

Knowledge management and natural disaster preparedness: A systematic literature review and a case study of East Lombok, Indonesia

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ABSTRACT

Disaster impacts can be significantly reduced with disaster preparedness. Knowledge management is one of the building blocks of disaster preparedness. This paper comprehends the current state of the literature on knowledge management in community preparedness towards natural disasters. The paper identifies and develops a categorization of community-related knowledge management in disaster preparedness using a systematic literature review. Subsequently, the categorization is utilized in a case study to determine if community-related knowledge management in the preparedness phase can improve communities' responses in the event of natural disasters. The case study was conducted in the Lombok Island community of Indonesia, which experienced two major earthquakes in mid-2018 and early 2019. The results show that knowledge transfer and creation towards and among the Lombok community increased after the mid-2018 earthquake. Consequently, the community was better able to respond to the early-2019 earthquake. Better disaster preparedness activity designs are crucial in attracting participation and motivating residents to be more prepared.

1. Introduction

In recent years, the world witnessed an increase in disastrous events across the globe. Hence, a significant problem that challenges nations is natural disaster vulnerability. This vulnerability requires effective disaster management to lower the impacts, ensure quick and proper responses, and realize recovery in a short amount of time [1,2]. However, despite its size, the humanitarian sector is continually facing challenges. The humanitarian sector situation is volatile and needs more effort in preparedness [2,3]. Within the context of knowledge management, especially in sudden-onset disasters, humanitarian actors face constraints on how to monitor and evaluate the current situation [4] and to synchronize multiple actors' efforts and stakeholders' interests [2,3].

Disaster preparedness is vital in determining disaster management's success [5–7]. The Sendai Framework for Disaster Risk Reduction (SFDRR) sets enhancing disaster preparedness as a priority, as the response can be more effective. In this way, the capacity is in place for better recovery [8]. Disaster preparedness consists of developing knowledge and capacities by individuals, communities, governments, and humanitarian organizations. Focus is placed on effectively anticipating and responding to, and recovering from, disasters [9]. Disaster preparedness plays a critical role in disaster risk reduction. It can

minimize the impacts and improve the capability to cope with the disruption [5,10].

Knowledge management has been recognized as a vital part of disaster management. Several knowledge management roles in the extant studies include: (1) increase the visibility of humanitarian operations [11], (2) increase the ability to make decisions [4,12,13], (3) increase the response speed [12,14], (4) increase coordination [13,15], and (5) help the capacity development of the humanitarian actors and communities by supporting the creation and transfer of tacit and explicit knowledge among humanitarian actors and communities [4,12,16]. The implementation of knowledge management in the preparedness phase will support better responses during the response phase [11,15]. However, despite its potential contributions, the humanitarian sector is still characterized by knowledge-management related problems (e.g., low visibility of data for decision making; lack of coordination; low capabilities of actors, communities, and other stakeholders) [2,3,15].

Many studies have focused on enhancing the capabilities of the community responding to natural disasters (see Allen [17]; Kapucu [18]; Troy, Carson, Vanderbeek, and Hutton [19]; Weichselgartner and Pigeon [13]; Mathbor [20]). Most of these studies illustrate knowledge management's contribution to enhancing community capabilities during the preparedness phases and the need to integrate knowledge

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management with disaster risk reduction (DRR) policies and actions. More specifically, Weischelgartner and Pigeon [13] implies that research in disaster risk reduction must also about producing and transferring knowledge during preparedness stage so that people become less vulnerable towards disasters. However, researchers have yet to focus on a comprehensive framework of the operationalization of knowledge management towards communities during the preparedness phase and how it can impact communities' capacities during the response phase. Consequently, our study aims at filling the gap by investigating knowledge management during the preparedness and response phase in the community. More specifically, we aim to answer the following research questions:

RQ1: What is the current state of the art of community-related knowledge management for the preparedness stage?

RQ2: How does community-related knowledge management during the preparedness phase make a difference in the community's responses during the response phase of sudden-onset natural disasters?

This study focuses on sudden-onset natural disasters since this type of disaster is extremely volatile and unpredictable [2,11]. This is accomplished in several steps. First, we conduct a systematic literature review to better understand the current state of community-related knowledge management during the preparedness phase to address our research objectives. Then, we operationalize a case study to see how knowledge management during the preparedness phase can make a difference in the community's responses during the response phase. We investigate the case of Lombok Island in Indonesia. Lombok was stricken by a sequence of earthquakes in the middle of 2018 and again at the beginning of 2019. Both earthquakes caused significant damage in terms of human loss and assets [21]. It is expected that the research will contribute by identifying knowledge management activities during the preparedness phase in the current literature and providing insights on how the knowledge creation and transfer in the preparedness phase can make a difference during the response phase of a natural disaster.

The remainder of this paper is organized as follows. Section 2 presents the literature review. Section 3 explains the research methodology. Section 4 discusses the SLR results and the operationalization of variables derived from a framework built upon the SLR's result. Section 5 presents the findings of the case study. Section 6 discusses the findings, and Section 7 explains the conclusions and provides recommendations for future research.

2. Literature review

2.1. Disaster preparedness

Disaster preparedness is a stage in the disaster management cycle in which the response mechanisms are implemented to overcome factors that cannot be mitigated by society ([7]; pp.45–46). Disaster preparedness is necessary for disaster types with a greater risk of death that are difficult to predict (e.g., earthquakes) [22], as the impact is higher when communities are ill-prepared. Activities in disaster preparedness include: educating residents regarding disaster risks in the area; educating residents about safety procedures in the event of a disaster; developing, testing, and exercising emergency plans; and installing early warning systems [23].

From the perspective of humanitarian organizations, five building blocks of disaster preparedness must be in place and interconnected prior to a disaster taking place: human resources, knowledge management, logistics, financial resources, and the community [7]. Based on this perspective, Tomasini et al. [7] highlighted that humanitarian organizations: (1) must have well-trained human resources that can work professionally under uncertain circumstances; (2) need to be able to learn from previous experiences and ensure that tacit knowledge becomes explicit knowledge; (3) should have the appropriate skills in logistics management; (4) need to have sufficient financial resources that can efficiently be utilized, as well as the ability to raise funds; and (5)

need to be able to collaborate with other stakeholders (e.g., governments, private businesses, other humanitarian organizations, communities).

Doocy, Russell, Gorokhovich, and Kirsch [24] argue that communities must be the center of an emergency plan, as they are the first responders in the event of a disaster [22]. They also need to be able to work together and make decisions during the critical situation [25]. Hence, community-based disaster preparedness (CBDP) is an integral part of disaster risk reduction. It can be developed if there are partnerships among humanitarian organizations, the government, and the communities [24]. To have beneficial effects, however, CBDP must include community-driven participatory activities [26], in which the community obtains disaster preparedness knowledge by acquiring disaster preparedness information from various activities (e.g., socialization, education, workshops) and disseminating the information among themselves [27].

2.2. Knowledge management

The word "knowledge" has a mixture of meanings and interpretations. Gao, Li, and Clarke [28] state that knowledge is linked to various terms (e.g., data, information, intelligence, skills, experience, expertise, ideas, intuition, insight), depending on the context. Davenport and Prusak [29] define knowledge as a fluid mix of framed experiences, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. Weischelgartner and Pigeon [13] explain knowledge as the continuum of facts, data, information, knowledge, and wisdom.

Knowledge can be further differentiated as explicit and tacit/implicit [28]. Explicit knowledge is the knowledge that a person can easily explain or describe. It is a formalized and written knowledge, expressed in the form of data, scientific formulas, specifications, manuals, or textbooks. Implicit or tacit knowledge is the knowledge that a person may be unaware of having. It is difficult to articulate. It is action-based, unformulated, highly personal, and difficult to transfer. Gao et al. [28] also argues that tacit knowledge and implicit knowledge are not mutually exclusive. Hence, revealing them in an organization will require the allocation of organizational resources [30,31].

Knowledge management is defined as the process by which knowledge is created, shared, and utilized [12]. It is part of a strategy that turns an organization's intellectual assets, recorded information, and members' talents into greater productivity, new value, and increased competitiveness. It also consists of a method to simplify the sharing process by distributing, creating, capturing, and understanding the knowledge [29,32]. Knowledge management has been the central focus of many researchers in the past decade. Much of the literature on knowledge management addresses issues such as how to facilitate the creation, storage, and transfer of knowledge. Lin [68] describes individual factors and organizational factors that influence knowledge management in an organization. Grenier et al. [69] address the influence of the organizational environment on selecting knowledge management strategies. Gao et al. [28] discuss the nature, scope, and methodologies of knowledge management, while Desouza [70] describes the impact of the organizational structure on knowledge transfer and utilization among the different functions in the perspective of system theory. Nelson [73] develops knowledge maps for a not-for-profit firm. Harlow [71] proposes using the tacit knowledge index (TKI) to assess the level of tacit knowledge within firms and its effect on firm performance. Taylor [31] reviews the term tacit knowledge, while Platts & Yeung [30] describe some insight and approaches into managing tacit knowledge. Jasimuddin [72] addresses how knowledge is transmitted among the members of a large organization.

Concerning knowledge creation, Nonaka & Takeuchi [33] assume that the creation and development of knowledge occur through the interaction between explicit and tacit knowledge. They propose four knowledge conversion modes known as SECI model (see Fig. 1). The

	Tacit knowledge	To	Explicit knowledge
Tacit knowledge	Socialization		Externalization
From			
Explicit knowledge	Internalization		Combination

Fig. 1. The SECI model ([33]; p. 62).

conversion mode from tacit knowledge to tacit knowledge is named as socialization (S), in which, experience is shared and, hence, creating tacit knowledge. The second conversion mode is from tacit knowledge to explicit knowledge, which is called as externalization (E), whereby tacit knowledge is enunciated into explicit notions. The third conversion mode is from explicit knowledge to explicit knowledge, called as combination (C), which is the process of combining different kinds of explicit knowledge into a knowledge system. The last conversion mode is from explicit knowledge to tacit knowledge, named as internalization (I), which involves incorporating explicit knowledge into tacit knowledge. Furthermore, Nonaka & Takeuchi [33] also posit that knowledge is created at different levels (individual, group, organizational and inter-organizational). Hence, knowledge management can be implemented at the individual and the community/organizational levels [28], and it should not merely be about recording and manipulating explicit knowledge; it should also include addressing implicit knowledge, of which the benefits can only be derived through the process rather than the content [29].

2.3. Knowledge management in the humanitarian sector

Knowledge management plays a role in disaster management [4,11,12]. Studies on how knowledge management can be utilized on natural disaster management have been published by some researchers. For example, Allen [17] and Kapucu [18] investigate how local communities utilizes local knowledge and wisdoms in natural disaster management. Knowledge management will increase humanitarian operations' visibility by enabling data analysis and current situations to speed the response and support correct decision-making [11]. Knowledge management will also boost coordination and networking among the humanitarian actors and stakeholders [13,15,34] which will speed up the response.

Human resource management is a persistent problem in the humanitarian sector [35,36]. Knowledge management supports the creation and transfer of tacit and explicit knowledge. This action occurs among humanitarian actors by multiple media (e.g., training, coaching, workshops), which increases the humanitarian actors' capacity, despite high turnover in this sector. Knowledge management will also support institutional learning in the humanitarian sector by enhancing the process by which tacit knowledge learned during one disaster is transformed into explicit knowledge that can be used to prepare for the next disaster [2,16,37]. In addition, knowledge management supports disaster risk information's availability and accessibility. It also enables humanitarian actors' capacity development, communities, and stakeholders through knowledge creation and sharing [12,17,19].

The role of knowledge management in the preparedness phase is vital [16,37]. During this phase, knowledge management activities are mostly related to creating and transferring knowledge [12,16]. Knowledge is created during the preparedness phase by developing

books/methods/data (e.g., development of the Term of Reference (TOR) of disaster mitigation programs, historical disaster data, disaster mitigation books, government regulations) [17,38]. Knowledge creation during the preparedness phase also includes the transformation of tacit knowledge from previous disasters into explicit knowledge to prepare for the next disasters [2,12,16,17,37]. The knowledge transfer during the preparedness phase includes knowledge transfer among the same type of humanitarian stakeholders (e.g., knowledge transfers from one humanitarian organization to another humanitarian organization), or it can be transferred among different types of humanitarian stakeholders (e.g., from the government or humanitarian organizations to communities) [12,16,17,37].

3. Research methods

The research was conducted in three steps. First, we performed a systematic literature review (SLR) to better understand the current literature on community-related knowledge management during the preparedness stage. The focus was placed on how knowledge is created and transferred to the community during the preparedness phase. In the next step of this investigation, we examined how the community utilized this knowledge during the response phase. Second, in-depth interviews (IDIs) with practitioners were conducted to gain deeper insights into the kinds of knowledge creation and transfer that usually occurred during the preparedness phase of a disaster. We also utilized IDIs results to verify SLR results in the Indonesian context. Lastly, results from SLR and IDIs were used to develop a survey questionnaire for a case study in East Lombok regency, to investigate whether the knowledge created and transferred during the preparedness phase would make a difference in the response phase.

3.1. Systematic literature review and in-depth interview

The systematic literature review synthesizes the existing information related to a set of research questions in an unbiased presentation in five main steps: (1) formulating research questions; (2) locating studies; (3) selecting and evaluating studies; (4) analyzing and synthesizing results; and (5) reporting [39]. Here, we adopted the systematic literature review steps proposed in Denyer and Tranfield [39] and Thomé, Scavarda, and Scavarda [40].

Since our primary objective is to identify how knowledge is created and transferred to the community during the preparedness phase, we developed our keyword search as: "(knowledge OR information) AND (management OR create OR transfer) AND (community) AND (organization) AND (humanitarian OR disaster)". The steps are as follows. Firstly, we included 'knowledge OR information' as these words are often used together to explain the transfer of knowledge toward the community. Secondly, we used 'management OR create OR transfer' to point out management, creation, and transfer of knowledge. Thirdly, we used 'organization' to point out the second parties outside the community. Fourthly, we used 'community,' as this is the focus of our study, and lastly, we used 'humanitarian OR disaster'.

Our search process required that our keywords appeared either in the title or content of the article. We conducted our search on ABI/INFORM and ScienceDirect, since these are the two largest academic databases in the social sciences field. We limited the search period to after 2004, since this period was the beginning of the humanitarian operations hype [2]. We also limited our search to academic and peer-reviewed articles to ensure the quality of the articles. Next, we applied the inclusion and exclusion criteria to the result of our metasearch. We only included articles with the subject specifically related to disaster management, humanitarian/disaster operations, and disaster preparedness. We only included articles written in English and excluded non-English articles. Next, we conducted the title and abstract screening and quality assessment. We based our quality assessment on the content, the methodology, and the result. These steps resulted in 26 articles. We expanded this

number by snowballing and resulted in the final of 29 articles (see Fig. 2).

We interviewed eight informants from eight humanitarian organizations (HOs). Five of the informants were from non-governmental organizations (NGOs), two were from governmental organizations (GOs), and the last was from the Indonesian Red Cross (PMI). These organizations are actively involved in disaster management, including providing emergency responses in the East Lombok regency during the mid-2018 and early-2019 earthquakes. NGO1 and NGO2 are local organizations with national operational scope, while NGO4 is an international organization with its headquarters in Indonesia. The international organizations include UK-based NGO3 and USA-based NGO5. Furthermore, GO1 is East Lombok's Regional Agency for Disaster Management (BPBD Lombok Timur), while GO2 is East Lombok's Division of Social Welfare; Both GO1 and GO2 manage volunteers from the 240 communities.

We conducted the interviews between April and June 2019. Participants were asked about the preparedness and response stages of disaster management in Indonesia, in general. They were also asked about knowledge management activities towards the community in Lombok before the mid-2018 earthquake and between the mid-2018 and early-2019 earthquakes. Every interview lasted about 90–120 min, and all interviews were recorded and transcribed.

3.2. Case study: the Lombok Indonesia earthquakes of 2018 and 2019

We examined how the community utilized the knowledge that had been created and transferred during the preparedness phase into actions during the response phase. We conducted a case study of the Lombok Indonesia mid-2018 and early-2019 earthquakes. Lombok is an island located in Indonesia that was stricken by earthquakes measuring 7.0 on the Richter scale in July 2018, 6.8 on the Richter scale in February 2019, and hundreds of low Richter earthquakes in between.

The case study focused on the East Lombok Regency, one of the regencies located on Lombok Island in the West Nusa Tenggara Province of Indonesia. The island is where Mount Rinjani, the second-highest stratovolcano in Indonesia, is located (see Fig. 3). The East Lombok regency was selected as the case study because it has not experienced a massive earthquake for at least four decades. Lombok Island is home to 3,005,738 people, with more than one-third of the population living in the East Lombok Regency [41]. Just like in other rural parts of Indonesia, the community here is well known for its local wisdom of mutual cooperation called as "gotong royong".

Indonesia's Meteorology, Climatology, and Geophysics Agency (BMKG) stated that the 7.0 Richter scale earthquake that shook the

Lombok region in West Nusa Tenggara (NTB) on Sunday, 9 August 2018, was the most massive earthquake in the region's history. BMKG also recorded the number of earthquakes in 2019 for Lombok. There were 5330 earthquakes. The highest frequency of earthquakes took place in February 2019 with 636 earthquakes. Two sub-districts in East Lombok were selected for investigation (i.e., Sembalun, Sambelia) because of their proximity to the earthquake's center. These were also the two most affected villages during the disaster.

3.2.1. Population and sampling

We conducted a survey in Sembalun and Sambelia sub-districts and employed the purposive sampling method. Our questionnaire was distributed to 200 respondents. These survey participants were individuals who resided in the Sembalun or Sambelia sub-districts and experienced both earthquakes.

3.2.2. Operationalization of variables and data analysis

We used a structured questionnaire as a data collection tool. The questionnaire was systematically constructed chronologically. It consisted of five parts: respondents' characteristics, knowledge management activities before the first earthquake, respondents' response during the first earthquake in mid-2018, knowledge management activities between both earthquakes, and respondents' response during the second earthquake in February 2019. The knowledge management activities examined in the questionnaire were developed based on the categorization in Fig. 3, derived from SLR and IDI. The survey data were analyzed using statistical software (SPSS). Some secondary data were also collected during the fieldwork (e.g., earthquake mapping, disaster mapping, logistics distribution, other official documents).

3.2.3. Data collection

The data were collected between March and July 2019. The fieldwork in Lombok was conducted in July 2019; a small-scale earthquake also took place during that month that the researchers experienced. Two types of data were collected: primary and secondary data. The secondary data was collected from articles and reports related to the mid-2018 and early-2019 earthquakes. Primary data was collected using in-depth interviews (IDIs) and a survey conducted in the Sembalun and Sambelia sub-districts in July 2019. The survey aimed to determine whether or not the respondents acted (responded to the disaster) correctly (similar to the guidelines for disaster preparedness, published by the National Agency for Disaster Management (BNPBB)). The guidelines were shared with the community through HOs, GOs, and PMIs during the disaster preparedness activities (e.g., community meetings, socialization (social

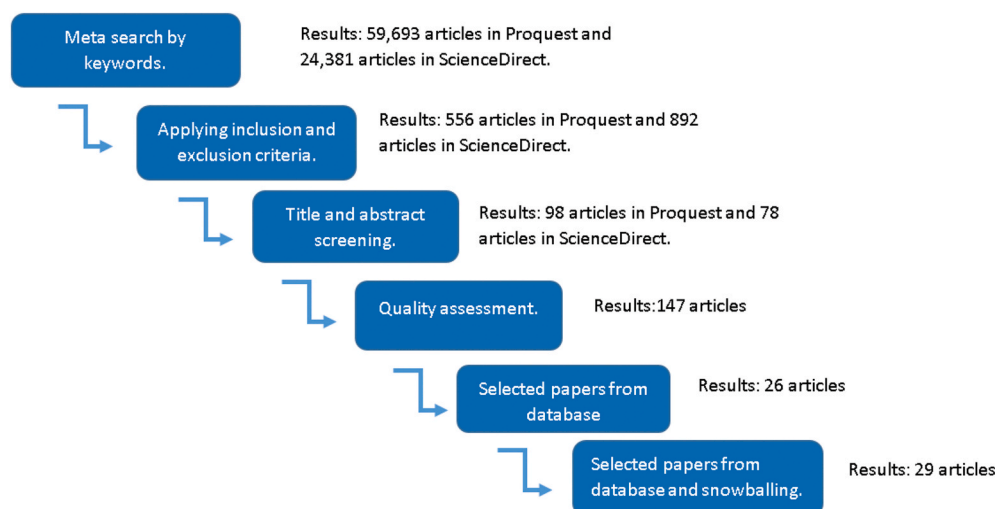


Fig. 2. The systematic literature review steps in this study.

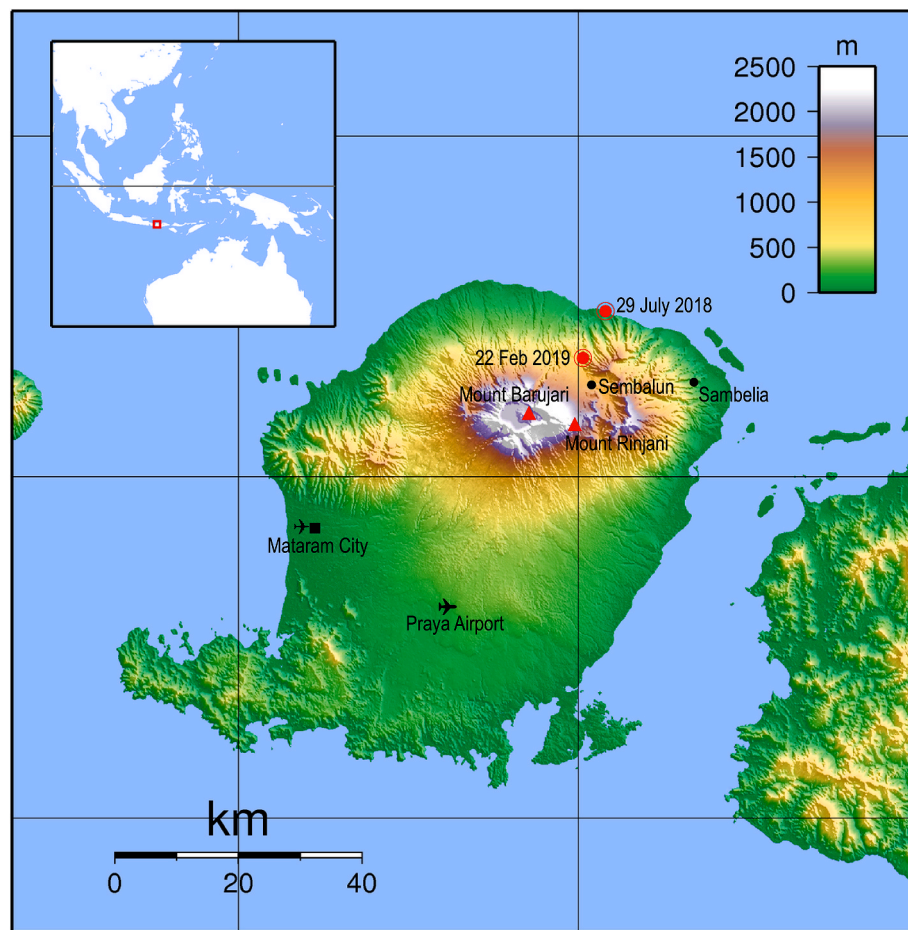


Fig. 3. Map of Lombok. *Note:* The red dots indicate earthquake epicenters and event dates. Black dots indicate field survey locations. The black square denotes the province's capital. *Source:* Wikimedia, BNPB. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

engagements), and simulations).

4. Results of the SLR and IDI: community-related knowledge management during the preparedness phase

Our systematic literature review illustrates how knowledge is created and transferred to the community during the preparedness phase. We find that the knowledge management activities related to the community during the preparedness phase can be categorized into two groups (see Table 1). The first group is the transfer of knowledge towards the community. The second group is the creation and transfer of knowledge among the community.

Knowledge management towards community includes activities with the aims of sharing and transferring information and knowledge (including skills) from the external to the internal community [42,43]. The creation of that knowledge had been developed outside the community. The information source and knowledge could be from books, mass media, or articles. The information and knowledge management towards the community can be initiated and managed by NGOs, the government, companies, research institutes, other communities, and other stakeholders [44,45]. This activity can be managed in either one-way or two-way methods of interaction.

In a one-way method of interaction, the providers (e.g., NGOs, governments) can share the information and knowledge with the community through one-way media (e.g., internet, newspapers, television, pamphlet, leaflets, socialization) [13,42,46,47]. The information and knowledge sharing could be performed offline or online. During this

method, the community will receive information and knowledge from any media or methods that do not allow feedback from the community.

In a two-way interaction method, the information and knowledge are shared with the community and transformed using two-way media or methods. More specifically, the communication and coordination between NGOs or the government and the community [1,42,45]; or establishing collaborations and partnerships with the community [57]. Providers can also network with the community to share information and let the community participate in the information sharing process [44,48,49]. This action could be conducted both offline and online. Information technology can be optimized to develop online networking [19]. Providers can also manage information and knowledge sharing by providing public consultation and participation [42].

During the public consultation process, the participants (community) will have the opportunity to receive information and knowledge. At the same time, they will deliver feedback to the providers of the public consultation. Workshops can also be used by providers [42]. During a workshop, participants obtain knowledge and have an opportunity to participate in some exercises. In a more advanced method, the knowledge transfer process can be facilitated by a simulation [54,55]. During a simulation, participants will have the opportunity to obtain the provider's knowledge and experience real-life situations based on the designed scenarios. Participants will have the opportunity to explore different responses and actions in a real-life situation, which will be more effective in terms of knowledge and skill retention. In the humanitarian context, simulations have been proven to be useful and effective in transferring skills and knowledge to the community.

Table 1
Knowledge creation and transfer related to the community during the preparedness phase.

[illegible]

In terms of knowledge management among the community, most processes include three interaction methods among community members: community sharing, community planning, and community practice [17,20,51,52]. In community sharing, community members share their information, tacit knowledge, explicit knowledge, and skills with other community members [50,51,56]. This activity can take place in various ways. It could be a story from a mother or father told to their sons or daughters or an experience shared by a community leader with his/her community members. It can also take place in a more formal manner (e.g., community meetings), where all community members share their information and knowledge with others [18,58].

The next level of knowledge management among the community involves community planning and community practices. In community planning, community members will participate in developing planning and programs for their community with regards to the mitigation of disasters [17,18,53]. The community planning process can be internally facilitated by community members or by inviting external stakeholders (e.g., NGOs, government). In community practices, community members can participate to implement the designed programs.

The SLR results are corroborated by the IDI informants. All humanitarian organizations (HOs) included in our IDI recognize and have practiced one or more knowledge transfer methods in the community. Knowledge sharing is the most commonly practiced method of knowledge transfer. Workshops and simulations have been practiced by a third of our interviewed organizations. Two out of six interviewed organizations have built a long-term collaboration by having volunteers in selected disaster-prone areas who will act as gatekeepers in the community. One of the interviewed organizations has actively facilitated community sharing and planning, which helped the community developing a disaster risks map, response plan, and evacuation route.

The categorization of information and knowledge management towards and among the community is illustrated in Fig. 4.

The categorization was transformed into a questionnaire. By using the questionnaire, we investigated the activities practiced before the mid-2018 earthquake and between the mid-2018 earthquake and the early-2019 earthquake. We also investigated the community's responses during the two earthquakes to determine the activities' impact on the community's responses during the disasters.

5. Case study results

We interviewed representatives from the Indonesian Red Cross at the East Lombok, Division of Social Welfare of East Lombok Regency, and

the Regional Agency for Disaster Management at East Lombok (BPBD Lombok Timur). The interviews revealed that respondents understood that before the mid-2018 earthquake, the area was prone to volcano eruptions and flash floods. Therefore, the disaster preparedness activities which were conducted in the area were aimed at preparing the residents for both types of disasters. The informant from the Indonesian Red Cross (PMI) further stated that the local wisdom had been incorporated into the safety procedure, for instance, if a disaster occurred, the village mosque would announce early warning to the villagers through the mosques' sound speakers and traditional slit drums called "kentongan". In addition, a communal food stock (in which the villagers contribute) was also set up to prepare for the disaster. However, the residents were not aware of the safety procedures for earthquakes.

We initially considered the responses to be correct, as they are similar to the guidelines for disaster preparedness from the National Agency for Disaster Management (BNPB). Standard of preparedness measures provided in the guidelines when an earthquake occurs are based on the individuals' position. Whenever an earthquake occurs, and the affected residents are indoors, they are advised to get under a table or drop, cover/hold, and avoid window glass.

During the interview with the representatives from BPBD Lombok Timur, the informants stated that during the disaster preparedness activities, they advised the residents who were indoors (when the earthquake occurs) to run outside. This advice is because the local house structures often do not follow a minimum standard and may not last more than 30 s during an earthquake ([59]; Informant from BPBD East Lombok, 2019).

Consequently, in this study, we consider two correct response versions to the earthquake for indoor affected residents. The correct response, Version 1, is if the respondents conducted the drop, cover, and hold. The correct response, Version 2, is when the respondents conducted the drop, cover, and hold or ran outside.

5.1. Respondents profile

Our respondents consisted of 100 people from the Sambelia sub-district and 100 people from the Sembalun sub-district. Most of the respondents were farmers who owned their land (49%), farmworkers (18%), and entrepreneurs (18%). Most of our respondents' educational backgrounds were junior/secondary (30%) and primary level (28%).

Table 2 details the profile of our respondents and explains the changes in monthly income for each observation period. On average, the monthly household income decreased after the mid-2018 earthquake

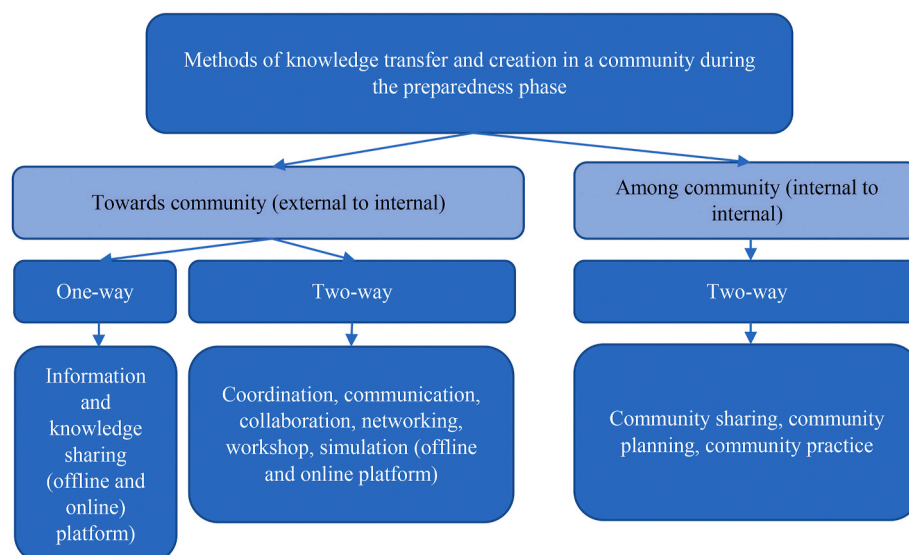


Fig. 4. Knowledge creation and the transfer of a community during the preparedness phase.

Table 2
Respondents profile.

Total samples		200	
Gender		Age	
Male	83 (42%)	Mean	39.035
Female	117 (58%)	Std. Dev.	11.589
		Min	18
		Max	85
Occupation		Highest level of education attended	
Farmers (own land)	96 (48%)	No school	20 (10%)
Farm laborer	36 (18%)	Elementary	57 (28.5%)
Civil servant	6 (3%)	Junior high	63 (31.5%)
Private employee	3 (1.5%)	High school	40 (20%)
Entrepreneur	17 (8.5%)	Diploma	3 (1.5%)
Not working	10 (5%)	Bachelor's Degree	13 (6.5%)
Others	32 (16%)	Other	4 (2%)
Monthly income before July 2018	Freq.	Percent	Cum.
less than IDR 1 million (70 USD) per month	75	37.69	37.69
between IDR 1 million (70 USD) & 2 million (140 USD) per month	81	40.7	78.39
between IDR 2 (140 USD) million & IDR 5 million (340 USD) per month	32	16.08	94.47
higher than IDR 5 million (340 USD) per month	11	5.53	100
Total	199	100	
Monthly income between July 2018 and March 2019			
less than IDR 1 million (70 USD) per month	144	73.85	73.85
between IDR 1 million (70 USD) & 2 million (140 USD) per month	40	20.51	94.36
between IDR 2 (140 USD) million & IDR 5 million (340 USD) per month	10	5.13	99.49
higher than IDR 5 million (340 USD) per month	1	0.51	100
Total	195	100	
Monthly income after 2019			
less than IDR 1 million (70 USD) per month	105	53.3	53.3
between IDR 1 million (70 USD) & 2 million (140 USD) per month	70	35.53	88.83
between IDR 2 (140 USD) million & IDR 5 million (340 USD) per month	19	9.64	98.48
higher than IDR 5 million (340 USD) per month	3	1.52	100
Total	197	100	

Note: The 200 respondents lived in Sembalun and Sambelia. Monthly income is in millions of Indonesian rupiah. Source: Authors' calculations.

and bounced back after the early 2019 earthquake. Household incomes have not fully recovered to the level of the condition prior to the mid-2018 earthquake. Most respondents believed that they had not yet recovered from the income losses due to the disasters. Almost 80% of the respondents had only one person who earned income for the family. Hence, it is understandable that most households were vulnerable to the loss of the only breadwinner.

5.2. Knowledge management before the mid-2018 earthquake

An incomplete understanding impeded effective knowledge transfer concerning disaster preparedness at the individual levels on how the preparedness process works. In some cases, the community might also affect the way households prepared for disaster risks. Based on our interviews, most disaster education programs that took place before the earthquake in mid-2018 were aimed at preparing people for landslides and flooding.

The survey results indicate that before the mid-2018 earthquake, only 5 out of 200 respondents had knowledge about disaster risks, the disaster-prone area map, the evacuation route, and safety procedures. Out of the five people, three respondents obtained the information by accessing mass and social media, while the other two respondents acquired the information from attending socializations and simulations organized by the local government.

The results further revealed that before the mid-2018 earthquake, most respondents (145 or 72.5%) did not realize that their area was prone to earthquakes. Even though our informants at the Division of Social Welfare and BPBD East Lombok regency stated that during that time the local government organized socializations and simulations for disaster preparedness towards flash floods, volcanic eruptions, and landslides, only 103 respondents (or 51.5%), 15 respondents, and 21 respondents knew that their area was prone to flash floods, volcanic eruptions, and landslides, respectively.

5.3. Response during the mid-2018 earthquake

For households, self-preparation towards disaster risk at home was considered a way to reduce the impact of severity from an earthquake disaster. The results showed that most respondents (123 people or 61.5%) were indoors when the earthquake occurred. Table 3 presents the response of the respondents to the disaster. It can be seen that out of 123 respondents who were indoors, if drop, cover/hold is the only correct response (correct response Version 1), only 13 respondents (10.6%) did it correctly. If running outside is also considered a correct response (correct response 2), 116 respondents (94.3%) acted correctly. The other seven people responded incorrectly by staying still and doing nothing during the earthquake.

Regarding the other 77 respondents who were outdoors when the disaster occurred, 65 (84.4%) did one of the correct actions by staying still/covering themselves/avoiding trees, electric poles, buildings, soft soil, and landslides. The rest (12 people/15.6%) responded incorrectly by running to find their family members during the middle of the earthquake.

After the earthquake stopped, 98 of the 200 respondents conducted the correct procedure by going to the safety zone/shelters/agreed meeting points, while the other 102 respondents conducted incorrect procedures by staying still. More specifically, only 7 out of the 98 respondents went to the agreed meeting points.

The results also reveal that 62.5% of the respondents contacted their family members after the earthquake, and 13.5% contacted village officials after the earthquake.

5.4. Knowledge management between the mid-2018 earthquake and the early 2019 earthquake

After the mid-2018 earthquake, there was an increase in community-

Table 3
Responses towards mid-2018 earthquake (indoors respondents).

	Correct response Version 1	Correct response Version 2
Correct action	13 (10.6%)	116 (94.3%)
Incorrect action	110 (89.4%)	7 (5.7%)
Total	123 (100%)	123 (100%)

related knowledge management activities. Socialization by HOs was the method of knowledge transfer that had the largest number of participants; this was followed by mass media. Part of the community also participated in simulations on disaster preparedness. Between the mid-2018 earthquake and the early 2019 earthquake, communities strengthened the knowledge transfer process among their members by managing village meetings and strengthening coordination and collaborations with HOs. As a result, HOs established volunteers in the communities.

Table 4 explains the number of respondents that understand each type of disaster knowledge, and the source of the knowledge. For instance, 26 respondents understand the disaster risk of the area, and they obtain the knowledge from mass media. As shown in Table 4, disaster risk and safety procedures were the most widely transferred knowledge to the community. This was followed by evacuation routes and disaster-prone area maps. Regarding the information source, the number of respondents that obtained the information from socialization/education activities was the highest in every disaster preparedness knowledge category, specifically the disaster risk and safety procedures. Concerning socialization/education and simulations, the respondents stated that the local government, the Indonesian Red Cross (PMI), and NGOs organized the activities.

The increase in knowledge activities after the mid-2018 earthquake was in line with the average increase in the community understanding of disaster preparedness knowledge. Before the mid-2018 earthquake, only 5 out of 200 respondents acquired knowledge about disaster preparedness. After the mid-2018 earthquake, 108 out of 200 respondents stated that they had acquired disaster preparedness knowledge. The average and standard deviation of the respondents' perceived understanding of disaster preparedness knowledge is presented in Table 5. We asked respondents about their understanding of disaster preparedness knowledge on a 6-point Likert-scale, where 1=strongly disagree and 6=strongly agree. Safety procedures had the highest average value of 3.81 and disaster risk had the lowest average value of 3.51.

The findings reveal that although the number of respondents who acquired disaster preparedness knowledge had increased after the mid-2018 earthquake, most of these respondents received knowledge from offline media (e.g., socialization, mass media). The utilization level of the internet was still low. The findings are understandable, as the respondents live in a rural area with limited access to telecommunications networks. Hence, they tend to obtain information from mass media and face-to-face activities (e.g., village meetings, socialization/education, simulations), instead of the internet and social media.

5.5. Response during the early 2019 earthquake

The survey results show that during the early 2019 earthquake, most respondents (148 people or 74%) were outdoors, probably because some of them were still in temporary shelters (tents). Out of 148 respondents, 123 people (83.1%) conducted the correct procedures at the time of the disaster by staying still/covering themselves/avoiding trees, electric poles, buildings, soft soil, and landslides, while the other 25 people (16.9%) conducted incorrect procedures by running to find their family

Table 4
The respondents' disaster preparedness knowledge and sources.

Information source	Disaster preparedness knowledge			
	Disaster risk	Disaster-prone area map	Evacuation route	Safety procedure
Mass media	26	9	0	18
Social media	8	1	4	9
Internet	9	0	3	10
Village meeting	23	4	10	15
Socialization/ Education	50	15	22	48
Simulation	19	9	10	16

Table 5
The respondents' perceived understanding of disaster preparedness knowledge.

	Disaster preparedness knowledge			
	Disaster risk	Disaster-prone area map	Evacuation route	Safety procedure
Average	3.51	3.66	3.70	3.81
Standard deviation	1.66	1.83	1.81	1.54

members.

For the other 52 people who were indoors, their response at the time of the disaster is presented in Table 6. Out of 52 respondents, only 12 people (23%) conducted the drop, cover, hold, 35 (67.3%) ran outside, and 5 (9.7%) stayed still waiting for the earthquake to be over. Hence, 23% of the respondents conducted the correct response Version 1 and 90.3% of respondents conducted the correct response Version 2.

After the earthquake stopped, 133 respondents (66.5%) conducted the correct procedures by going to the safety zone/shelters/agreed meeting points, while the other 67 respondents (33.5%) conducted the incorrect procedures by staying still. In particular, only 14 out of 133 respondents went to the agreed meeting points; the other 119 looked for a safe area. The results also reveal that 71% of the respondents contacted their family members after the earthquake, and 6.5% contacted village officials after the earthquake.

We combined the respondent responses who were indoors and outdoors during the earthquakes (Table 7). In terms of correct responses during the disaster, there is a significant increase from 39% to 67.5% for Version 1, while for Version 2, there is a slight decrease from 90.5% to 85%. There is a significant increase from 49% to 66.5% concerning the correct response after the earthquake stopped. Hence, even though there is a slight decrease in the correct response for Version 2, we can generally conclude that disaster preparedness activities indeed improved the residents' preparedness towards the earthquake.

The number of respondents who acquired disaster preparedness knowledge in between earthquakes is 108 (54%); however, the percentage of respondents with correct responses during the second earthquake is higher than that (Table 7). This result may be the result of their experience with the mid-2018 earthquake, which created tacit knowledge. This line of reasoning concurs with the recommendations in Dube and Munsaka [50] and Tuladhar et al. [56]; who argue that the community can use previous experiences to create tacit knowledge. Thus, the tacit knowledge from experiences, combined with the explicit knowledge obtained during disaster preparedness activities, made them better prepared and improved their responses when the disaster occurred.

6. Discussion

Our results reveal that knowledge management can be practiced in multiple ways. In our case study, NGOs managed some methods of knowledge transfer. The attention to the need to increase the community's disaster capacity was aroused after the first earthquake, consequently resulting from evaluating the devastating impact of the 2018 earthquake. The 2018 earthquake increased the community's awareness of the importance of disaster identification and management knowledge. The number of individuals who actively searched disaster-related information from mass media, social media, and the internet

Table 6
Responses towards early 2019 earthquake (indoors respondents).

	Correct response Version 1	Correct response Version 2
Correct action	12 (23%)	47 (90.3%)
Incorrect Action	40 (77%)	5 (9.7%)
Total	52 (100%)	52 (100%)

Table 7
Comparison between respondents' responses to both earthquakes.

	Mid 2018 earthquake	Early 2019 earthquake
Correct response during earthquake (Version 1)	78 out of 200 (39%)	135 out of 200 (67.5%)
Correct response during earthquake (Version 2)	181 out of 200 (90.5%)	170 out of 200 (85%)
Correct response after the earthquake stopped	98 out of 200 (49%)	133 out of 200 (66.5%)

increased compared to before the earthquake. Hence, it could easily be understood that not all community members had access to mass media, social media, and the internet between the 2018 and 2019 earthquakes. This is because they lived in a village and/or were still accommodated in the shelter after losing their property. Another reason that can explain why not all individuals accessed mass media, social media, and the internet is their lack of education that limited them from accessing highly complicated materials on the internet.

The most dominant method to transfer knowledge in the community between the earthquakes in 2018 and 2019 was public socialization/education. Between the earthquakes in 2018 and 2019, HOs managed several public socialization and education meetings in the villages and shelters. Disaster risks and safety procedures were the most common knowledge transferred to the community during socialization and education, followed by the evacuation route and the disaster-prone area map. The disaster simulations were organized by HOs, primarily by GO1 and PMI. At the community level, community-meetings and community-planning had been activated by the facilitation of some HOs, especially GO1, and contributed to facilitate the community to develop disaster risk maps, evacuation routes, and disaster response procedures at the village level. All villages had volunteers connected to HOs and actively communicated the current situations to the HOs.

The operationalization of knowledge management between the 2018 earthquake and the 2019 earthquake showed the results in terms of increasing the community knowledge related to disasters. There was an increase in the average level of disaster preparedness knowledge during this time period, when compared to the period before the 2018 earthquake, especially in safety procedure knowledge. In terms of understanding preparedness knowledge, the highest understanding is of safety procedures. This result may be because, at that time, the respondents had just experienced the first earthquake and felt that safety procedures were the most relevant preparedness knowledge, as compared to the others.

The knowledge management operationalization between the 2018 and 2019 earthquakes impacted the community response during the response phase of the 2019 earthquake. More specifically, there was an increase in the number of individuals who responded correctly, based on Version 1, that while indoors, reacting in the manner of drop, cover, and hold was the only correct response during the earthquake (Table 7). However, the actual percentage of individuals who responded correctly based on Version 2 when they were in the building during the earthquake was slightly lower. These findings could be because some individuals had traumatic experiences, while others had physical obstacles that prevented them from reacting more quickly. The physiological factors and the complicated situation during a disaster could affect individual response effectiveness during disasters.

The operationalization of knowledge management presented results about the community's response after the earthquake stopped. More specifically, there was an increase in the number of individuals who responded correctly after the earthquake stopped by directly approaching the determined disaster center and contacting authorized persons (including HOs volunteers).

In general, the response improved during the second earthquake, indicating that the residents were more prepared than they were before. However, several respondents did not proceed correctly. This situation

implies that a better design of disaster preparedness activities that can attract the residents' participation and facilitate the knowledge transfer effectively to motivate preparedness actions are still needed.

Findings of the case studies also implies that disaster preparedness knowledge has been created and transferred in the preparedness phase, predominantly by the method of socialization/education. Knowledge in created at the individual level by converting tacit to tacit knowledge, and explicit to tacit knowledge, and at the community level, knowledge is created when the knowledge is transferred from each member to other members of the community, for instance through village meeting.

7. Conclusions and implications

7.1. Conclusions

This study aims to identify the practices of the creation and transfer of knowledge management related to the community during the preparedness phase and better understand how the creation and transfer of knowledge management during the preparedness phase can affect community responses during the response phase of sudden-onset natural disasters. Our study illustrates that knowledge management can be operationalized between external parties (e.g., HOs) and the community and can be internally operationalized. There can either be one way or two-way relationships between the external parties and the community, while the relationships among the community are mostly two-way relationships. HOs can optimize different approaches to maximize the desired impact.

Our study also shows that knowledge management practices during the preparedness phase affected the community's capacity regarding disaster knowledge. However, improvement in knowledge transfer methods is still needed to attract participation and motivate residents to conduct preparedness actions.

7.2. Research implications

Knowledge management (KM) may play a role in disaster management [4,12,60]. This study supports the importance of community-related knowledge management during the preparedness phase. Community-related knowledge management could take on multiple approaches during the preparedness phase. During the preparedness phase, knowledge management helps the community to become more aware about disaster knowledge and skills. Regarding the challenging situation of a disaster, having knowledge management in place during the preparedness phase helped the community to respond better.

7.3. Practical implications

Improving the community's capacity requires multiple approaches based on the situation and the desired impacts. HOs can use multiple methods to transfer knowledge and skills to the community. Based on our case study in Lombok, volunteers in disaster-prone areas were beneficial for both community and humanitarian organizations. They helped the practice of knowledge transfers from HOs to the community. They also helped to maintain information flow and coordination between HOs and the community. During the time of the disaster, these volunteers helped HOs to quickly gather information about the current situation. Findings of the case study can be used by HOs in other disaster-prone rural areas in emerging countries to build the community's capacity during the preparedness phase.

7.4. Research limitations and future research opportunities

Disaster preparedness at the individual level is an effective mechanism during an earthquake. It can reduce injuries and fatalities, particularly inside buildings. However, knowledge transfer through disaster education and communication mediums is still questionable. This

investigation sought to identify community preparedness indicators through a systematic literature review and interviews with salient practitioners. We then employed these measures to evaluate nine villages' preparedness in the Sambelia and Sembalun sub-districts of the West Nusa Tenggara province in Indonesia. This action represents a critical case study, because of the two recent earthquakes in mid-2018 and early 2019. However, this study has limitations. The selected keywords used in the SLR stage may limit the number of papers collected in the initial stage, consequently, it may not capture all methods of knowledge creation and transfer in the disaster preparedness phase. Furthermore, this study only considered individuals in a rural area on a small island close to the earthquake center. Future studies can be extended to households with different characteristics (e.g., urban areas).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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