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Review

Emergency Decision Making: A Literature Review and Future Directions

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Abstract: In recent decades, various types of emergencies have started to occur more frequently. Their impact and complexity have increased significantly, bringing serious challenges to the sustainable development of the economy, society and the environment. Emergency decision making (EDM) for emergencies is vital for successfully handling crisis events and achieving sustainable development goals. It has attracted widespread academic attention. The purpose of this study is to summarize the progress made so far in research and identify future directions through a literature review. First, a two-stage literature search was conducted to identify a sample of studies. Then, the literature was analyzed econometrically and coded for content. Finally, a theoretical framework based on stakeholder theory was developed to identify current insights and to uncover what needs to be further researched. The article suggests that future in-depth research should be conducted in four areas: analysis of social media information related to emergencies, improvement in computer-aided tools, the influence of decision makers' characteristics on decision outcomes, and efficient linkage of multiple subjects in the organization and implementation phase of emergency projects. This study hopes to draw the attention of more scholars to conduct research related to EDM to promote theoretical progress and contribute knowledge on the sustainable development of the practice of EDM.

Keywords: emergency decision making; emergencies; stakeholders; social media; decision support systems; public participation

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1. Introduction

In past decades, along with the quick advancement of economic globalization and increasing global climate change, various types of emergencies have evolved from occasional to frequent. Emergencies significantly increase in scope and complexity, including accidents caused by human negligence and natural disasters brought on by environmental degradation [1–4]. Emergencies cause considerable losses to human life or property and may cause severe environmental damage, social panic, and potential secondary disasters [5–7], bringing difficult challenges for achieving sustainable development goals [8]. Many countries have strengthened their research on emergency management, such as the National Emergency Response Project in the US and the Global Monitoring for Environment and Security (GMES) project in the European Union [9].

Natural disasters, accidents, public health issues, and social security issues all qualify as emergencies because they can happen suddenly, they result in or potentially result in loss of life or property, economic harm, social harm, or environmental degradation, and they require the organization and implementation of an emergency project to respond to them [10]. In order to minimize all kinds of losses when emergencies occur suddenly or when signs appear, a reasonable emergency project should be carried out in a limited amount of time.

Therefore, conducting research on emergency decision-making (EDM) in emergencies is essential to successfully deal with crisis events and achieve sustainable development

goals, and this issue has attracted extensive attention in academic research [11]. Current research on EDM has been conducted across multiple disciplines, such as mathematics, security science, public management, information systems, and psychology. Moreover, research findings on EDM cover multiple perspectives. It is challenging for academics and professionals to comprehend the state of research due to issues including the development of decision support systems (DSS), the assessment programs of multi-criteria decision-making, and conflict management in teamwork decision-making.

There are few literature reviews on EDM. One example, Hou et al. [12], applied econometric analysis to give a thorough summary and understandable depiction of the EDM literature. They did not explain the logical relationships between existing research topics, and the research sample was limited to articles published between 2010 and 2020. Zhou et al. [13] provided an overview of EDM for natural disasters from a methodological perspective. They did not consider EDM for other types of emergencies and did not examine them from a theoretical perspective. This makes it difficult for scholars and practitioners to systematically understand the current state of research and to guide future research. Considering the current research gap, we believe it is necessary to construct a theoretical framework to summarize research progress and uncover promising research themes. This study hopes to draw more scholars' attention to this issue and to conduct research related to EDM, so as to enhance theoretical progress and contribute knowledge to the sustainable development of EDM in practice.

The remainder of the paper is organized as follows. The concept and traits of EDM are introduced in Section 2. The study methodology is presented in Section 3, specifically including literature search, econometric analysis, content-coding, and derivation of the theoretical framework. Section 4 presents econometric analysis results and a theoretical framework for EDM. Section 5 summarizes current research progress and provides an outlook on future research. Section 6 goes into detail about potential research directions. Finally, we discuss the study's contributions and limitations.

2. Definition and Characteristics

2.1. Definition

EDM refers to the sudden occurrence of an emergency event or the emergence of signs of one; decision makers must quickly collect relevant information, clarify the problem and objectives, and draw up a variety of feasible options [14]. After analysis and evaluation, they select a practical emergency project and organize its implementation [14]. They should continuously adjust decision objectives and the emergency project with the situation's development and public feedback up until the conclusion of the urgent rescue [15]. Information gathering, problem characterization, goal evaluation, project design, project selection, organization and operation, and feedback adjustment are the six procedures that make up the EDM process [13], which are depicted in Figure 1.

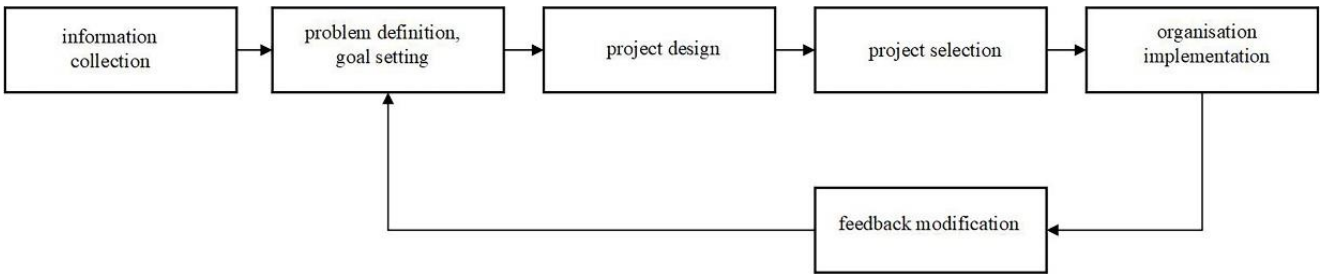


Figure 1. The six procedures of emergency decision-making (EDM).

2.2. Characteristics

Because of the suddenness, dynamism, randomness, destructiveness, and complexity of emergencies, EDM has shown the following characteristics:

1. From the viewpoint of the information collected by decision makers

The characteristics of the emergency itself, the urgency of time, the ambiguity of human thinking, and the combined effects of various subjective and objective factors mean that decision makers can have insufficient, unclear, uncertain, or heterogeneous information about the preferences of each emergency project [16]. In addition, decision makers who fail to make a timely emergency response or make wrong decisions are likely to let it develop into a more significant catastrophic event [17]. Therefore, EDM for crisis events belongs to the category of risk-based decision-making [17].

2. From the perspective of participating subjects

These are: (1) the government, which can be subdivided into the Ministry of Emergency Management, Ministry of Public Security, Ministry of Transportation, Ministry of Civil Affairs, and Internet Information Office, etc.; (2) society, which can be subdivided into the public, expert groups, and social organizations; and (3) the market, which refers to various types of enterprises. In general, the government plays a leading role and unifies the command. Then, experts provide advice; social groups actively participate, assist in formulating decision-making objectives, and provide real-time feedback in the process of decision implementation, prompting dynamic adjustments in decision-making. Enterprises donate funds, organize forces to rescue, and take the initiative to assume social responsibility. Each subject has its own interests, among which the government's interests are to implement efficient decision-making and establish prestige; society's interests are to exercise rights and obligations according to the law and seek self-development; and enterprises' interests are to maximize profits and pursue sustainable development [18]. Various government departments may give different opinions based on different interest demands [19]. Therefore, conflict management is crucial to EDM [13]. There are also some psychological traits of humans under danger, such as diminishing sensitivity and distorted probability judgment, according to a vast number of psychological studies [20]. Since emergency decisions are risky decisions and their decision outcomes are difficult to predict, in order to develop fair and workable ways to handle emergencies, decision analysis must take into account the decision makers' restricted capacity for reason. Additionally, decision procedures that comprehend human psychological behavior must be established [20].

3. From the perspective of decision objectives

There are multiple attributes of the decision problem, which differ in importance [21].

3. Research Methodology

3.1. Literature Search

First, a literature search is conducted to identify a sample of studies [22]. To find pertinent material, a two-stage comprehensive search methodology is employed [22]. Through a thorough literature review, this strategy represents a repeatable technique and further screens the initially retrieved articles by several criteria to reduce prejudice [22].

In this paper, the Web of Science database was chosen as the search engine, an engine that is widely accepted by scholars [14,23]. The Web of Science database provides a broad coverage of articles in management, decision sciences, and information systems [15]. In addition, based on our personal experience, the Web of Science database presents a collection of articles that are most pertinent to the study's subject. No restrictions were placed on the time frame of the search in this paper to obtain a perfect sample of studies [24].

To ensure that all pertinent articles in the database are covered, we must create and verify the keywords used to search in the database's title field [25]. This article used a set of suggested keywords, namely "emergency decision-making", "emergency decision making", " emergency decision", and "emergency decisions". We cross-checked the preliminary results of the Web of Science database with the latest review [12]. We discovered that a few publications were omitted, so we added and tested more keywords [25]. Every keyword was added separately and if it produced a significant number of unrelated publications (e.g., 15–20) it was removed and we replaced the keyword with a new keyword [25]. The

first phase of the search can be considered complete when no new concepts are found in the searched set of articles [26]. A total of 290 studies were found in the literature search's initial phase.

In the following stage, we read the titles and abstracts of the literature. Then we screened the 290 pieces of literature with screening criteria including (1) eliminating literature that did not match the topic of the study; (2) eliminating gray literature (e.g., conference papers); (3) searching backward, i.e., adding references that were missed in the literature; and (4) searching forward, i.e., adding references to this literature [24].

This paper ensured that no vital literature was missed by using a two-stage search method [22]. In this way, a sample of 212 studies was finally identified for this study.

3.2. Econometric Analysis

We performed a preliminary metric analysis of 212 documents using VOS Viewer software, a project for creating bibliometric maps [12]. It allows the construction of web links to keywords, publications, researchers, etc. [12]. In past decades, VOS Viewer has been extensively utilized for bibliometric analysis in several study fields [12].

3.3. Content Encoding

Next, the 212 papers were coded for content. In addition to basic information such as source journal, author, and year, this article focused mainly on research themes, core topics, research questions, research methods, theoretical/technical perspectives, and research findings in the coding process, as suggested by Webster and Watson [26]. In Appendix A, we show the results of content coding for some representative literature.

3.4. Deriving the Theoretical Framework

We propose a theoretical framework for EDM based on stakeholder theory, combined with the results of bibliometric analysis and content coding, and more importantly, based on our understanding and grasp of the literature in this field after an in-depth reading.

4. Econometric Analysis Results and Theoretical Framework

4.1. Econometric Analysis Results

The co-word results are shown in Figure 2, where the dimensions of the nodes represent the entire number of keyword occurrences; the thickness of the links indicates the number of occurrences of two keywords together, and the nodes with a standard color indicate clusters with similar topics [12]. Figure 2 shows four small categories of keyword clusters with relatively clear boundaries: decision information (including information representation, aggregation operators, linguistic sets, etc.), large group decision making (including consensus, risk, uncertainty, etc.), emergency DSS (including ontology, knowledge management, emergency management, etc.), and case-based reasoning (including Bayesian networks, prospect theory, etc.).

Figure 3 displays the findings of the co-citation study. The size of the nodes represents the entire number of citations, the thickness of the linkages denotes the frequency with which two publications are referenced jointly in other articles, and units of standard color indicate clusters with similar themes [12]. Figure 3 shows three relatively specific genres: (1) the expression of decision-maker preference information, with Zadeh et al. [1] as well as Zhou et al. [13] as the core co-citation literature; (2) the construction of consensus models for large group EDM, with Yu et al. [1] as well as Xu et al. [27] as the core co-citation literature; (3) studies of EDM putting decision makers' psychological tendencies into consideration, with Wang et al. [28], Wang et al. [1], Liu et al. [1], Tversky et al. [1], and Kahneman et al. [1] as core co-citations.

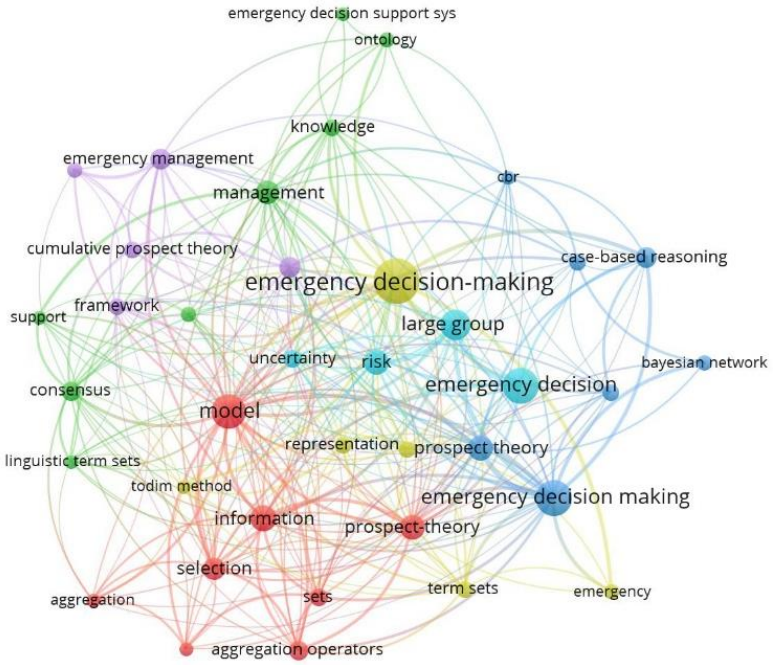


Figure 2. Co-word analysis results.

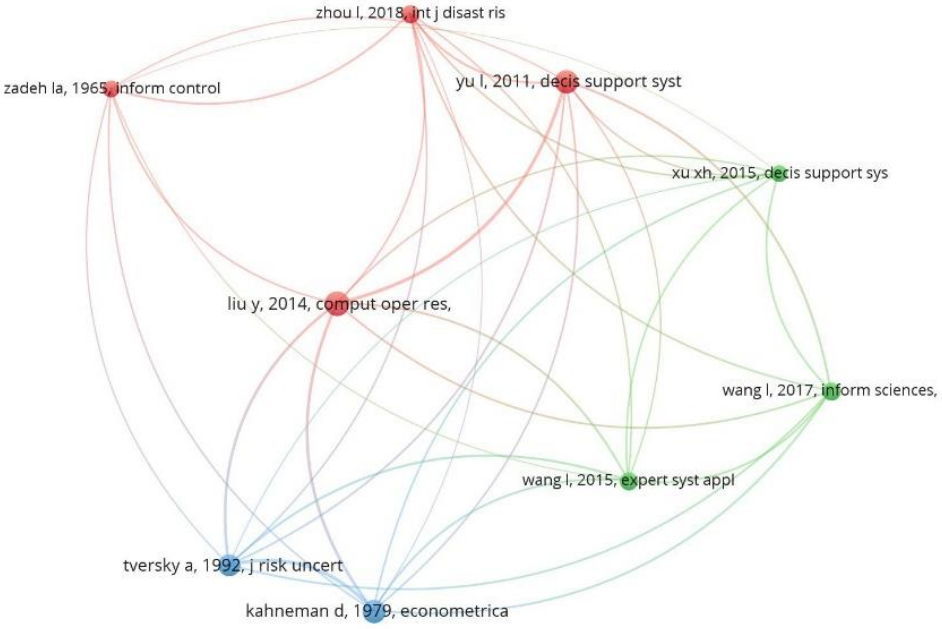


Figure 3. Co-citation analysis results [1,13,27,28].

4.2. Theoretical Framework

The theoretical framework is shown in Figure 4. It helps us summarize the current research progress and inspires future research on EDM.

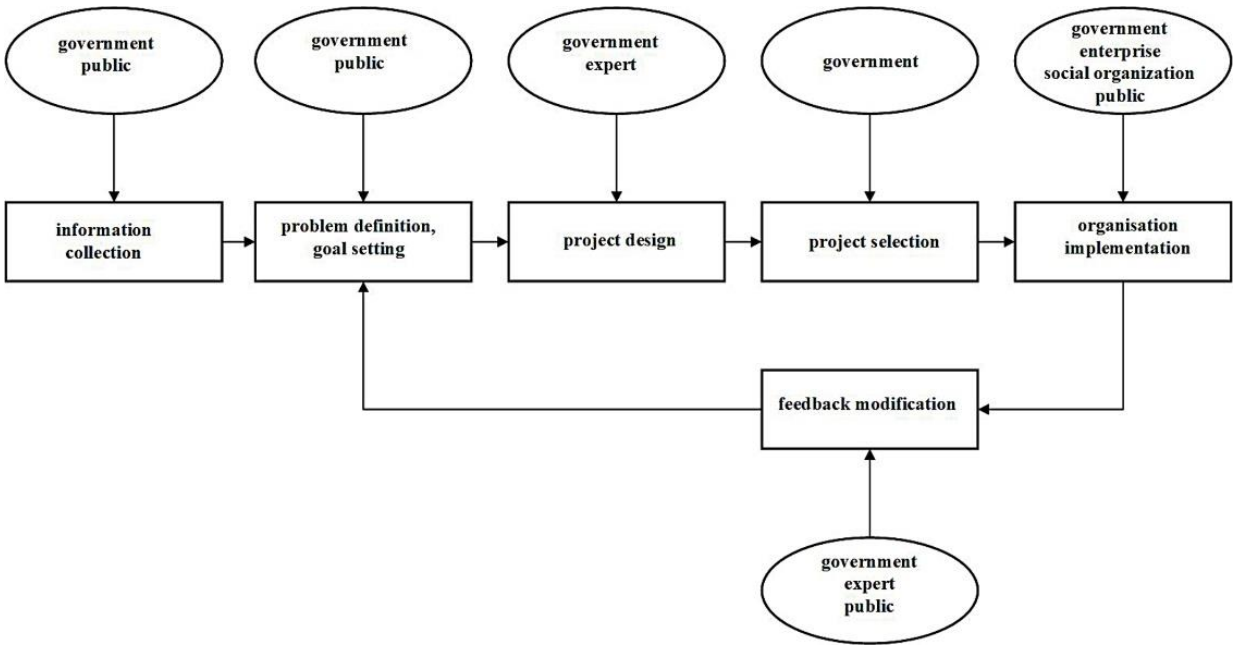


Figure 4. Theoretical framework.

Stakeholders are all the individuals and groups that can influence an organization's goals [29,30]. Stakeholders in EDM are divided into three categories: (1) government, which can be subdivided into the Ministry of Emergency Management, the Ministry of Public Security, the Health and Welfare Commission, and the Internet Office, etc.; (2) society, which can be subdivided into the public, expert groups, and social organizations, etc.; (3) and the market, which refers to various types of enterprises. In general, the government plays a leading role and unifies the command, and experts provide advice. Social groups actively participate in assisting in the formulation of decision-making objectives and in providing real-time feedback during the implementation of the decision, prompting dynamic adjustment of the decision. Enterprises donate funding and take the initiative to assume social responsibility. Each subject has its own interests, among which the government's interests are to implement efficient decision-making and establish prestige; the society's interests are to exercise rights and obligations according to law and seek self-development; and the enterprises' interests are to maximize profits and pursue sustainable development [18].

Stakeholder theory refers to the management activities of an organization's managers to balance the interests of various stakeholders in an integrated manner [29,30]. Stakeholder theory emphasizes that organizations should focus on identifying and valuing stakeholder feedback when making decisions, helping people to "convert external changes into internal changes", relieving the risk of uncertainty caused by external changes, and ensuring the effectiveness of organizational management [31]. In the six stages of EDM, the government, as the leading decision maker, should focus on the public and enterprise's needs and feedback to ensure effective decision-making. Particularly with the accelerated growth of the mobile Internet, and social media sites like Twitter, WeChat, and microblogs, the information communication tools connecting the physical and virtual worlds have gradually become crucial real-time information access channels in EDM [32]. It has been suggested that social media, as a more effective two-way information dissemination mechanism, not only facilitates the government in obtaining emergency information from the public but also provides a new way for the public to participate in EDM actively [33].

In the information collection stage, decision makers should pay attention to the information collected by various governmental functions and the information released by the public on social media such as WeChat and microblogs [34]. Within the golden X hours after an emergency, real-time information about the event is crucial for EDM. Social media can

disseminate information and maintain practical communication under extreme conditions, and they are more resilient to disaster impacts than traditional communication tools [35].

In the problem definition and goal setting phase, the government plays a leading role and needs to identify and pay attention to the information posted by the public on social media. By pooling large-scale real-time social media data and monitoring the content of a topic within a particular spatial and temporal range, it is possible to detect the occurring emergencies for the first time and keep abreast of the public demands [36].

In the project design stage, the government should organize the participation of experts as a social force [37]. Experts, with their professional advantages and objective positions, can help the government to analyze and investigate the decision event itself, and rationalize and avoid decision risks, thus optimizing the emergency project [37].

In the project selection stage, the government plays a leading role, combining the decision goals to select the best option.

In the organization and implementation stage, the government quickly organizes relevant functional departments to link up with enterprises and social forces. In addition, social media also links resources, which can effectively link enterprises, the public, and government rescue agencies to provide material and psychological services for disaster victims, etc. [38].

In the feedback modification stage, the government plays a leading role in making decision adjustments [37]. However, relying only on government departments to assess the developmental dynamics of events is time-consuming and laborious. With the continuous collection of social media information related to emergencies, deep-level association mining information in social media can effectively estimate the macroscopic dynamics of emergencies and provide more rapid and reliable support for EDM [36].

Stakeholder theory makes sense as the theoretical foundation for the framework for two primary reasons. First, it includes all subjects related to EDM, specifically the three main subjects: government, society, and market. Therefore, it is an inclusive framework that can integrate all the variables in the study. Furthermore, stakeholder theory has been frequently employed to explain risk decision-making and emergency risk communication [39–42].

Based on the theoretical framework and literature analysis, this article first discusses the current research themes in various stages of EDM. Then, this article provides an outlook on future research in EDM, considering the limitations in existing research and research directions with scientific value and practical significance.

5. Research Themes

5.1. Information Collecting, Problem Definition, and Goal Setting Phase

Information is the basis for emergency decisions. There are two dominant types of information sources: one is the external environment, including changes in the disaster-prone environment, damage assessment of disaster-bearing bodies, population distribution in the disaster area, distribution of rescue teams, and rationing of rescue materials [43]; the other is historical experience, including laws, regulations, emergency plans, and the knowledge of decision makers [44]. The current research on decision information collection mainly focuses on information extraction from emergency policy documents and information collected from government administrative departments about the external environment. Studies such as Cun-Xiang, D. et al. [4] used variables and constraints to represent the objects and rules of the emergency decision problem. They constructed an emergency decision model based on emergency plans and quickly generated an emergency disposal project that satisfies the constraint rules by solving the model [4]. Zhao, Q. S. et al. [45] delve into the theory of complex spatial relationships between entity objects, construct a qualitative representation model of extended spatial topology theory, and design an algorithm to extract emergency decision information based on spatial predicate representation.

Users post a lot of text, pictures, and videos on social media in real-time about casualties, property damage, and emergency assistance during emergencies. This multimodal information plays a vital role in EDM [46]. The current research on social media information

analysis mainly focuses on the identification of emergency sub-events and the determination of attribute architecture and weight. Studies such as Xu, X. et al. [47] introduced a clustering method based on public preference big data analysis, which clustered the considerable data about preference posted on social media by the public at the event site, identified multiple sub-events related to the event, and derived the objective risk level of each sub-event [47]. They then combined this with expert empirical judgment to synthesize the risk level of each sub-event [47]. Xu, X. et al. [11] introduced user-generated content in social media into emergency decision selection, and evaluated public concern targets to determine attribute weights. Compared with traditional methods, the formulation of decision attribute weights takes into account the public's tendency to pay attention to information, which can make up for the lack of subjective interference in the determination of weights by experts. However, the depth of research on social media information analysis is still insufficient. For example, the information on public emotion expression and the evolution of public opinion has not been explored in depth, which leaves the value of social media information not maximized and fails to solve the public opinion crisis. The first problem for further study is how to deeply explore the information related to emergencies in social media to assist EDM.

5.2. Project Design Phase

In the project design phase, the government organizes experts, a social force, to participate [37]. The main existing approaches to emergency project generation are designing and developing emergency DSSs, automated planning, and case-based reasoning. However, there is still room for further research on each method, as will be discussed next.

The DSS uses computer tools and mathematical methods to assist decision makers in analyzing problems and solving them [48]. In order to provide accurate decisions when managing emergencies, researchers and practitioners have proposed improving or developing new information technology systems to support EDM [49]. For example, Molina and Blasco [50] developed a DSS which receives actual data recorded by sensors. They used multi-intelligence methods to explain the data and suggest emergency plans [50]. Then, Li and Xie [51] established an ontology model-based emergency DSS. However, emergency DSSs for integrating different types of information, such as geospatial and document information, are still less studied, which brings about a second problem for further study: how to efficiently integrate information from external environments and policy documents to make better decisions.

Furthermore, existing DSS function only after emergencies, and less research has been conducted on designing and developing early warning systems for emergencies. Suppose early warnings can be provided when the signs of emergencies appear. In that case, the outbreak of emergencies will be effectively curbed, and the damage caused by emergencies will be significantly reduced, which brings about a third problem for further study: how to design and develop an early warning system for emergencies. In addition, no research has been conducted to evaluate the effectiveness of DSSs, which can help improve the systems' performance. Then it brings about a fourth problem for further study: how to evaluate the effectiveness of emergency DSSs.

Planning is reasoning about actions, where a set of actions is selected and organized to achieve a pre-given goal as far as possible by anticipating the desired effect of the action [52]. Automated planning is a technique for action reasoning using artificial intelligence methods [52]. Automated planning includes classical, neoclassical, and hierarchical task network planning (HTN) [52]. Among them, the HTN planning method is one of the most frequently employed automated planning methods. It uses computer technology to automatically generate emergency projects without needing preplanning or case matching and modification, simplifying the EDM process and reducing time [52]. Existing research on automated planning has focused on generating high-quality plans. Zhao P. et al. [53] considered the resource constraint problem in EDM. However, emergency decision problems often require multiple types of resources to be involved in the emergency response.

There are complex constraints between these resources, which brings about a fifth problem for further study: how to deal with the complex constraint relationships between different types of resources in automated planning.

Case-based reasoning is a method that utilizes knowledge to resolve fresh decision-making issues [54]. Existing studies applying case-based reasoning for emergency project generation have focused on the combination with Bayesian networks, improving the efficiency of case retrieval, and dealing with missing value attributes, as well as inconsistency in the set of attributes. For example, La, R. et al. [55] investigated a Bayesian network approach for EDM based on case-based reasoning. Li, H. M. et al. [54] constructed a unified framework representation for significant infrastructure accident cases. To increase the effectiveness of retrieval, they pre-classified cases based on their main qualities using an inductive indexing strategy [54]. To deal with the missing attribute values in situations and effectively improve search efficiency and accuracy, they also suggested an integration framework and an attribute matching method. Dong, Q. X. et al. [56] addressed the proposed problem of non-consistent attribute sets of target cases and historical cases. They extracted historical cases with a greater matching degree to form a new sub-case pool, reduced the amount of case similarity calculation, and improved the speed of emergency decision solution generation [56]. However, the quality of cases affects the reliability of the emergency project. And the increase in the number of cases can cause the system to run slowly, which brings about a sixth problem for further study: how to add high-quality cases and enrich the cases' material while reducing redundant cases to make case-based reasoning more practical and reliable.

5.3. Project Selection Phase

In the project selection phase, multiple emergency projects are evaluated by experts from various government departments, and the information from various government departments is combined to select the best project. The project selection phase consists of two main steps: one is to quantify the evaluation information used by decision makers about the emergency scenarios, and the other is to model the evaluation information to select the best project with high acceptance.

The combination of factors like the complexity of emergency problems, the urgency of time, the characteristics of qualitative criteria, and the fuzziness of human thinking makes it difficult for people to evaluate projects with actual confirmed numbers. The emergence of fuzzy sets makes it possible to handle the fuzziness of evaluation information. Fuzzy sets use affiliation as a measure to indicate the level of support and opposition of decision makers to items [57]. In order to keep the initial information of decision makers, a large number of scholars have researched the extended form of fuzzy sets [57]. For example, Wu J. et al. [58] proposed an innovative distance metric and applied the TOPSIS approach to the probabilistic hesitant fuzzy area. Li, P. et al. [57] introduced the intuitionistic fuzzy cross-entropy method, which will protect the accuracy of the decision-making information. Ding, X. F. et al. [1] applied fuzzy image sets to deal with the vagueness and uncertainty of decision makers' evaluation of solutions.

Whereas decision makers frequently assess options using linguistic abstractions such as "good", "likely", and "a little", Zadeh suggested using linguistic variables to describe the ambiguous information [59]. In order to communicate the evaluation information of decision makers accurately and flexibly, many extended linguistic sets have been investigated [59]. Li and Wei [60] introduced some new algorithms for probabilistic linguistic term sets; Chai, J. et al. [59] introduced Z-uncertain probabilistic linguistic variables after taking information credibility into account, which make the decision results more accurate.

However, EDM has high complexity and risk, requiring decision makers to make decisions in the shortest time. There is a lack of complete information and their judgment and processing ability of information is limited. Some decision makers fail to give comprehensive decision information, which brings about a seventh problem for further study: how to handle the incompleteness of decision makers' evaluation information. Moreover,

different decision makers may have different opinions about different criteria, and the criteria defined in the emergency problem may be different, such as qualitative or quantitative. Therefore, decision makers may use different types of information to express their opinions or assessments depending on their knowledge, experience, and the nature of the criteria, which brings about an eighth problem for further study: how to deal with the heterogeneity of decision makers' evaluation information.

In the EDM process, due to the business differences among experts from various government departments, coupled with the complexity and uncertainty of the EDM problem itself, conflicts inevitably arise among decision makers [61]. Failure to quickly obtain an EDM opinion with a great degree of consensus may make the conflict further escalate, delay the decision-making time, and then lead to the best time for rescue being affected, further expanding the harm of the emergency [62]. Therefore, before modeling the evaluation information of decision makers to select the best solution, conflict coordination is required [63]. Scholars have investigated the conflict resolution process of decision members. For example, Xu, X. et al. [62] obtained the level of conflict among decision groups and compared it with the threshold value by measuring the level of preference conflict among decision groups. Then they organized the relevant decision group members to coordinate and give feedback to each other through a decision coordinator, and used normalization approach to correct and improve the decision members' preferences, so that the preference conflict level of the group decision gradually decreases and converges, and thus perform conflict resolution coordination [62].

Moreover, the criteria for evaluating conflict-based EDM methods include two main aspects: (1) decision timeliness; and (2) decision quality, which mainly examines whether the majority approves the final solution and whether minority opinions (if they exist) are given due attention [63]. Emergency decisions may bring incalculable losses if they are wrong, so all parties' opinions must be fully considered, and the importance of minority opinions cannot be ignored [63]. The majority's will may not always be rational, and its interests and demands may not always be reasonable. This situation is more likely to occur in EDM, where the lack of information may be acute. A minority of reasonably different opinions can make the majority's decisions better and prevent the abuse of the majority principle to some extent [63]. Xu X. et al. [63] proposed a treatment method for dealing with minority opinions based on the principle of protecting minority opinions, they defined the conditions for determining the existence of minority opinions and the criteria for determining that minority opinions are valued, and then they established a corresponding treatment model [63].

Because compromise frequently entails giving up one's interests, there are often a number of people or groups that are hesitant to change their beliefs in order to achieve an agreement in multi-criteria group choice situations [64]. Decision makers who exhibit uncooperative behavior can generally be classified into three types: (1) leaders, who have the power to decide the final decision and who may offer original, forward-thinking viewpoints; (2) experienced experts, who tend to have considerable knowledge of the decision problem and can offer persuasive opinions; and (3) youthful and active decision makers, who have fairly radical and strongly motivated ideas [27]. The viewpoints offered by the first two of these three types of decision makers should be properly taken into account. In contrast, the opinions provided by the third must be carefully considered [64], which brings about a ninth problem for further study: how to differentiate noncooperative behavior according to the type of decision maker and to analyze different types of noncooperative behavior specifically.

After conflict coordination, the evaluation information of decision makers needs to be modeled to select the best project. There are two main existing modeling approaches: (1) knowledge fusion and (2) evidence theory.

Knowledge fusion, i.e., the fusion of the personal knowledge of decision makers to generate collective knowledge, leads to timely and effective EDM [65]. For example, Zhang and Wang [66] constructed a knowledge meta-model for EDM from the expected

overall characteristics of different scientific domains. They supported the representation and fusion of multi-domain knowledge [66]. Evidence theory has apparent advantages in dealing with information uncertainty, representing deterministic and uncertain information in the form of evidence, and achieving decision-making through the fusion of evidential information [7]. For example, Chen X. et al. [7] gave an evidence-theoretic representation of a multi-attribute contingency decision problem (including focal elements and their essential probability assignments). They solved the problem of the independence assumption in the process of evidence fusion [7]. They proposed a method to measure the relevance of information sources and gave a rule for mixing and synthesizing evidence considering the relevance of information sources [7]. However, when the evidence inference chain is long, the computational complexity and time will increase. A more rapid and reliable information fusion method should be explored in the future to select the best decision solution.

Furthermore, it has been demonstrated that under risk, people have bounded rationality and their psychological characteristics have a significant impact on the EDM due to the uncertainty of emergencies and the unpredictable outcome of emergency decisions [67].

Prospect theory is considered to be the most influential uncertainty decision theory because it well characterizes the behavior of decision makers [28]. It gives formulas for gains, losses, and values, which have been frequently employed in problems that consider the psychological characteristics of people due to the simplicity and logical clarity of the computational process [28]. For example, Ren, P. J. et al. [68] introduced a negative exponential function in prospect theory to describe the psychological behavior of decision makers.

However, decision methods using prospect have the inherent limitation that the desired level needs to be known previously, which is generally difficult to achieve in reality [67]. The advantage of the TODIM approach over prospect theory is that the decision outcome is decided by computing the level of gain or loss of a solution in comparison with other solutions without the need to know the level of expectation in advance [67]. For example, Sun K. et al. [67] proposed the TODIM decision-making approach. They fully considered the psychological factors. The TODIM decision-making approach does not need to establish reference points and only needs to calculate the relative dominance degree for a comprehensive evaluation by comparing two alternatives, simplifying the decision-making process and improving decision-making efficiency [67].

Furthermore, some scholars have also suggested that the limited rationality of decision makers, such as their risk appetite, or risk-averse individuals, often poses a risk to the final decision outcome, resulting in a final decision that is not optimal [69]. Therefore, for group participation in EDM, group members should be screened according to risk preferences, and decision members who are risk neutral should be selected [69]. Some scholars have suggested that EDM needs to consider the limited rationality of decision makers to make the decision results more acceptable to people. So, why are there inconsistent findings? The psychological characteristics of people may not be the most significant factor affecting the decision outcome. Boundary conditions may determine the effect of people's psychological behavior on the outcome, which brings about a tenth problem for further study: what are the boundary conditions for the influence of decision makers' psychological behavior on decision outcomes?

5.4. Organization and Implementation Phase

In the organization and implementation phase, the government transmits the emergency project to relevant functional departments, the public, social organizations, businesses, and other stakeholders so that all parties can understand [70]. The government should establish an emergency command center to convey instructions and organize relevant functional departments to quickly link up with enterprises, the public, and social organizations [71]. It uses a unique information-sharing platform to integrate personnel, materials, and funds for rational allocation [71].

The current research related to the organization and implementation stage only involves the participation of various government functional departments and does not

consider the power of society and market subjects. The government must play a leading role as the main body of crisis governance. However, the efficient linkage of the government with society and market subjects also plays a significant role in the organization and implementation stage [70], which brings about an eleventh problem for further study: how can the government establish an emergency command center to integrate the forces of society and market actors into the organizational implementation phase of emergency projects? How can the information platform be used to allocate resources for society and market actors rationally?

In addition, social media also links resources, which can effectively link companies, the public, and government relief agencies to provide material and psychological services for disaster victims, etc. [38]. However, research in this area is lacking, which brings about a twelfth problem for further study: how can social media information be used to provide appropriate assistance?

5.5. Feedback Modification Phase

Emergencies are characterized by dynamic evolution, and the public will have some feedback on the initial emergency project; therefore, decision objective and emergency project adjustment must be taken into account [3]. At the early stage of an emergency event, decision makers can only make preliminary emergency decisions because they have incomplete and inaccurate information about the decision [3]. After the implementation of the initial emergency project, with the progress over time, the trend of changes in the emergency becomes clear, the public has some feedback on the initial emergency project, and the information available to the decision maker is improved. The decision maker needs to judge whether the initial emergency target is appropriate and whether the initial project can control the development of the emergency based on the newly obtained emergency information. If not, the decision target and the emergency project need to be adjusted to ensure that the emergency response achieves good results [3]. For example, Zhang K. [3] used case-based reasoning techniques to analyze how to generate the most effective plan to control the development of an emergency through continuous improvement and change of information.

However, the existing studies limit information collection to the relevant governmental functions. The government judges the decision objective and the implementation effects of the initial emergency project using the collected information and experience. It ignores the feedback information on the emergency project released by the public on social media, which brings about a thirteenth problem for further study: how to obtain and integrate feedback from the public on social media about emergency projects to assist in the adjustment of emergency decision targets and emergency projects.

6. Future Directions

Thirteen associated problems for further study in the subject of EDM have been presented in Section 5. Here we group these problems into four areas of future research. Table 1 summarizes future directions and associated problems.

Table 1. Future directions and associated problems.

Future Directions	Associated Problems
1. Analysis of social media information associated with emergencies	1. How to deeply explore the information related to emergencies in social media to assist EDM? 12. How can social media information be used for needs mining to provide appropriate assistance? 13. How to obtain and integrate feedback from the public on social media about emergency projects to assist in the adjustment of emergency decision targets and emergency projects?

Table 1. *Cont.*

Future Directions	Associated Problems
2.Improvement of computer-aided tools	2. How to efficiently integrate information from external environments and policy documents to make better decisions? 3. How to design and develop an early warning system for emergencies? 4. How to evaluate the effectiveness of emergency DSS? 5. How to deal with the complex constraint relationships between different types of resources in automated planning? 6. How to add high-quality cases and enrich the cases' material while reducing redundant cases to make case-based reasoning more practical and reliable?
3. Impact of decision maker's characteristics on decision outcomes	7. How to deal with the incompleteness of decision makers' evaluation information? 8. How to deal with the heterogeneity of decision makers' evaluation information? 9. How to differentiate noncooperative behavior according to the type of decision maker and to analyze different types of noncooperative behavior specifically? 10. What are the boundary conditions for the influence of decision makers' psychological behavior on decision outcomes?
4. Efficient linkage of multiple subjects in the organization and implementation phase of emergency projects	11. How can the government establish an emergency command center to integrate the forces of society and market actors into the organizational implementation phase of emergency projects, and how can the information platform be used to allocate resources for society and market actors rationally?

6.1. Analysis of Social Media Information Associated with Emergencies

The first potential research direction is analyzing social media information related to emergencies. Previous studies have mainly focused on information extraction from emergency policy documents and information collected from government administrative departments about the external environment. However, the occurrence of emergency events also attracts extensive public attention. Particularly with the accelerated growth of social media sites like Twitter, WeChat, and microblogs, the information communication tools connecting the physical and virtual worlds have gradually become crucial real-time information access channels in EDM [32]. Users post a lot of text, pictures, and videos on social media in real-time about casualties, property damage, and emergency assistance during emergencies [46]. It has been shown that this multimodal information has a unique value for EDM [46]. Therefore, in order to lessen the danger brought on by the informational imbalance that exists between the public and decision-making professionals [72], and also to provide new ways for the public to participate in EDM actively [33], it is desirable to explore and effectively use the information in social media.

Information from social media might be analyzed in three stages: information acquisition, information integration, and information mining [36]. Multimodal information related to emergencies can be acquired from real-time data in social media, followed by semantic description and association of multimodal information using topics or events as basic units. Finally, tacit knowledge valuable for EDM can be mined from this multimodal information and applied to emergency management for specific application scenarios [36].

Regarding information acquisition, social media contains a large amount of noisy data that is irrelevant, redundant, or false to the emergent events, and there is a severe information overload problem [36]. Therefore, future research needs to focus on identifying information related to breaking events from large-scale social media data and on extracting the fine-grained information from them for decision-making [36]. For example, how can target keyword retrieval and exact matching be used to obtain relevant social media information? How can one use other more efficient methods (e.g., feature engineering, deep learning, etc.) to assign information to more fine-grained categories according to different scenarios to meet the information needs of different stakeholders?

Moreover, there is a large amount of repeatedly reposted content on social media, and removing the redundant information in the data processing is necessary. It is therefore worthwhile to study in depth how to adopt an efficient method to identify the same or

similar information in the dataset and remove the redundant information. In addition, compared with formal official messages, there are problems of informal language, abbreviations, misspellings, ambiguous wording, and arbitrary grammar in social media [36]. It is also worthwhile to think about how to verify the validity and authenticity of the original information quickly.

Regarding information integration, information related to emergencies in social media exists in the form of independent entries, and the amount of information exceeds the information processing capacity of the human brain. In contrast, as a unified method of organizing information, events can accurately reflect the objective facts of entities at a specific time and place, which is vital for the in-depth understanding of social media information [36].

When signs of emergencies appear, dynamic monitoring of social media data is used to predict the events that will occur in order to achieve early warning of crises. Most traditional preventative information collection relies on facilities such as professional sensors and communication platforms, which are costly. In addition, they mainly monitor natural disaster crises and do not pay much attention to artificial social crises [38]. In contrast, as the primary medium of public communication, social media can provide basic information for crisis prevention, such as geographic location, network relationships, and crisis rhetoric, and thus provide risk analysis [38].

After an emergency event, the amount of information related to a topic on social media over a while and in a particular region suddenly increases, reflecting the actual state of the event. On the one hand, existing research mainly focuses on using textual information in social media for sub-event detection and risk analysis, while image information in social media is more intuitive for presenting unexpected events. Integrating image features into event summaries and using keywords, geographic locations, representative tweets, and images to represent each sub-event is vital in the risk analysis of sub-events. On the other hand, currently there is less research on the feedback information posted by the public on social media. How to integrate this information to assist in making emergency decision goals and adjustments to emergency projects is something we need to consider in the future.

Regarding information mining, social media provides a significant amount of implicit data that can be further mined in addition to the obvious information about events [36]. First, the attribute architecture and the weight determination of the emergency decision problem can be assisted by identifying the subjective emotional tendencies of users hidden in the social media information. For example, using more accurate and fine-grained sentiment words to label information, such as machine learning or deep learning, can assist in setting decision goals. Second, analyzing the characteristics of theme and sentiment evolution in different stages of emergencies on social media can help emergency management departments understand the public's perception and sentiment tendency in emergencies, predict the future direction of public opinion, and adequately respond to the hot spots of public concern. For example, opinion leaders contribute significantly to the spread of online public opinion. We use some methods to identify opinion leaders in online comments. Then we guide opinion leaders with positive comments to actively express, to reduce negative emotions and reasonably respond to existing problems.

Furthermore, social media users also post content to describe their own or other people's difficulties and seek help. Therefore, extracting more fine-grained information on event elements such as affected people, resource needs, and damages from social media information can guide emergency management departments to use this as a basis to optimize the dispatching strategy of materials and personnel and provide accurate relief services. For example, the classification model is used to identify social media content containing user needs, and to further extract structured information such as demand subject, demand resources, demand time, and location. In addition to single demand mining, resource supply information related to donation and rescue can also be identified from social media information. The similarity calculation or attribute pairing between

demand and supply is used for automatic supply and demand matching to assist the dispatch of resources, thus improving the speed of emergency response.

Finally, the devastation and uncertainty of emergencies intensify negative emotions such as public anxiety and panic. The affected people in the event are more likely to have psychological problems, such as post-traumatic stress disorder. By discovering a series of negative emotions (including panic, anxiety or sadness, etc.) of different users after the event through emotion mining of social media information, and tracking public emotional changes by combining spatio-temporal data, we can find people with abnormal psychological conditions and provide psychological assistance in a timely fashion.

Through the analysis of social media information on emergencies, public participation and feedback are fully taken into account, enhancing EDM's sustainability.

6.2. Improvement of Computer-aided Tools

A second potential research direction is the improvement of computer-aided tools. In order to provide timely and accurate decisions when managing emergencies, researchers and practitioners have called for adopting computer-aided tools to support EDM [48]. There is still room for further improvement in related research.

First, emergency DSSs play a crucial part in enhancing decision-making precision and there is still room for further improvement in current research. There are two main types of information sources: one is the external environment, including changes in the disaster-prone environment, damage assessment of disaster-bearing bodies, distribution of rescue teams, and rationing of rescue supplies [43]; the other is historical experience, including laws, regulations, emergency plans, and experience of experts [44]. How to import different types of information into the system and match it with different categories of emergencies is what to consider in future research. Moreover, the problem of increased computational complexity and decreased efficiency when massive data are input is also to be researched. Furthermore, the design and development of an early warning system for emergencies is also something to be investigated in the future because, if timely warnings can be provided when signs of emergencies appear, the outbreak of emergencies will be effectively curbed. In addition, finding suitable metrics to assess the effectiveness of emergency DSSs and thus improve their performance is also to be explored.

Second, since automated planning techniques have significant advantages in terms of efficiency in generating emergency projects, there is still room for further improvement. There are complex constraints between different types of resources, and how to deal with the constraints between resources is something we need to consider in the process of applying automated planning technology in the future.

Finally, the case-based reasoning technique is effective in generating the reliability of emergency projects, and there is still room for further enhancement in future research. The quality of cases affects the reliability of the emergency project, and the increase in the number of cases will lead to the slow operation of the system. How to design appropriate indicators to evaluate the reliability and validity of cases, increase high-quality cases, enrich the content of cases, and reduce redundant cases needs to be investigated in the future.

In summary, the efficiency and reliability of EDM will be significantly improved in the future by improving the performance of computer-aided tools.

6.3. Impact of Decision Makers' Characteristics on Decision Outcomes

The core of EDM is people, i.e., decision makers. Therefore, the characteristics of decision makers in EDM situations will significantly impact the decision outcome. Current research on decision makers has produced a wealth of results, but some issues still deserve attention.

First, how to quantifiably represent evaluation information given by decision makers is something that needs to be studied in the future. Due to the randomness and complexity of emergencies and EDM's high-risk and time-sensitive requirements, decision makers have limited knowledge. They may provide incomplete evaluation information, and

how to make up the value of the incomplete information of decision makers needs to be considered in the future. For example, how to estimate the residual values in the evaluation information, taking the psychological acceptability of decision makers into account?

Moreover, the criteria of decision problems may have different natures, and different experts may have different opinions about different criteria. They may use different types of information to express their evaluations, so how to deal with heterogeneous information also needs to be researched in the future. For example, how does one design different transformation functions to unify heterogeneous information from decision makers into one type for fusion?

Second, how to specifically analyze different types of noncooperative behaviors needs to be explored in the future. In EDM, experts from different government departments have different interests and thus may exhibit noncooperative behavior [64]. Because compromise frequently entails giving up one's interests, there are a number of people or groups that are hesitant to change their beliefs in order to achieve an agreement in multi-criteria group decision situations [64]. Decision makers who exhibit uncooperative behavior can generally be classified into three types: (1) leaders, who have the power to make the ultimate choice and who may offer original, forward-thinking viewpoints; (2) experienced experts, who tend to have considerable knowledge of the decision problem and can offer persuasive opinions; (3) youthful and active decision makers, who have fairly radical and strongly motivated ideas [27]. The viewpoints offered by the first two of these three types of decision makers should be properly taken into account. In contrast, the opinions provided by the third must be carefully considered [64]. How to differentiate noncooperative behaviors according to the types of decision makers and how to analyze different types of noncooperative behaviors specifically needs to be investigated in the future. For example, how to conduct a thorough background investigation of decision makers to distinguish between different types of decision makers, retaining as much as possible the opinions provided by leaders and experienced experts, and excluding opinions provided by decision makers with extreme preferences?

Further, the boundary conditions of the influence of the decision maker's mental behavior on the decision outcome need to be studied in the future. The process of EDM should be as close as possible to human thinking. The dynamic nature of emergencies and the unpredictability of decision outcomes make decision makers have bounded rationality; therefore, the influence of decision makers' psychological characteristics on decision outcomes should be considered. However, if there are extreme risk preferences or extreme risk aversions among decision makers, it will often bring risks to the final decision outcome, resulting in the final decision outcome not being the optimal decision. Therefore, how to filter or screen out the extreme risk preferences or extreme risk aversions among decision makers needs to be considered in the future.

In summary, the operability of EDM will be significantly improved in the future by establishing an EDM method that understands human behavior as much as possible. Moreover, the organic combination of human decision theory and computer-aided tools in the future will be of great significance in promoting the scientific and practical EDM.

6.4. Efficient Linkage of Multiple Subjects in the Organization and Implementation Phase of Emergency Projects

In the organization and implementation stage of emergency projects, the efficient linkage of the three main subjects, government, society, and market, can help achieve an effective response to emergencies [71]. Currently, there is little research on this issue. Therefore, the efficient linkage mechanism of multiple subjects needs further exploration.

The government is the main body of emergency response. Emergency volunteer services have an essential role in emergency response to emergencies with their strong sense of social responsibility, accurate relief demand identification ability, and rapid response ability [71]. Emergency volunteer services mainly come from three channels: professional volunteer service organizations, corporate volunteer service teams, and volunteer service

groups formed by private individuals spontaneously, which involve social organizations and the public, but also enterprises. However, these volunteer services from different channels are often fragmented and unable to form an efficient linkage mechanism [71]. Therefore, according to the different natures of emergencies, how can the government set up the corresponding emergency command center? Moreover, while arranging various functional departments to initiate emergency measures, the management of emergency volunteer services should also be included in the work of the emergency command center. The establishment of a volunteer service coordination department to make cooperative arrangements for volunteer services from different subjects needs to be investigated in the future.

In addition, there is a lack of research on resource integration mechanisms. The lack of resources will directly affect the performance of emergency volunteer services, and even may cause volunteer casualties, which not only increases the cost of emergency volunteer services but also brings a negative impact on the subsequent emergency rescue. Therefore, the establishment of an information platform for the rational allocation of human, financial, and material resources needs to be considered in the future. For example, how can one establish a comprehensive data information platform to unite all kinds of volunteers in a database and realize information interchange? How can we integrate all kinds of service demand information to ensure an effective match between volunteer service supply and volunteer service demand, and at the same time allocate appropriate resources for the corresponding volunteer service supply?

In summary, in the future, by establishing an efficient linkage mechanism for multiple entities in the organization and implementation stage, the losses caused by emergencies can be quickly reduced.

7. Conclusions

In recent years, various types of emergencies have occurred frequently. Their impact and complexity have increased significantly, bringing serious challenges to the sustainable development of economy, society, and environment. The study of EDM is essential for successfully managing crisis events and achieving sustainable development goals, which has attracted widespread academic attention. However, the diversity of research findings on EDM, which covers multiple perspectives, makes it difficult for scholars and practitioners to understand the current state of research. Therefore, this study uses a literature review to summarize research progress as well as to identify future directions. First, a two-stage literature search was applied to identify the research sample. Then, the literature was analyzed econometrically and coded for content. Finally, a theoretical framework based on stakeholder theory was established to identify the known contents and uncover the contents to be further researched. The article suggests that future in-depth research should be conducted in four areas: analysis of social media information related to emergencies, improvement of computer-aided tools, influence of decision makers' characteristics on decision outcomes, and efficient linkage of multiple subjects in the organization and implementation stage of emergency projects.

This study has both theoretical and practical significance. From a theoretical research perspective, this review presents a theoretical framework for EDM based on stakeholder theory. The framework guides us to understand the current state of research on EDM and identifies what remains to be further researched. From the perspective of guiding practice, this study hopes to draw more scholars' attention to and conduct research related to EDM, thus contributing knowledge to the sustainable development of EDM practice. In particular, researching social media information related to emergencies can enhance the satisfaction of EDM. Furthermore, in-depth research on the characteristics of decision makers and computer-aided tools can develop decision models that combine scientific decision-making methods with the subjective will of decision makers to improve the rationality and effectiveness of EDM.

There are two main limitations of this study. First, this study is limited to the articles in the chosen database that match the selection criteria. Researchers can gain further insights from practitioners' other articles, books, and journals to enrich the theoretical framework. Second, not enough empirical studies have been done in this area. Future research on EDM in different cultural contexts could be explored.

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Appendix A

Research Topics		Core Issues	Author and Year	Source Journal	Research Questions	Research Methodology	Theoretical/Technical Perspective	Results
Government	Information collection stage	Extraction of information from emergency policy documents	Cun-xiang, D. et al. (2010) [4]	ComputerEngineering	How to quickly generate an emergency project based on the emergency plan?	Quantitative studies	/	A constraint satisfaction problem (CSP) based emergency decision method is proposed.
Government and Public	Problem definition phase	Event classification and determination of event risk level	Xu, X. et al. (2020) [47]	Operations Research and Management Science	How to classify events and determine event risk levels based on extensive data about public preferences?	Quantitative studies	Big Data Analytics	The preferred extensive data information posted on social media is clustered and analyzed to identify sub-events and to derive an objective risk level for each sub-event.
Government and Public	Goal setting stage	Attribute Architecture and Weights	Cao, J. et al. (2022) [72]	Expert Systems with Applications	How to solve the problem of access to attribute information in large group EDM?	Quantitative studies	Big Data Analytics	A complete data-driven method for acquiring attribute information for public attention topic analysis is proposed.
Government and Experts	Project design phase	Automated Planning	Li, M. L. et al. (2016) [52]	Journal of Intelligent & Fuzzy Systems	How to consider time preference in hierarchical task network planning?	Quantitative studies	HTN (Hierarchical Task Network) Planning	A temporal HTN planner TPHTN (Temporal Preferences HTN) is proposed to handle temporal constraints with preferences.

Research Topics		Core Issues	Author and Year	Source Journal	Research Questions	Research Methodology	Theoretical/Technical Perspective	Results
Government and Experts	Project design phase	Case-based Reasoning	Dong, Q. X. et al. (2016) [56]	Control and Decision	How to solve the problem of non-consistent attribute sets of target cases and historical cases?	Quantitative studies	Case-based Reasoning	We extract the historical cases with better matching degrees based on the matching degree to form a new sub-case database.
Government	Project selection phase	Fuzzy Decision Making	Ashraf, S. et al. (2022) [1]	Journal of Ambient Intelligence and Humanized Computing	How to propose an emergency decision method under generalized spherical fuzzy Einstein aggregation information?	Quantitative studies	Spherical fuzzy sets	A multi-criteria decision approach based on the generalized Einstein aggregation operator is proposed for the group decision problem in a spherical fuzzy environment.
Government	Project selection phase	Language Evaluation Information	Li, P., and Wei, C. P. (2019) [60]	International Journal of Disaster Risk Reduction	The standardization process can result in the loss of some decision information.	Quantitative studies	Glossary of Probabilistic Language Terms	Some new operators for probabilistic linguistic term sets are proposed based on D-S evidence theory, which preserves the form of probabilistic linguistic term sets.
Government	Project selection phase	Expert Weights	Chen, K. et al. (2020) [1]	Control and Decision	How to solve the problem of expert weights?	Quantitative studies	/	A new expert assignment method is proposed for the problem of consistency intervals in the hesitant fuzzy decision preference matrix of large groups.

Research Topics		Core Issues	Author and Year	Source Journal	Research Questions	Research Methodology	Theoretical/Technical Perspective	Results
Government	Project selection phase	Consensus	Xu, X. et al. (2017) [63]	Journal of Management Sciences in China	How to model conflict-based large group EDM considering the protection of minority views?	Quantitative studies	/	Based on the principle of protecting minority opinions, we propose a treatment method for dealing with minority opinions, define the conditions for determining the existence of minority opinions and the criteria for determining that minority opinions are valued, and establish a corresponding treatment model.
Government	Project selection phase	Knowledge aggregation	Zhang, L., and Wang, Y. (2017) [66]	Systems Engineering-Theory & Practice	How do you capture the personal knowledge of emergency experts and fuse it to generate collective knowledge?	Quantitative studies	Knowledge Meta	We construct a knowledge meta-model for EDM to support the representation and integration of multi-domain and multi-disciplinary explicit and tacit knowledge.
Government	Project selection phase	Theory of Evidence	Chen, X., and Wang, Y. (2018) [7]	Systems Engineering-Theory & Practice	How to investigate the problem of uncertain information source relevance in multi-attribute EDM?	Quantitative studies	Theory of Evidence	The proposed approach weakens the evidence theory's assumptions regarding the independence of information sources and expands its scope in practical applications.

Research Topics		Core Issues	Author and Year	Source Journal	Research Questions	Research Methodology	Theoretical/Technical Perspective	Results
Government	Project selection phase	Consider the psychological behavior of decision makers	Sha, X. Y. et al. (2021) [1]	Journal of Intelligent & Fuzzy Systems	How to establish an EDM approach considering the psychological characteristic of people?	Quantitative studies	Cumulative prospect theory	The representation of the cumulative vision value is improved for the problem that the attribute weights of different vision states have different effects on the cumulative vision value.
Government	Feedback modification phase	Dynamic adjustment	Zhang, K. (2014) [3]	Computer Engineering and Application	How to adjust the emergency project according to the changing situation of the emergency?	Quantitative studies	Scenario-Response	Predicting the next moment's scenario based on the objective trend of the attributes and the subjective prediction of the experts enables the scenario prediction to be more accurate.

Note: Due to the limitation of space, this article selected representative literature by considering the core topic relevance of the article, journal impact and article citation rate.

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