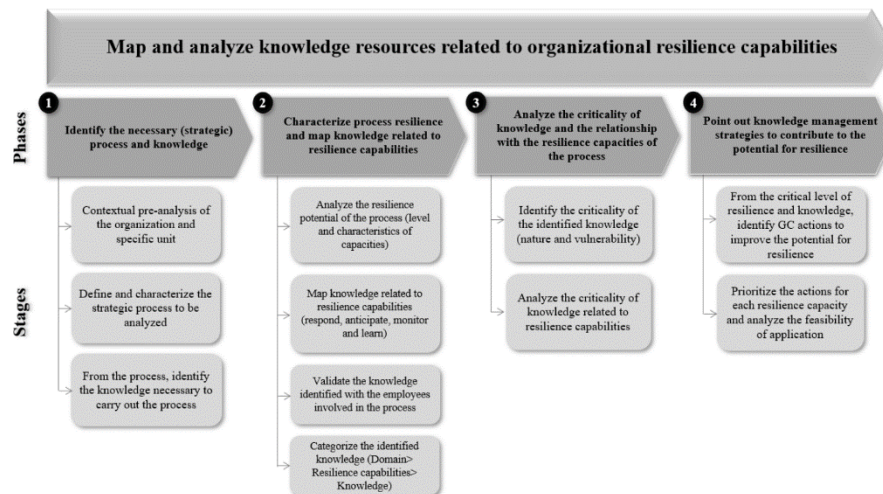


Figure 4: Analysis Framework for Knowledge Resources Critical to Resilience Capabilities. Source: Fraga (2019)

In this study, data was collected using forms, spreadsheets, individual interviews, and group meetings, following the steps described by Fraga (2019). The participants included two internal coordinators (Monitoring and Alert and a Regional Coordinator), one external coordinator (meteorology), three managers (operations, hydrology, and training and education), and four expert advisors (two geologists and two hydrologists). This allowed for a comprehensive understanding of organisational context, knowledge-intensive processes, and identification of key knowledge assets and gaps. The main phases and stages of the data collection process are presented in Figure 4, and the results of the study's application will be discussed in the following sections.

4. Analysis of Organisational Resilience of SCCD

In this section, the steps used to analyse the resilience potential of SCCD, according to the guidelines of Fraga's (2019) framework, as well as the results obtained at each stage of application of the tool, will be presented.

4.1 Phase 1 - Identification and Required Knowledge

The first phase aimed to identify the process and knowledge that would be analyzed. To do so, it was subdivided into three distinct stages carried out with the support of the following data collection instruments as demonstrated in Figure 5.

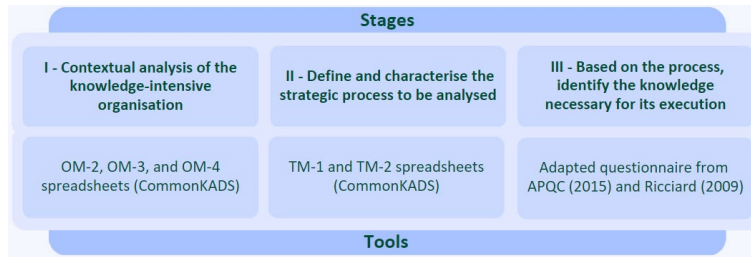


Figure 5: Data Collection Instruments for Phase 1. Source: Fraga (2019) Adapted by Authors

Based on documentation review and the researcher's experience over the last 4 years at the institution, the "Risk Assessment Process" was suggested and approved by the area responsible for it and, after the application of Phase 1, the results shown in Figures 6 and 7 were obtained.

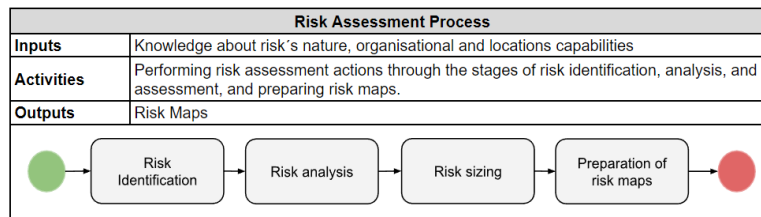


Figure 6: Representation and Characterization of the Process. Source: Authors

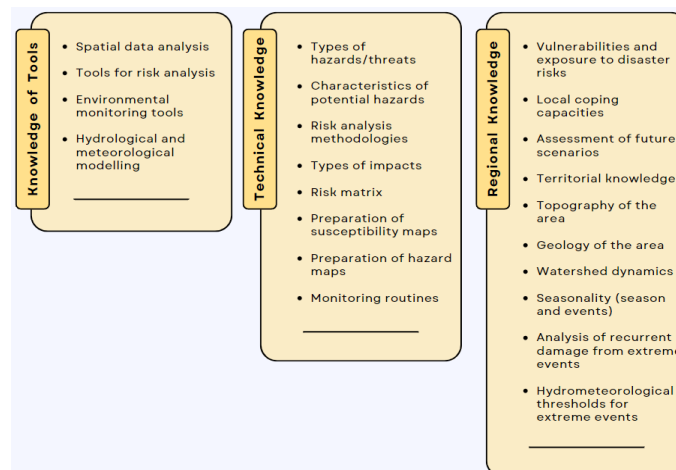


Figure 7: Table of Knowledge Required to Perform the Process. Source: Authors

4.2 Phase 2 - Characterization and Related Knowledge

The second phase aims to characterise the resilience of the process (by identifying related risks and analysing its potential for resilience) and map knowledge related to resilience capabilities (respond, anticipate, monitor, and learn). To do so, it was divided into three distinct stages, which were carried out with the support of the data collection instruments demonstrated in Figure 8.

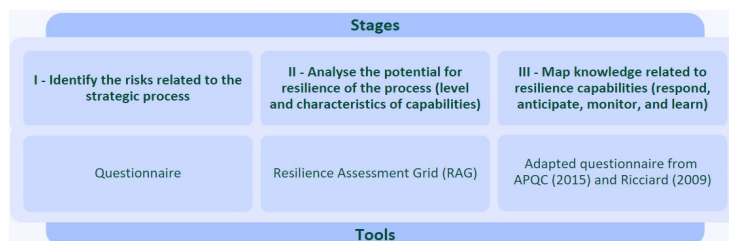


Figure 8: Data Collection Instruments for phase 2. Source: Fraga (2019) Adapted by Authors

After Phase 2 was implemented, the SCCD achieved a score of 2.79 for potential organisational resilience, which is considered acceptable based on the methodology used. This result was uniformly perceived by all interviewees, increasing the accuracy of the outcome. Moreover, individual scores were assigned to each

resilience capacity, with scores of 2.83 for anticipation, 3.00 for response, 2.83 for monitoring, and 2.50 for learning. Besides, figure 9 illustrates the list of risks related to the process.

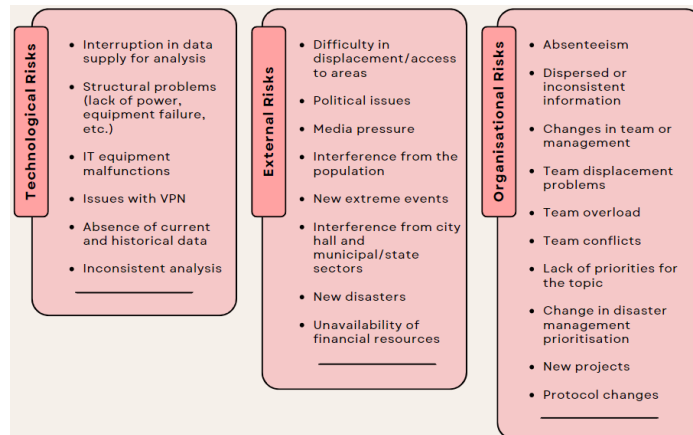


Figure 9: Risks Related to the Process. Source: Authors

In this phase, knowledge was also mapped, and in the next subsection, the analyses of the knowledge related to each resilience capability will be presented. In the following subsection, this knowledge was presented with an evaluation of criticality according to the criticality criteria used in the methodology.

4.3 Phase 3 - Criticality Analysis

In the third phase, the criticality of the previously mapped knowledge was identified according to the criteria presented in Fraga's framework, and an analysis of the importance of the knowledge was conducted based on the ratings given by the interviewees. To do so, it was subdivided into 2 distinct steps, which were carried out with the support of the following data collection instruments as demonstrated in Figure 10.

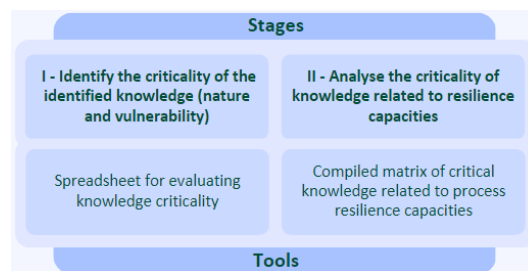


Figure 10: Data Collection Instruments for Phase 3. Source: Fraga (2019) Adapted by Authors

To perform data collection in the first stage of this phase, spreadsheets for risk assessment were used with the knowledge mapped in the previous phase. To guide the interviewees, following Fraga (2019), a Likert scale with 3 levels (1 - Low, 2 - Medium, 3 - High) was defined to grade the criticality factors of knowledge regarding their nature and vulnerability related to each of the mapped knowledge for each of the 4 resilience capabilities.

In the second stage of this phase, to analyse the criticality of the knowledge, the coefficients are calculated per criticality factor based on the median of the ratings assigned by criteria for each knowledge. With the completion of Stages I and II of the third phase of the framework, it was possible to calculate the coefficients of the criticality factor (presented in Figure 3) for each knowledge related to each resilience capacity, based on the median of the responses from the 10 interviewees.

The average of the resulting critical factors for each knowledge was calculated in order to obtain a unified score for each critical factor of the knowledge related to resilience capacities. In total, 16 knowledge related to the capacity to anticipate, 9 related to the capacity to respond, 11 related to the capacity to monitor, and 10 related to the capacity to learn were identified. After that, some inferences and revisions were made in the recorded interviews in order to identify the main knowledge to be prioritised. With this analysis, it was possible to draw specific conclusions about the knowledge related to each resilience capacity, as well as general conclusions considering all the knowledge from the different capacities together.

The first conclusion was the identification of knowledge with the highest averages, considering all six critical factors for each capability: AK9 for anticipating (knowledge of communication techniques), RK5 for responding

(knowledge of meteorological and hydrological operational processes), MK11 for monitoring (knowledge of monitoring tools), and LKs 1 and 9 for learning (knowledge of the history of risks and updating of hydrometeorological thresholds for extreme events).

These knowledges stood out not only for their high averages but also because their innovative content, technical content, and alignment with the strategy were the main contributors to these results. Another important inference was that some knowledge from the capacities presented direct relationships with each other, allowing generalisation of specific knowledge (Table 1).

Table 1: Critical Knowledge to be Prioritised

Critical General Knowledge	Abilities	Specific Knowledge
Processes Anticipating	Anticipating	AK3 - Internal process flows
	Responding	RK9 - Internal process flows
	Monitoring	MK4 - Institutional processes
	Learning	LK6 - Continuous process improvement techniques
Monitoring tools	Anticipating	AK7 - Monitoring tools
	Monitoring	MK11 - Monitoring tools
Internal competencies	Anticipating	AK2 - Competencies of other internal areas
	Responding	RK6 - Institutional operational procedures
Communication techniques	Anticipating	AK9 - Communication techniques
	Responding	RK10 - Communication
Techniques for analysing historical data	Learning	LK1 - Risk history
		LK3 - Ability to interpret and qualify historical data
		LK9 - Ability to update hydrometeorological thresholds for extreme events
	Monitoring	MK3 - Ability to interpret monitored data and its indicators

Source: Authors.

4.4 Phase 4 - Knowledge Management Strategies for Organisational Resilience

Phases 1, 2, and 3 of the framework had been applied earlier and the subsequent phase, phase 4, aimed to mitigate risks of failures in asset execution and improve asset resilience. This phase consisted of two distinct stages, which utilised analysis instruments depicted in figure 11. The primary objective of phase 4 was to implement KM actions specific to the risk assessment process to enhance the asset's resilience.

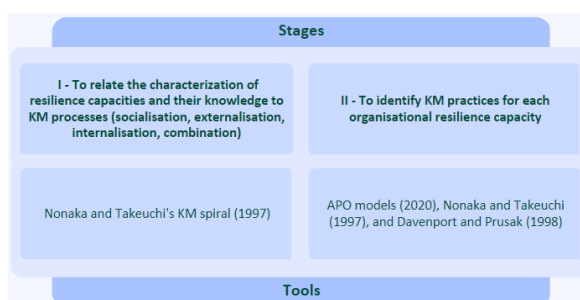


Figure 11: Data Collection Instruments for Phase 4. Source: Fraga (2019) Adapted by Authors

By mapping and prioritising critical general knowledge, along with characterising their respective resilience capacities (anticipate, respond, monitor, and learn), it became possible to identify and define some KM practices, according to the typification proposed by Nonaka and Takeuchi (1997) (socialisation, externalisation, internalisation, combination).

After analysing the previous data, as well as the results presented, it was possible to survey KM practices (such as mentoring programs, communities of practice, training, capacity-building, etc.). The intersection of these practices with issues to be solved to address knowledge deficiencies related to each of the resilience capacities of the "Risk Identification, Analysis, and Sizing" process resulted in the data presented in table 2.

Table 2: Matrix of Actions for Managing Critical Knowledge Related to Resilience Capacities

Ability to anticipate			
Issues to be addressed	Related knowledge	KM process	KM practices
Poor alignment with organisational strategy	AK2, AK3, AK9	Externalisation	Creation of discussion forums
Communication failures	AK9	Socialisation	Mentoring program, creation of discussion forums
Deficient dissemination of tacit knowledge	AK7	Socialisation	Communities of practice
Ability to respond			
Issues to be addressed	Related knowledge	KM process	KM practices
Dispersed or inconsistent information	RK6, RK9, RK10	Combination	KM through intranet
Limited knowledge about organisational processes	RK6, RK9	Socialisation	Space for sharing information and experiences
Complexity of knowledge	RK10	Internalisation	Mentoring program, trainings and capacity-building initiatives
Ability to monitor			
Issues to be addressed	Related knowledge	KM process	KM practices
Knowledge about monitoring tools	MK3, MK11	Socialisation	Communities of practice
Lack of documentation on the tools	MK4, MK11	Combination	KM through intranet
Ability to use data for analysis	MK3, MK11	Internalisation	Trainings and capacity-building
Ability to learn			
Issues to be addressed	Related knowledge	KM process	KM practices
Absence of current and historical data	LK1, LK3	Combination	Use of artificial intelligence tools
Diffuse knowledge	LK3	Socialisation	Communities of practice
Complexity of knowledge	LK3, LK9	Internalisation	Trainings and capacity-building

Source: Authors.

5. Conclusions

This research has provided valuable insights into the role of knowledge management in enhancing the resilience potential of public defence organisations, as exemplified by the Santa Catarina Civil Defence (SCCD) in Brazil. By focusing on critical knowledge and implementing targeted strategies, this study has demonstrated the measurable cognitive value of knowledge management in improving organisational resilience.

The findings of this research offer practical implications for SCCD and other similar organisations involved in risk and disaster management. The identified knowledge management strategies, such as communities of practice, mentoring programs, and discussion forums, provide tangible approaches to address knowledge deficiencies and enhance organisational alignment, communication, and technical expertise. By implementing these strategies, organisations can strengthen their ability to anticipate, respond to, monitor, and learn from

unexpected events, ultimately improving their resilience and their capacity to protect the communities they serve.

Importantly, the framework and methodologies used in this study can be adapted and applied to other public defence organisations facing similar challenges. By employing the Resilience Analysis Grid (RAG) and the framework for analysing critical knowledge resources, organisations can assess their resilience potential, identify knowledge gaps, and develop tailored improvement plans. This adaptability and scalability of the research methodology increases its utility and value for a wide range of organisations operating in diverse risk and disaster management contexts.

The nature of the results obtained in this study holds significant utilitarian value. By enhancing their organisational resilience through effective knowledge management, public defence organisations can save lives, reduce financial losses, and mitigate the long-term impacts of disasters on communities. The practical implications of this research extend beyond academic discourse and can be directly applied to improve the preparedness and response capabilities of organisations involved in risk and disaster management.

Further research could build upon this study by applying the proposed framework and methodologies to other public defence organisations, validating and expanding upon the findings presented here. Future studies could also explore the long-term impact of implementing knowledge management strategies on organisational resilience and the effectiveness of these strategies in different risk and disaster management scenarios.

In summary, this research has highlighted the measurable cognitive value of knowledge management in enhancing organisational resilience. By leveraging knowledge management strategies and adopting the proposed improvement plan, organisations like SCCD can better anticipate, respond to, monitor, and learn from unexpected events, ensuring the safety and well-being of the communities they serve. The applied approach has effectively guided the identification and implementation of appropriate methods and techniques that address the specific needs of SCCD. Besides, the outcomes of this research offer practical insights that can be adapted, mapped, and utilised by other organisations involved in risk and disaster management, ultimately contributing to the broader goal of building resilient communities and mitigating the impacts of disasters.

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