Decision-making in the field of Resilience: literature review

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ABSTRACT

In recent years, the concept of "Decision-making" in the field of resilience has become particularly important, which explains the frequency of publications in this context. Based on literature published in various journals, this article proposes a classification of 66 articles in the four dimensions of resilience (technical, organizational, economic and social), to help researchers, and decision-makers avoid confusion and optimize their search method.

Keywords: Resilience, Disasters, Decision-making, Classification

INTRODUCTION

Currently, natural hazards (earthquakes, hurricanes, floods, climate change, etc.) and human-induced risks (wars, terrorist events, information warfare, financial crisis, etc.) are more frequent and violent, which engender enormous impacts on societies and economic stability. For this reason, several studies and research are focusing on the term "Resilience". In fact, this term has emerged in many fields such as psychology, psychiatry, material sciences, economics, engineering, social science and so on, which has opened the door to numerous definitions. Holling (1973) [1], was the first scientist who defined the concept of resilience while describing the evolution of ecological systems. He proposed two definitions: one focuses on the existence of system functions; "ecological resilience" and the other focuses on the efficiency of these functions; "the engineering resilience". Examining adaptation concepts in the context of climate change, Levina and Tirpak (2006) [2], identified the resilience first as the ability of a system to continue functioning despite a disaster and second as the ability of a system to recover after being affected by the disaster. By focusing on the resilience of communities with critical infrastructure, O'Rourke (2007) [3], identified resilience as the preparation of a community to react and then rapidly recover from disruptive damage. Maguire and Catwright (2008) [4], defines the resilience on three stages; stability, recovery and then transformation. Moreover, several organizations and scholars have identified disaster resilience in different ways. For

example, The Intergovernmental Panel on Climate Change (2001) [5], defines the resilience of a system affected by climate change as "amount of change a system can undergo without changing state", which is not entirely true because climate change often has negative effects on the state of systems. Similarly, the US National Infrastructure Advisory Council (USNIAC 2008) [6] defines disaster resilience as, which focuses on the importance of taking into account the resilience of critical infrastructures when developing risk assessment strategies, the resilience of infrastructure can be characterized by four features: robustness, resourcefulness, rapid recovery and learning. The first refers to the inherent resistance or ability of a system to withstand a potential level of stress without any degradation or lack of functionality. The Second feature "resourcefulness" was viewed as the capacity of a system to provide services and resources in order to flexibly respond to and cope with disruptions or crises. Rapidly recovery was viewed as the excess capacity to rapidly transform negative impacts to positive and prevent critical states. The last characteristic "Learning" refers to the ability of a system to learn new lessons from the disruptive event.

Currently, there is much literature defined resilience, which makes it difficult to extract a common definition. Thanks to these various definitions, we can have an overall vision of this concept. Analyzing 113 articles, Clément et al. (2018) [7] established three main types of the resilience definitions. Two common aspects characterize each type: Absorption and Response. According to this study, some authors defined resilience as the capacity of a system to return to the original level of performance after being affected by a disturbance. Authors illustrated the objective as an acceptable level of performance should be achieved, and not necessarily reach the original level. More than just absorbing and responding, for other authors, resilience is the adaptation of the system to its new level of performance and the ability to operate stably. In this article, in order not to limit the collection process, we have taken into account all articles dealing with our subject of analysis, whatever the definition of resilience used.

Nevertheless, often literature dealing with resilience has emphasized another important term, which is "decision". Also, in recent years, approaches, theories, studies of decision-making have been enormously developed and agreed that the process of decision-making is complex and time-constrained. However, the large number of publications dealing with resilience in several fields (engineering, social sciences, business, etc.) blurs the vision and makes the decision-making process more complex. For example, if decision-makers decide to focus on the resilience of infrastructure, they will find difficulties, first, to understand the appropriate concept of resilience and second, to recognize the decision-making approaches can be used in this area.

This paper is primarily addressed to decision-makers and researchers who look for improving resilience, through applying appropriate decision-making approaches, to help them reach the suitable publications based on dimensions of resilience used in their research.

Wied et al. (2019) [8] have analyzed 251 definitions of resilience, to clarify this concept and understand its involvement in engineering systems. Clément et al. (2018) [7] have analyzed the concepts "resilience" and "robustness" based on 113 articles discussing these terms, to extract three main definitions for each one. However, almost no article analyzes the literature, dealing with the two terms "Resilience" and "Decision-making".

This paper focuses on risks/uncertainties of natural and human and proposed a classification of 66 articles discussed the two terms: "Resilience" and "Decision-making", into four clusters, according to four dimensions of resilience.

COLLECTION AND SELECTION METHOD

Regarding system resilience assessments, several authors, organizations, and scholars argue that there are several dimensions to consider (Kamissoko et al., 2019 [9]). United States Department of Homeland Security (USDHS 2009) [10] have classified the several dimensions of resilient systems into two, "Hard systems" related to technical/physical resilience (e.g., organizations, infrastructure, assets), while "soft systems" are pertaining to psychology, human needs, behavior within organizations and communities. Also, in the context of transport infrastructure, five levels were considered dimensions of resilience according to Victoria Transport Policy Institute (VRPI 2019) [11], which are individual, community, design, economic and strategic planning. However, Bruneau et al. (2003) [12] summarized the multidimensionality of resilience in four levels (TOSE):

- technical: the capacity of physical systems to successfully achieve an acceptable level when a hazard event occurs
- organizational: the capability of an organization to reach an acceptable level of resilience by making decisions to better cope with an incident and to save the organization from the critical state.
- social: the ability of communities to suffer less from the negative consequences of a dangerous event
- economic: the capacity to reduce direct/indirect economic losses after a disruptive event

In this work, we used Bruneau's model in our classification process, because first, TOSE serves as relevant constructs for understanding the high-level dimensions of resilience (Hughes et al., 2014 [13]), and second, it can be applied for various types of systems (Bruneau et al., 2003 [12]).

To identify articles dealing with the two target terms, we conducted a structured search. We have chosen one of the most trusted databases of scientific articles: Web of Science (WoS). Only English papers from 1975 to 2020 were considered. The principle of the search process focused on the title of articles, using the keyword "Resilien* AND Decision-mak*". As a result, we found 66 articles to classify.

In this step, we focused on reading and analyzing the title, the abstract, the introduction and the conclusion of each 66 articles, and the classification process has depended on this analysis. Considering our analysis, 21 of the 66 articles were considered irrelevant because they didn't address the target topic (disaster resilience and decision-making). Thus, as results, 24 articles have treated the term "Decision-Making" in the context of technical resilience, 17 discussed this term with relation to the organizational dimension of resilience, moreover, two articles dealt with both "Decision-Making" and "Social Resilience", and two focused on the economic dimension of resilience and the importance of decision-making in this field. The results of the classification are as follows:

- ***articles using the decision-making concepts in the <u>Technical</u> dimension of resilience:*** Decision making under uncertainty for design of resilient engineered systems [MacKenzie et Hu - 2019], Multi-criteria decision-making for seismic resilience and sustainability assessment of diagrid buildings [Asadi et al. - 2019], Decision-Making Analytics Using Plural Resilience Parameters for Adaptive Management of Complex Systems [Thekdi et Santos - 2019], Bayesian networks as a resilience tool for decision-making processes in uncertainty conditions [Novi - 2018], Working with decision-makers for resilient forests: A case study from the UK [Young et al. - 2018], Resilient Decision Making in Steam Network Investments [Bungener S.L. et al. - 2015], Resilient critical infrastructure management with a

service oriented architecture: a test case using airport collaborative decision making [Hall-May et al. - 2011], Ecosystem Services to Enhance Coastal Resilience in Mexico: The Gap between the Perceptions of Decision-Makers and Academics [Lithgow et al. - 2017], Implementing fuzzy decision making technique in analyzing the Nile Delta resilience to climate change [Batisha - 2015], Realizing resilience for decision-making [Grafton et al. - 2019], Resilience, Decision-making, and Environmental Water Releases [Chu et al. - 2018], Utility and regulatory decision-making under conditions of uncertainty: Balancing resilience and affordability [Decker - 2018], Missing data resilient decision-making for healthcare IoT through personalization: A case study on maternal health [Azimi et al. - 2019], Designing resilient infrastructure systems: a case study of decision-making challenges in railway tunnel projects [Cedergren - 2013], Characterizing a Naturalistic Decision-Making Phenomenon: Loss of System Resilience Associated With Implementation of New Technology [Patterson et al. - 2016], Groundwater recharge indicator as tool for decision makers to increase socio-hydrological resilience to seasonal drought [Hund et al. - 2018], Resilient Decision Making in Open Pit Short-term Production Planning in Presence of Geologic Uncertainty [Rahmanpour et Osanloo], A catchment scale Integrated Flood Resilience Index to support decision making in urban flood control design [Miguez et Veról - 2017], Adding value to the decision-making process of mega projects: Fostering strategic ambiguity, redundancy, and resilience [Giezen et al. - 2015], Risk-Based Decision Making for Sustainable and Resilient Infrastructure Systems [Lounis et McAllister - 2016], Practical Resilience Metrics for Planning, Design, and Decision Making [Ayyub - 2015], Articulating the differences between safety and resilience: The decision-making process of professional sea-fishing skippers [Morel et al. - 2008], A decision-making model for Lean, Agile, Resilient and Green supply chain management [Cabral et al. - 2012], Systems Resilience for Multihazard Environments: Definition, Metrics, and Valuation for Decision Making [Ayyub - 2014]

- ***articles using the decision-making concepts in the <u>Organizational</u> dimension of resilience:*** Empowering strategic decision-making for wildfire management: avoiding the fear trap and creating a resilient landscape [Castellnou et al. - 2019], A multi-criteria decision making method for urban flood resilience evaluation with hybrid uncertainties [Li et al. - 2019], A Reinforcement Learning-Based Stakeholder Value Aggregation Model for Collaborative Decision Making on Disaster Resilience [Zhang et al. - 2019], A decision making support tool: The resilience management fuzzy controller [Cardenas et al. - 2016], Analysis of dynamic decision making underpinning supply chain resilience: A serious game approach [Nonaka et al. - 2016], How CEOs of small firms make decisions to ensure information systems resilience? [Sarkar et Wingreen - 2015], Resilient Supplier Selection Through Introducing a New Interval-Valued Intuitionistic Fuzzy Evaluation and Decision-Making Framework [Davoudabadi et al. - 2019], Interactive Fuzzy Multi Criteria Decision Making Approach for Supplier Selection and Order Allocation in a Resilient Supply Chain [Mari et al. - 2019], Decision making framework for emergency response preparedness: A supply chain resilience approach [Timperio et al. - 2016], Decision-Making and Building Resilience to Nexus Shocks Locally: Exploring Flooding and Heatwaves in the UK [Howarth et Brooks - 2017], Understanding decision making during emergencies: a key contributor to resilience [Mishra et al. - 2015], Resilience metrics for improved process-risk decision making: Survey, analysis and application [Jain et al. - 2018], Resilience and brittleness in the

ALERTA RIO system: a field study about the decision-making of forecasters [Dolif et al. - 2013], Adaptation Planning Support Toolbox: Measurable performance information based tools for co-creation of resilient, ecosystem-based urban plans with urban designers, decision-makers and stakeholders [van de Ven et al. - 2016], Coping with uncertainty: police strategies for resilient decision-making and action implementation [van den Heuvel et al. - 2014], Towards a resilience indicator framework for making climate-change adaptation decisions [Engle et al. - 2014], Towards Integrated Security and Resilience Framework: A Tool for Decision-makers [Chmutina et al. - 2014]

- ***articles using the decision-making concepts in the Social dimension of resilience:*** Rebuild or Relocate? Resilience and Postdisaster Decision-Making After Hurricane Sandy [Binder et al. - 2015], Community resilience, globalization, and transitional pathways of decision-making [Wilson - 2012]
- ***articles using the decision-making concepts in the Economic dimension of resilience:*** Using Financial Reporting for Decision Making as a Measure Towards Resilient Government Finances: The Case of Switzerland [Fuchs et al. - 2017], A Model to "Make Decisions and Take Actions": Leif Johansen's Multisector Growth Model, Computerized Macroeconomic Planning, and Resilient Infrastructures for Policymaking [Halsmayer - 2017]

This classification shows that studies focus more on the concepts of decision-making in the technical and organizational dimensions of resilience and ignore the social and economic dimensions, which already considered non-resilience from the side of scientists and researchers.
From 2000 to 2019, the 45 articles (24+17+2+2) have been cited within the Web of Science databases only 35 times on average per year, which reflects the non-interest of researchers in this context. However, looking closely, for the 10 most cited articles (from the 45), the graph of the sum of times cited per year shows a strong trend (see Figure 1).

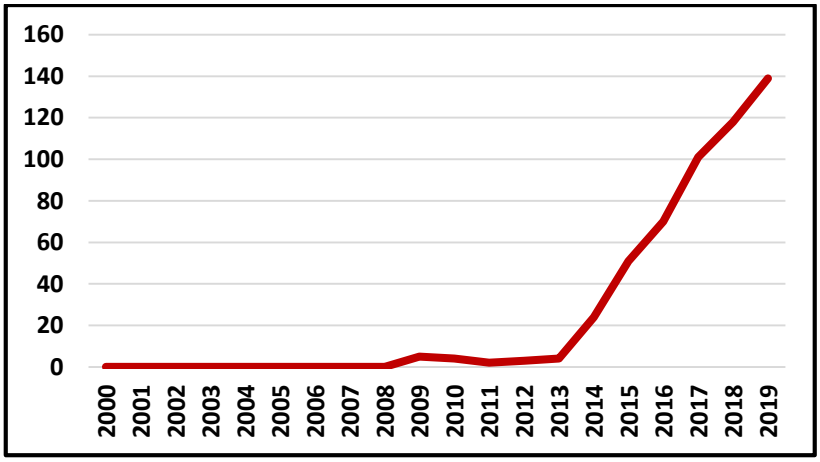

Figure 2: Sum of Times Cited by Year

The trend started in 2013, which means that this context is new in the scientific field. This trend also shows how recently decision-makers and researchers are increasingly focusing on

the use of decision-making concepts in the four dimensions of disaster resilience, which proves the importance of literature review in this context to help future research.

CONCLUSIONS

Studies, theories, and approaches of decision-making in relation to disaster resilience are constantly increasing, which blurs the vision of researchers and decision-makers and makes it difficult to find suitable publications. The main objective of this paper is to clarify the vision and to help researchers and decision-makers to find articles relevant to their research. A structured analysis was carried out regarding the subject of decision-making in the resilience field, on the basis of 66 articles published from 1975 to 2020. This paper classified these articles into four clusters, depending on the resilience dimensions, which allows researchers or decision-makers to search directly in the dimension that corresponds to their research. This paper also discussed the trend of using decision-making concepts in these four dimensions.

To conclude, this article offers an overall visualization of the intersection between the two concepts "Resilience" and "Decision-making", which can help for future studies in this context.

ACKNOWLEDGEMENTS

This paper shows a result of the RESIIST project (Résilience des infrastructures et systèmes interconnectés - Resilience of Interconnected Infrastructures and Systems https://research-gi.mines-albi.fr/display/resiist/RESIIST+Home [in French]). The RESIIST project is funded jointly by the French National Research Agency (ANR) and the General Secretary of Defense and National Security (SGDSN). The authors acknowledge these organizations for their support.

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