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RESEARCH ARTICLE

Improving the Effectiveness of Disaster Mitigation in Wonogiri Regency, Indonesia Using House of Risk Method

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Abstract Wonogiri Regency, the Republic of Indonesia, is an area that has potential to be affected by various types of disasters. This study aims to identify the types of disaster potentials in the Wonogiri Regency and to provide recommendations for effective disaster mitigation strategies that can be effectively implemented by the Regional Disaster Management Agency (*Badan Penanggulangan Bencana Daerah* or BPBD in short) of the Wonogiri Regency during 2021-2026 time period by using the House of Risk (HoR) method. The study found that floods, landslides, strong winds, volcanic eruptions, earthquakes, tsunamis, forest and land fires, droughts, and extraordinary events are likely to take place in the regency. The implementation of the HoR phase 1 yields 19 disaster risk events and 19 disaster risk agents. The use of Pareto diagram to the disaster risk agents results in 8 dominant risk agents of disaster, namely "Unstable ground"; "The trees are too old and fragile"; "The trees are too dense"; Lack of water resources"; Heavy rain intensity"; "Struck by disaster materials"; "Epidemic of a disease"; and "The building construction is not strong". The implementation of the HoR phase 2 produces 15 mitigation strategies along with their priority order in which the 5 mitigation strategies with the highest priority are "Working with related parties to reduce the potential of disasters"; "Conducting socialization and education of disasters"; "Establishing disaster-resilient villages"; "Mapping disaster-prone areas"; and "Training for disaster volunteers".

1. Introduction

Wonogiri is a district in Central Java, Indonesia. It is located between 7°32' - 8°15' South Latitude and 110°41' - 111° 18' East Longitude and consists of 25 sub-districts, 251 villages, and 43 urban villages with an area of 182,236.02 Ha (1). Wonogiri Regency consists of mountainous areas, limestone rocks, reservoirs, forests, beaches, and so on. With the diverse characteristics of the region, the potential for disasters is enormous hit Wonogiri Regency. Table 1 describes the number of villages that experienced disasters in Wonogiri in 2011, 2014, and 2018 (BPS Wonogiri, 2020). Sources from National Disaster Management Agency (*Badan Nasional Penanggulangan Bencana* or BNPB in short) of Republic of Indonesia (BNPB, 2021) stated that, during the 2010-2019 period, there were 401 disasters in Wonogiri, consisting of 174 landslides; tornado/ strong wind 123 times; flooding 53 times; forest and land fire 32 times; fires ten times; drought eight times; and tidal wave/abrasion one time.

Disaster management is a systematic process of using administrative guidelines in organizations or institutions by integrating operational skills and capacities, strategic policies, and increasing the ability to minimize hazards and vulnerabilities from disaster risk (Lin, 2018). In planning an activity, a good management is required (Sufa & Khoiriyah, 2017), and hence a quick response to particular disaster, for instance, is very likely to reduce loss of life and the suffering of the disaster survivors (see, e.g., (Setiawan et al., 2019)). Disaster management mainly lies at the strategic level of disaster management. Relevant parties, therefore, need to collect information, analyze, and disseminate problems related to disaster potentials (Boin & Lodge, 2016). Disaster mitigation includes efforts to reduce or eliminate the possibility or consequences of a hazard or both(Coppola, 2015). Risk is the probability of an outcome having a negative impact on people, systems, or assets (UNDRR, 2021). Risk assessment requires evaluating two variables (Bandaly et al., 2012): the probability of an adverse event occurring and the magnitude of the impact of the event. Disaster risk reduction and management requires good governance (Ahrens & Rudolph, 2006). Community's low understanding about disaster mitigation is likely to contribute to the creation of disaster's victims (Iskandar et al., 2022).

As far as the authors are aware, there hasn't been any research done on efforts to improve the effectiveness of disaster mitigation in the Wonogiri Regency. The use of storie approach to identify the Wonogiri Regency's zone of landslide vulnerability can be found in (Darmawan et al., 2018). The application of Markov chain approach in predicting natural disasters in Wonogiri Regency was carried out by (Melati & Jatipaningrum, 2018). (Pratamaningtyas et al., 2016) analyze the preparedness of Dr. Soediran Mangun Sumarso Hospital, Wonogiri, in response to disaster arrivals. (Suyanto & Hartono, 2019) investigates the impact of employing a disaster response manual on family coping mechanisms in a tsunami-vulnerable community in Wonogiri.

Table 1. Number of villages that experienced disasters in Wonogiri Regency in 2011, 2014, and 2018

Disaster Event	Number of villages experiencing disaster		
	2011	2014	2018
Flood	35	22	64
Earthquake	3	1	21
Landslide	102	73	113

In this article, the authors discuss the findings on improving the effectiveness of disaster mitigation for Regional Disaster Management Agency (*Badan Penanggulangan Bencana Daerah* or BPBD in short) of Wonogiri Regency using the HoR method for the years of 2021 to 2026. The Wonogiri's BPBD was selected in this instance based on the regulation, as BPBD is an organization with the authority to manage disasters in a district under Law No. 24 of 2007 (Sekretariat Negara RI, 2007). Additionally, the Wonogiri's BPBD is in charge of all disaster management-related actions within the region. Numerous studies point out the necessity of enhancing disaster management institutions' effectiveness (see, e.g., (Theodora, 2020; Tuladhar, 2019)) and the significance of increasing their capacity (see, for instance, (Few et al., 2016; Scott et al., 2016; Scott & Few, 2016). The HoR technique can pinpoint risky situations, rank risky root causes, and choose risk mitigation tactics (Ambarwati & Nugroho, 2019). The HoR technique was chosen because it was a good fit for the issues raised by this investigation.

2. Methods

This study uses the HoR method (see (Pujawan & Geraldin, 2009)), a method that combines the principles of FMEA (Failure Mode and Effect Analysis) with the HoQ (House of Quality) process. The HoR method consists of two phases, namely HoR phase 1 and HoR phase 2. Phase 1 HoR determines the dominant risk agent to be mitigated, while phase 2 HoR is needed to produce priority mitigation strategies.

The implementation of HoR phase 1 begins with gathering disaster potentials in Wonogiri Regency through a series of interviews with the Head of the Prevention and Preparedness Section and the Prevention and Preparedness Section Staff of the Wonogori's BPBD as resource persons in the research. Disaster potentials are analyzed to find disaster risk events and disaster risk agents. The next step is to determine the Aggregate Risk Potential (ARP) value by firstly determining the severity of the risk event, occurrence (level of probability of occurring) for the risk agent, and the weight or correlation value between risk events and risk agents. In this case, the rating scale for severity is 1 (no impact) to 10 (failure to meet safety or regulatory requirements); the rating scale for occurrence is a scale of 1 (very low) to 10 (very high); and alternative correlation values between risk events and risk agents are 0 (no correlation), 1 (low correlation), 3 (medium correlation), and 9 (high correlation). Secondly, Pareto diagram is implemented to the resulted ARP values to determine the rank of the dominant risk agent.

In the HoR phase 2, a focused group discussion (FGD) was conducted with the resource persons to (1) produce mitigation strategies; (2) determine the correlation values between the mitigation strategies and the dominant risk agents; (3) calculate the total effectiveness (TEK) of each mitigation strategy; (4) assess the degree of difficulty (Dk) of each mitigation strategy with a choice of values of 3, 4, or 5 (depending on how difficult the mitigation strategy can be); and (5) calculate the value of effectiveness to difficulty (ETD) for each mitigation strategy. The results of the HoR phase 2 method are the priority order of disaster mitigation strategies by the Wonogiri's BPBD for the time period of 2021-2026.

3. Result and Discussion

The number of disaster events in Wonogiri Regency in 2015-2020 is presented in Table 2. Several disasters that have the potential to hit Wonogiri Regency and have impacts that cause damage to the surrounding community are presented in Table 3. The results of identifying the disaster risk events (Ei) in the Wonogiri Regency are shown in Table 4. Based on the disaster risk events, disaster risk agents (Ai), which are the causes or sources that can cause risk events, are subsequently obtained. The disaster risk agents are shown in Table 5. By entering the disaster risk events and their level of severity, the disaster risk agents and their occurrence, and the correlation values of the disaster risk events and the disaster risk agents into the HoR phase 1 (see Table 6), the dominant disaster risk agents can eventually be produced.

As shown in Table 2, landslides, floods, and strong winds are disasters with a relatively high number of occurrences in the Wonogiri Regency. Fires are disasters with several subsequent circumstances. In 2019-2020, floods and strong winds were two types of disasters with a relatively higher number of events than other types of disasters.

Based on the interviews conducted, it was revealed that there are 9 disaster potentials in Wonogiri Regency (see Table 3). In addition to floods, landslides, strong winds, and fires, the other disaster potentials are volcanic eruptions, earthquakes, droughts, tsunamis, and extraordinary events. The 9 disaster potentials are in accordance to the Law no. 24 of 2007 (Sekretariat Negara RI, 2007). These results are similar to a the study conducted in Surakarta (see (Prasetyo, 2020), which found that disaster potentials in the city are floods, hurricanes, volcanic eruptions, extraordinary events (Kejadian Luar Biasa or KLB in short), fires, and industrial accidents/ technological failures. Regional characteristics and geographical location cause differences in the disaster potentials. The 9 disaster potentials also have similarities with the disaster potentials related to Central Sulawesi revealed in 2011 (Martini, 2011), where floods, landslides, earthquakes, and tsunamis are stated as disaster potentials that may occur in the area. The disaster potentials are also similar to those in Landak Regency, West Kalimantan, found in 2015 (Wahyuningtyas & Pratomo, 2015), namely floods, landslides, hurricanes, forest and land fires, and fires in settlements.

Table 2. Number of disaster events in Wonogiri Regency in 2015-2020

Years	Number of Events	Type of Disaster			
		Landslides	Floods	Strong winds	Fires
2020	227	34	95	93	5
2019	748	56	134	498	60
2018	359	113	64	119	63
2017	1317	976	267	51	23
2016	362	207	131	0	24
2015	468	276	33	116	43

(Source: Wonogiri's BPBD)

Table 3. Disaster potentials in the Wonogiri Regency

Disaster potential	No	Disaster potential
Floods	6	Tsunamis
Landslides	7	Forest and land fires
Strong winds	8	Droughts
Volcanic eruptions	9	Extraordinary events
Earthquake		

Table 4. Disaster risk events in Wonogiri Regency

Symbol	Risk event	Symbol	Risk event
E1	The overflow of puddles	E11	Community activities are hampered
E2	Broken embankment	E12	Casualties and injuries
E3	Disconnected road access	E13	Damage to land and crops
E4	Damage to houses/buildings	E14	The economy is hampered
E5	Loss of property and belongings	E15	Fallen tree
E6	Dead animal	E16	Damage to public facilities
E7	Smog	E17	Closed public facilities
E8	Air pollution	E18	Trauma for affected victims
E9	Material loss	E19	Education temporarily stopped
E10	Global warming		

Table 5. Disaster risk agents in Wonogiri Regency

Symbol	Risk agent	Symbol	Risk agent
A1	Littering	A11	The building construction is not strong
A2	River sediment	A12	The age of the building is old
A3	Lack of water catchment areas	A13	Burning materials
A4	narrow river flows	A14	Struck by disaster materials
A5	Materials covering the river flow	A15	Lack of public knowledge
A6	Heavy rain intensity	A16	Unstable ground
A7	Community negligence	A17	Lack of water sources
A8	Volcanic ashes	A18	No evacuation routes
A9	The trees are too old and fragile	A19	Epidemic of a disease
A10	The trees are too dense		

Based on Table 4, there are 19 disaster risk events in Wonogiri Regency. The 19 risk events differ from the 17 disaster risk events in Surakarta found by (Prasetyo, 2020), most likely due to the difference in disaster potentials between the two cities.

By observing Table 5, it can be seen that, in Wonogiri Regency, 19 disaster risk agents (or the source or cause of disaster risk events) were found. The disaster risk agents are slightly different from those found by (Prasetyo, 2020) in regard to City of Surakarta. Unstable soils, lack of water sources, and affected disaster materials were not found as the risk agents for Surakarta. On the other hand, the disaster risk agents have similarities with those found previously by (Larasati et al., 2017) with regard to Wonogiri Sub-Regency, namely littering, high rainfall intensity, lack of water catchment areas, material covering river flows, unstable soil, and lack of community knowledge.

Some of the disaster risk agents provided in Table 5 are in line with the results of previous research. Poor building quality was one of the causes of a large number of victims in the 2010 Haiti earthquake (Marshall et al., 2011). Lack of attention to the importance of good building construction was the cause of the large number of fatalities imposed by several earthquakes in Turkey (Green, 2005). Building safety is a crucial issue in relation with the post-disaster shelter reconstruction programs (Harriss et al., 2020). The unstable soil contributes to the severity of the earthquake impact in Turkey (Green, 2005) and is an essential factor in predicting the occurrence of landslides (Ho et al., 2012). The value of soil stability was concluded to be potentially a significant indicator of the vulnerability of an area to landslides (Sharma et al., 2012). Expansive soil is one type of soil that is prone to landslides (Hou et al., 2013). In Malawi, flooding increases as river sedimentation rises (Munthali et al., 2011). In Asian, South American, and African countries, scarcity of water resources creates a risk of conflict (Gunasekara et al., 2014). In Shimian, China, heavy rains caused destructive debris flows (Ni et al., 2014). (Kasdan, 2016) and (Hoffman, 2015) suggest that socio-cultural factors are essential elements in disaster risk management. In the context of the Greek society he studied, the effectiveness of disaster preparedness was strongly influenced by education (Theodora, 2020). In Australia, waste disposal poses a risk of flooding (Neuhold, 2013; Neuhold & Nachtnebel, 2011). An outbreak of foot and mouth disease in rural areas of the United Kingdom in 2001 was at risk of transmitting to visitors to these rural areas (Auty et al., 2019). Water catchment area is suggested as one of causes of flooding (Sulistyo et al., 2021).

After knowing the ARP value in the phase 1 of HoR matrix, then the data is processed using a Pareto diagram. The Pareto chart will refer to the 80:20 rule, where 80% of problems are affected by 20% of causes. Judging from the Pareto diagram in Figure 1, there are 8 disaster risk agents that are included in 80% of the dominant problems. The eight disaster risk agents are presented in Table 7.

Based on Table 7, it is found that eight dominant disaster risk agents will later be handled by proposing mitigation strategies. In this case, the disaster risk agent that occupies the highest priority to be dealt with is "Unstable ground" (the ARP value of 912). The next priority order with relatively significant differences in ARP values is "Trees are too old and fragile" and "Trees are too dense" (both with the ARP values of 312); "Shortage of water sources" (ARP value 288); "Intensity of heavy rain" and "Attached by disaster materials" (the ARP value of 252); "Disease outbreak" (the ARP value of 192); and "The building construction is not strong enough" (the ARP value of 147).

Table 6. House of Risk phase 1

Risk Event	Risk Agent																			Severity
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	
E1	3	9	3	1	1	3	1							1						2
E2																				1
E3						3	1		3	3	1	1		3	1	9		1		7
E4						1			3	3	3	3	1	3	1	3		1		6
E5						3	1		3	3	3	3	3	3	1	3		1		5
E6							1													3
E7								1												2
E8								1												2
E9									3	3	3	3	3			3				3
E10																				3
E11								1									3		3	3
E12								1						1						3
E13																9	9			3
E14																			3	3
E15						3			3	3						3				5
E16																1				5
E17																			3	5
E18													1	1					1	4
E19																			9	3
Occurance	6	6	3	4	4	4	4	2	4	4	3	3	2	4	5	6	8	6	3	
ARP	36	108	18	8	8	252	68	20	312	312	147	147	68	252	90	912	288	108	192	
Priority	15	10	17	18	19	5	13	16	2	3	8	9	14	6	12	1	4	11	7	

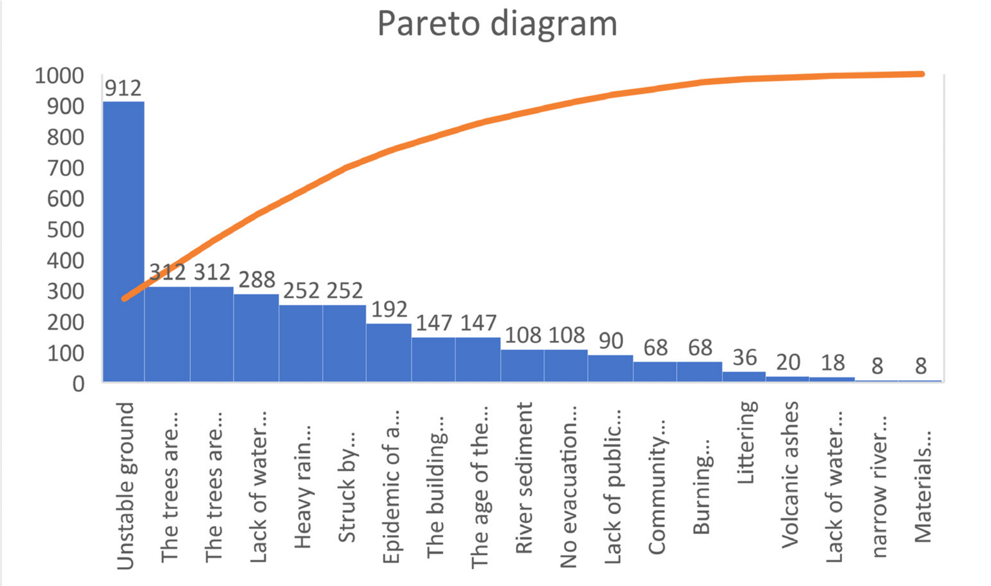

Figure 1. Pareto chart of aggregate risk potential (ARP) values of disaster risk agents in Wonogiri

Table 7. Dominant disaster risk agents

Symbol	Risk agent	ARP
A16	Unstable ground	912
A9	The trees are too old and fragile	312
A10	The trees are too dense	312
A17	Lack of water sources	288
A6	Heavy rain intensity	252
A14	Struck by disaster materials	252
A19	Epidemic of a disease	192
A11	The building construction is not strong	147

Table 8. The mitigation strategies for the dominant disaster risk agents

Symbol	Mitigation strategy	Dk	Symbol	Mitigation strategy	Dk
P1	Carrying out cleaning activities	3	P9	Installing evacuation points	3
P2	Establishing disaster-resilient villages	3	P10	Training for disaster volunteers	3
P3	Doing residential relocation	4	P11	Providing logistics and equipments	3
P4	Building talud	4	P12	Mapping disaster-prone areas	3
P5	Planting vegetative plants	3	P13	Reforestation	3
P6	Conducting socialization and education of disaster	3	P14	Building a water reservoir	3
P7	Installing early warning systems	4	P15	Working with related parties to reduce the potential of disasters	3
P8	Conducting disaster simulation	3			

House of Risk phase 2 is used to provide priority mitigation strategies by considering available resources. In HoR phase 2, the total effectiveness of each mitigation strategy (TEk) and the degree of difficulty of each mitigation strategy, Dk, are sought. By using both values, the proposed mitigation strategy (ETDk) is prioritized for handling the dominant disaster risk agents.

Based on interviews with resource persons, a mitigation strategy (Pi) was obtained to deal with the dominant risk agent in Wonogiri Regency from 2021 to 2026 (presented in Table 8). Based on the results of data processing obtained from interviews with the same parties, the priority order of mitigation strategies was obtained (Table 9). By including a description of each mitigation strategy, Table 10 represents the order of mitigation strategies that will be prioritized for handling by the Wonogiri Regency Regional Disaster Management Agency from 2021 to 2026.

Table 9. House of Risk phase 2

Risk Agent	Mitigation Strategy															ARP
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	
A16		9	9	3	9	9	9	9	9	9	3	9	9		9	912
A9	3	9			1	9				3	1	1	9		9	312
A10	3	1				9				9	1	1	1		9	312
A17	3	9	1		9	9				3	9	9	9	9	9	288
A6	9	3			3	9	3	3	3	9	3	9	3	9	9	252
A14	9	9	3	1		9		3	3	3	3	9			9	252
A19	9	9				9				9	9	9			9	192
A11					9		3	3	1						9	147
TEk	9000	18672	9252	2988	13191	22680	9405	10161	9867	17568	9192	17688	14676	4860	24003	
Dk	3	3	4	4	3	3	4	3	3	3	3	3	3	3	3	
ETDk	3000	6224	2313	747	4397	7560	2351.25	3387	3289	5856	3064	5896	4892	1620	8001	
Priority	11	3	13	15	7	2	12	8	9	5	10	4	6	14	1	

*TEk - Total Effectiveness, Dk - Degree of Difficulty), ETDk - Effectiveness to Difficulty ratio
*Correlation Weight = 0 (no correlation), 1 (low), 3 (middle), 9 (high).

Table 10. Mitigation strategies according to their order of rank

Symbol	Mitigation Strategy	ETDk	Rank
P15	Working with related parties to reduce the potential of disasters	8001	1
P6	Conducting socialization and education of disaster	7560	2
P2	Establishing disaster-resilient villages	6224	3
P12	Mapping disaster-prone areas	5896	4
P10	Training for disaster volunteers	5856	5
P13	Reforestation	4892	6
P5	Planting vegetative plants	4397	7
P8	Conducting disaster simulation	3387	8
P9	Installing evacuation points	3289	9
P11	Providing logistics and equipments	3064	10
P1	Carrying out cleaning activities	3000	11
P7	Installing early warning systems	2351	12
P3	Doing residential relocation	2313	13
P14	Building a water reservoir	1620	14
P4	Building talud	747	15

It can be seen in Table 10 that "Working with related parties to reduce the potential of disasters"; "Conducting socialization and education of disaster"; "Establishing disaster-resilient villages"; "Mapping disaster-prone areas"; and "Training for volunteers" are mitigation strategies that rank 1 to 5 to be implemented by the Wonogiri's BPBD in the period from 2021 to 2026. Meanwhile, "Reforestation"; "Planting vegetative plants"; "Conducting disaster simulation"; and "Installing evacuation points" are mitigation strategies in order 6th to 9th for the same timeframe. In this case, the 1st to 5th order mitigation strategies contributed 53.6% to the total ETD values of the 15 mitigation strategies. Meanwhile, the 1st to 9th mitigation strategies contributed 79.1% to the total ETDk values of the 15 mitigation strategies.

The mitigation strategies above have similarities with the findings of several researchers. (Rahman, 2015), for instance, proposed mitigation strategies in the form of compiling a database of areas of disaster potentials; installing an early warning system (EWS); conducting socialization, training, and disaster simulations; and providing information. (El-Masri & Tipple, 2002) discuss the importance of cooperation between related parties to carry out disaster mitigation within developing countries. The imperativeness of disaster mitigation strategies in the form of disaster socialization and education, procurement of logistics, relocation of settlements, identifying disaster-prone areas, disaster evaluation training, conducting disaster response volunteer training, and collaborating with the government and the community is suggested by (Martini, 2011). (Ferreira et al., 2016) accentuate the importance of zoning land uses to reduce seismic risk. The importance of reforestation to mitigate the risk of shallow landslides can be found in (Galve et al., 2016).

The following paragraphs provide a more detailed description of the 1st to 5th mitigation strategies. The description is on the proposed mitigation strategies in association with the Wonogiri's BPBD as well as similar proposals in various disaster contexts that can be found in several types of literature.

a. The first mitigation strategy: working with related parties to reduce the potential of disasters. the Wonogiri's BPBD, in carrying out disaster management in the regency, collaborates with several parties such as the government, academics, entrepreneurs, the community, and the mass media. Cooperation and coordination between these parties are essential to minimize the impact of disaster potentials that potentially occur in the Wonogiri Regency. The importance of cooperation in disaster management is in line with various other studies. In the context of hurricane Katrina and Rita disaster management in the United States, collaborative decision-making practices in the EMAC (Emergency Management Assistance Compact, an understanding of mutual assistance between states during natural and non-natural disasters in the United States) are at a relatively satisfactory level (Kapucu & Garayev, 2011). In the context of shipping in the Arctic region, cooperation among various stakeholders in disaster risk management is the most effective mechanism in formulating disaster prevention and emergency response plans (Mileski et al., 2018). Cooperation, collaboration, and coordination are essential aspects of disaster mitigation, according to (Parkash, 2015). (Lee, 2020) suggests that knowledge, experience, and skills of public officials affect the establishment of good cooperation between various parties involved in disaster management.

b. The second mitigation strategy: conducting socialization and education of disasters. Disaster socialization and education are carried out by the Wonogiri's BPBD in areas considered prone to disasters. The purpose of disaster socialization and education is to educate the public about the actions that must be taken when a disaster occurs and to raise awareness about the importance of mitigating a disaster before it occurs. Implementing educational measures in the context of preventing and reducing exposure to hazards and disaster vulnerabilities, increasing preparedness in emergency response and recovery, and thereby strengthening resilience is stated as one of the goals of the Sendai Framework (UNDRR, 2015). Disaster education is an essential means of ensuring public safety (Dufty, 2020). The importance of disaster education in reducing disasters and achieving human security is widely recognized (Shaw et al., 2011). In Japan, disaster prevention education accompanied by weekly exercise has increased self-efficacy (self-confidence about the ability to do something), where increased self-efficacy can improve physical fitness (Katayama et al., 2021). More specifically, disaster and emergency education is required to focus more on disaster-prone groups (Torani et al., 2019). In Indonesia, the importance of disaster education is stated by (Hayudityas, 2020), (Pahleviannur, 2019), (Suciana & Permatasari, 2019), (Suhardjo, 2011), and (Suharini et al., 2015), while (Asteria, 2016), (Kusumawati & Uman, 2019) and (Purworini et al., 2019) emphasize the importance of disaster communication.

   In the implementation of disaster education, various methods can be applied. A case study from Tamil Nadu, India, concluded that the disaster awareness workshop utilizing the contents of a DRH-Asia (Disaster Reduction Hyperbase-Asia) (Asharose et al., 2015) can improve the level of understanding about disasters and promote the significance of disaster mitigation actions. The combination of the principles of participatory action research (PAR) and grounded theory in a case study of disaster risk reduction education at a public school in Biliran Province, the Philippines, is stated as opening up opportunities for maximum contribution of the participants towards gaining knowledge, prioritizing problems, and conceptualizing solutions (Canlas & Karpudewan, 2020). The application of PAR method in Houston, Texas, also found that the method contributed positively to participants' knowledge on disaster-resilience (Meyer et al., 2018). Research on using a disaster awareness game (DAG) applied to grade 5 students in multi-cultural communities in the Turks and Caicos Islands in the Caribbean concluded that the approach effectively improved the awareness about various hazards caused by nature (Clerveaux et al., 2010). Another research on school-based disaster mitigation education in elementary schools in Da Nang City, Central Vietnam, resulted in conclusions about the importance of leadership and prioritization in helping schools on managing internal and external resources in order to find solutions to various challenges (Thi & Shaw, 2016).

c. The third mitigation strategy: establishing disaster-resilient villages. In 2021 the Wonogiri's BPBD had formed 169 disaster-resilient villages or often abbreviated as Destana. The establishment of a disaster-resilient village aims to empower rural communities independently so that they can identify, minimize, and control the risk of a disaster. This activity is carried out by forming village volunteers and providing briefings related to disaster mitigation actions and regional mapping. At the national level, establishing disaster-resilient villages is a follow-up to the Regulation of the Head of the National Disaster Management Agency (or BNPB) No. 1 of 2012 concerning General Guidelines for the Establishment of Disaster-Resilient Villages/ Kelurahan. In Indonesia, many studies related to disaster-resilient villages have been carried out. Some examples in this regard are research by (Maarif et al., 2012) on the use of the stimulus-response method in the initiation of the formation of disaster-resilient villages; (Oktari, 2019) regarding capacity building for disaster-resilient villages; and (Saroji et al., 2016) regarding the impact of the disaster-resilient village program on the resilience of coastal communities in facing the threat of a tsunami. In the broader context of various countries, disaster resilience can be found, for example, in the paper of (Odiase et al., 2020) about natural disaster-resilience in the Nigerian community in Auckland, New Zealand; in (Komino, 2014) about the importance of disaster-resilient communities and what can be done; in the research work of (Ainuddin & Routray, 2012) regarding community resilience to earthquake hazards in Baluchistan; in the manuscript of (Harrison & Williams, 2016) in the context of the use of a systems approach for disaster resilience; and in (Oliver et al., 2019) with regard to the application of a resilience index against the danger of flash floods in Colima-Villa de Alvarez, Mexico.

   Various studies on disaster resilience provide information and produce valuable findings. The formation of community resilience in dealing with natural disasters in Bangladesh is influenced by good and bad governance

(Choudhury et al., 2019). Based on a study of 36 people from 4 senior decision support groups who periodically experience high levels of stress (Farkash et al., 2017), it was found that the activity of sharing knowledge among them was proven to evoke cohesion and hope, and the intervention given to them was proven to strengthen their ability to deal with stressful situations. Two case studies from Japan and Nepal (Sakurai & Thapa, 2017) reveal that coevolution is a crucial factor in responding to changing conditions during disasters and that coevolution is influenced by collaboration and local knowledge. During the implementation of the Youth Leadership Program (YLP) after Hurricane Katrina (Osofsky et al., 2018), participants had higher self-efficacy than those who did not participate in the program. In general, building community resilience to disasters is a long process involving many actors, organizations, jurisdictions, and disciplines that interact with each other over time (Comfort, 2016).

d. The fourth mitigation strategy: mapping disaster-prone areas. Mapping disaster-prone areas is one technique to improve and strengthen disaster management (Mishra et al., 2012) and, more especially, disaster mitigation (Pratiwi et al., 2016; Sherly et al., 2015). Being possible to evaluate the effects of environmental degradation and development processes (Chakraborty & Joshi, 2016); a greater understanding of disasters (Battersby et al., 2011); and the integration of knowledge and action in the context of disaster mitigation (Cadag & Gaillard, 2012) are some advantages of mapping disaster-prone areas.

   There are numerous strategies and methods for mapping disaster-prone areas, either for each prospective disaster type or for all disaster potentials. Some of these strategies and methods are participatory mapping (Cadag & Gaillard, 2012; Jing et al., 2013; Kienberger, 2014; W. Liu et al., 2018); the World Meteorological Organization (WMO) model (Arnalds et al., 2004); online disaster atlases (Battersby et al., 2011); GIS (Anggeraini, 2015; Bagherzadeh & Mansouri Daneshvar, 2013; Daneshvar & Bagherzadeh, 2011; Li et al., 2012; Pratiwi et al., 2016; Tran et al., 2009); remote sensing (Pratama et al., 2014); GIS and remote sensing (Bisson et al., 2014; Handoko et al., 2017; Mani & Saranaathan, 2017; Purwanto et al., 2022); the analytic hierarchy process (AHP) method (Chakraborty & Joshi, 2016); the AHP and fuzzy variable set theory (Jia et al., 2019); the Landslide Hazard Evaluation Factor (LHEF) scoring scheme (Anbazhagan & Ramesh, 2014); rule mining based on the ant colony algorithm (Lai et al., 2016); probabilistic method (Hashemi et al., 2013); machine learning (Y. Liu et al., 2021); and fuzzy comprehensive evaluation method (Sun et al., 2014).

e. The fifth mitigation strategy: training for disaster volunteers. In a disaster situation, the natural human tendency is to assist anyone in need (Gallant, 2008). This is where volunteerism begins. Volunteers are of several types (Phillips, 2020): volunteers who are not affiliated with any organization; volunteers who are affiliated with a particular organization, professional volunteers; disaster survivors as volunteers; and international volunteers. Potential hazards are expected to continue and increase in the future, so the phenomenon of disaster volunteers is also likely to increase (Phillips, 2020). Experts call for the need for skills-based volunteerism (Anonymous, 2019). These skills may include disaster management, first aid, knowledge of radio communication, and food safety and storage (Noone, 2017).

4. Conclusion

Based on the results and discussion regarding the proposal for improving the effectiveness of disaster mitigation that should be carried out by Wonogiri's BPBD, the following conclusions were obtained. First, disasters that can potentially hit Wonogiri Regency are floods, landslides, strong winds, volcanic eruptions, earthquakes, tsunamis, forest and land fires, droughts, and extraordinary events (*Kejadian Luar Biasa* or KLB in short). Second, HoR phase 1 resulted in 19 disaster risk events and 19 disaster risk agents. Third, by implementing Pareto diagram to the disaster risk agents, it is found that there are eight dominant disaster risk agents, with "Unstable ground" as the disaster risk agent with the highest ARP value. Fourth, the implementation of HoR phase 2 resulted in 15 mitigation strategies wherein five mitigation strategies with the highest priority are "Working with related parties to reduce the potential of disasters"; "Conducting disaster socialization and education"; "Establishing disaster-resilient villages"; "Mapping disaster-prone areas"; and "Training for disaster volunteers". The results of this study can be considered by related parties, especially the BPBD of Wonogiri Regency, the Republic of Indonesia, in carrying out disaster mitigation in the Wonogiri Regency for the period of 2021 to 2026.

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References

Ahrens, J., & Rudolph, P. M. (2006). The importance of governance in risk reduction and disaster management. Journal of Contingencies and Crisis Management, 14(4), 207–220. https://doi.org/10.1111/j.1468-5973.2006.00497.x

Ainuddin, S., & Routray, J. K. (2012). Earthquake hazards and community resilience in Baluchistan. Natural Hazards, 63(2), 909–937. https://doi.org/10.1007/s11069-012-0201-x

Ambarwati, R., & Nugroho, M. T. (2019). Analisis Nilai Tambah dan Risiko Rantai Pasok Keripik Bayam (Studi Kasus: UKM Khasanah). Universitas Muhammadiyah Surakarta.

Anbazhagan, S., & Ramesh, V. (2014). Landslide hazard zonation mapping in ghat road section of Kolli hills, India. Journal of Mountain Science, 11(5), 1308–1325. https://doi.org/10.1007/s11629-012-2618-9

Anggeraini, D. P. (2015). Landslide Hazard Mapping Along Rantepao – Palopo Road Section, South Sulawesi Province. Journal of the Civil Engineering Forum, 1(3), 93. https://doi.org/10.22146/jcef.24008

Anonymous. (2019). Experts call for more skills-based volunteerism in disaster philanthropy. Nonprofit Business Advisor, 2019(362), 1–3. https://doi.org/10.1002/nba.30671

Arnalds, P., Jónasson, K., & Sigurdsson, S. (2004). Avalanche hazard zoning in Iceland based on individual risk. Annals of Glaciology, 38, 285–290. https://doi.org/10.3189/172756404781814816

Asharose, Saizen, I., Kumar, P., & Sasi, C. (2015). Awareness workshop as an effective tool and approach for education in disaster risk reduction: A case study from Tamil Nadu, India. Sustainability, 7, 8965–8984. https://doi.org/10.3390/su7078965

Asteria, D. (2016). Optimalisasi komunikasi bencana di media massa sebagai pendukung manajemen bencana. Jurnal Komunikasi, 01, 1–11.

Auty, H., Mellor, D., Gunn, G., & Boden, L. A. (2019). The risk of foot and mouth disease transmission posed by public access to the countryside during an outbreak. Frontiers in Veterinary Science, 6, 1–12. https://doi.org/10.3389/fvets.2019.00381

Bagherzadeh, A., & Mansouri Daneshvar, M. R. (2013). Mapping of landslide hazard zonation using GIS at Golestan watershed, northeast of Iran. Arabian Journal of Geosciences, 6(9), 3377–3388. https://doi.org/10.1007/s12517-012-0583-9

Bandaly, D., Satir, A., Kahyaoglu, Y., & Shanker, L. (2012). Supply chain risk management I: conceptualization, framework and planning process. Risk Management, 14(4), 249–271. https://doi.org/10.1057/rm.2012.7

Battersby, S. E., Mitchell, J. T., & Cutter, S. L. (2011). Development of an online hazards atlas to improve disaster awareness. International Research in Geographical and Environmental Education, 20(4), 297–308. https://doi.org/10.1080/10382046.2011.619807

Bisson, M., Spinetti, C., & Sulpizio, R. (2014). Volcaniclastic flow hazard zonation in the sub-apennine vesuvian area using GIS and remote sensing. Geosphere, 10(6), 1419–1431. https://doi.org/10.1130/GES01041.1

BNPB. (2021). Data & Informasi Bencana Indonesia. BNPB. https://dibi.bnpb.go.id/

Boin, A., & Lodge, M. (2016). Designing resilient institutions for transboundary crisis management: A time for public administration. Public Administration, 94(2), 289–298.

BPS Wonogiri. (2020). Kabupaten Wonogiri dalam Angka 2020.

Cadag, J. R. D., & Gaillard, J. C. (2012). Integrating knowledge and actions in disaster risk reduction: The contribution of participatory mapping. Area, 44(1), 100–109. https://doi.org/10.1111/j.1475-4762.2011.01065.x

Canlas, I. P., & Karpudewan, M. (2020). Blending the principles of Participatory Action Research approach and elements of Grounded Theory in a disaster risk reduction education case study. International Journal of Qualitative Methods, 19, 1–13. https://doi.org/10.1177/1609406920958964

Chakraborty, A., & Joshi, P. K. (2016). Mapping disaster vulnerability in India using analytical hierarchy process. Geomatics, Natural Hazards and Risk, 7(1), 308–325. https://doi.org/10.1080/19475705.2014.897656

Choudhury, M. U. I., Uddin, M. S., & Haque, C. E. (2019). "Nature brings us extreme events, some people cause us prolonged sufferings": the role of good governance in building community resilience to natural disasters in Bangladesh. Journal of Environmental Planning and Management, 62(10), 1761–1781. https://doi.org/10.1080/09640568.2018.1513833

Clerveaux, V., Spence, B., & Katada, T. (2010). Promoting disaster awareness in multicultural societies: The DAG approach. Disaster Prevention and Management: An International Journal, 19(2), 199–218. https://doi.org/10.1108/09653561011038002

Comfort, L. K. (2016). Building community resilience to hazards. Safety Science, 90, 1–4. https://doi.org/10.1016/j.ssci.2015.09.031

Coppola, D. P. (2015). Introduction to International Disaster Management (3th ed.). Butterworth-Heinemann.

Daneshvar, M. R. M., & Bagherzadeh, A. (2011). Landslide hazard zonation assessment using GIS analysis at Golmakan Watershed, northeast of Iran. Frontiers of Earth Science, 5(1), 70–81. https://doi.org/10.1007/s11707-011-0151-8

Darmawan, W., Suprayogi, A., & Firdaus, H. S. (2018). Analisis penentuan zona kerentanan gerakan tanah dengan metode storie (studi kasus Kabupaten Wonogiri). Jurnal Geodesi Undip, 7(4), 47–54.

Dufty, N. (2020). Disaster Education, Communication and Engagement. John Wiley & Sons, Ltd.

El-Masri, S., & Tipple, G. (2002). Natural disaster, mitigation and sustainability: The case of developing countries. International Planning Studies, 7(2), 157–175. https://doi.org/10.1080/13563470220132236

Farkash, H. E., Cohen, O., Lahad, M., & Aharonson-Daniel, L. L. (2017). Enhancing community resilience during emergencies by building organizational resilience in routine times. Prehospital and Disaster Medicine, 32(S1), S186–S187. https://doi.org/10.1017/s1049023x17004927

Ferreira, T. M., Maio, R., Vicente, R., & Costa, A. (2016). Earthquake risk mitigation: the impact of seismic retrofitting strategies on urban resilience. International Journal of Strategic Property Management, 20(3), 291–304. https://doi.org/10.3846/1648715X.2016.1187682

Few, R., Scott, Z., Wooster, K., Avila, M. F., & Tarazona, M. (2016). Strengthening capacities for disaster risk management II: Lessons for effective support. International Journal of Disaster Risk Reduction, 20, 154–162. https://doi.org/10.1016/j.ijdrr.2016.02.005

Gallant, B. J. (2008). Managing the Spontaneous Volunteer. In J. Pinkowski (Ed.), Disaster Management Handbook (pp. 459–469). CRC Press.

Galve, J. P., Cevasco, A., Brandolini, P., Piacentini, D., Azañón, J. M., Notti, D., & Soldati, M. (2016). Cost-based analysis of mitigation measures for shallow-landslide risk reduction strategies. Engineering Geology, 213, 142–157. https://doi.org/10.1016/j.enggeo.2016.09.002

Green, P. (2005). Disaster by design. British Journal of Criminology, 45(4), 528–546. https://doi.org/10.1093/bjc/azi036

Gunasekara, N. K., Kazama, S., Yamazaki, D., & Oki, T. (2014). Water conflict risk due to water resource availability and unequal distribution. Water Resources Management, 28(1), 169–184. https://doi.org/10.1007/s11269-013-0478-x

Handoko, D., Nugraha, A. L., & Prasetyo, Y. (2017). Kajian pemetaan kerentanan Kota Semarang terhadap multi bencana berbasis pengindraan jauh dan sistem informasi geografis. Jurnal Geodesi Undip, 6(3), 1–10.

Harrison, C. G., & Williams, P. R. (2016). A systems approach to natural disaster resilience. Simulation Modelling Practice and Theory, 65, 11–31. https://doi.org/10.1016/j.simpat.2016.02.008

Harriss, L., Parrack, C., & Jordan, Z. (2020). Building safety in humanitarian programmes that support post-disaster shelter self-recovery: an evidence review. Disasters, 44(2), 307–335. https://doi.org/10.1111/disa.12397

Hashemi, M., Alesheikh, A. A., & Zolfaghari, M. R. (2013). A spatio-temporal model for probabilistic seismic hazard zonation of Tehran. Computers and Geosciences, 58, 8–18. https://doi.org/10.1016/j.cageo.2013.04.005

Hayudityas, B. (2020). Pentingnya penerapan pendidikan mitigasi bencana di sekolah untuk mengetahui kesiapsiagaan peserta didik. Jurnal Edukas Nonformal, 1(2), 94–102. https://doi.org/10.1016/j.tmaid.2020.101607%0Ahttps://doi.org/10.1016/j.ijsu.2020.02.034%0Ahttps://onlinelibrary.wiley.com/doi/abs/10.1111/cjag.12228%0Ahttps://doi.org/10.1016/j.ssci.2020.104773%0Ahttps://doi.org/10.1016/j.jinf.2020.04.011%0Ahttps://doi.o

Ho, J. Y., Lee, K. T., Chang, T. C., Wang, Z. Y., & Liao, Y. H. (2012). Influences of spatial distribution of soil thickness on shallow landslide prediction. Engineering Geology, 124(1), 38–46. https://doi.org/10.1016/j.enggeo.2011.09.013

Hoffman, S. M. (2015). Culture: The Crucial Factor in Hazard, Risk, and Disaster Recovery: The Anthropological Perspective. In Hazards, Risks and, Disasters in Society (pp. 289–305). Elsevier Inc. https://doi.org/10.1016/B978-0-12-396451-9.00017-2

Hou, T. shun, Xu, G. li, Shen, Y. jun, Wu, Z. zhong, Zhang, N. ning, & Wang, R. (2013). Formation mechanism and stability analysis of the Houba expansive soil landslide. Engineering Geology, 161, 34–43. https://doi.org/10.1016/j.enggeo.2013.04.010

Iskandar, D., Sinar, T. S., Samad, I. A., & Gadeng, A. N. (2022). The values of natural disaster mitigation in discourse: the true story of the Acehnese tsunami victims. Forum Geografi, 36(1), 80–90. https://doi.org/10.23917/forgeo.v35i2.14032

Jia, J., Wang, X., Hersi, N. A. M., Zhao, W., & Liu, Y. (2019). Flood-risk zoning based on analytic hierarchy process and fuzzy variable set theory. Natural Hazards Review, 20(3), 04019006-1-04019006–04019008. https://doi.org/10.1061/(asce)nh.1527-6996.0000329

Jing, L., Liu, X. M., & Gang, L. (2013). Public participatory risk mapping for community-based urban disaster mitigation. Applied Mechanics and Materials, 380–384, 4609–4613. https://doi.org/10.4028/www.scientific.net/AMM.380-384.4609

Kapucu, N., & Garayev, V. (2011). Collaborative Decision-Making in emergency and disaster Management. International Journal of Public Administration, 34(6), 366–375. https://doi.org/10.1080/01900692.2011.561477

Kasdan, D. O. (2016). Considering socio-cultural factors of disaster risk management. Disaster Prevention and Management, 25(4), 464–477.

Katayama, A., Hase, A., & Miyatake, N. (2021). Disaster prevention education along with weekly exercise improves self-efficacy in community-dwelling japanese people—a randomized control trial. Medicina, 57, 1–9. https://doi.org/10.3390/medicina57030231

Kienberger, S. (2014). Participatory mapping of flood hazard risk in Munamicua, District of Búzi, Mozambique. Journal of Maps, 10(2), 269–275. https://doi.org/10.1080/17445647.2014.891265

Komino, T. (2014). Community resilience: Why it matters and what we can do. The Ecumenical Review, 66(3), 324–329. https://doi.org/10.1111/erev.12109

Kusumawati, F. A., & Uman, C. (2019). Komunikasi bencana sebagai sebuah sistem penanganan bencana di Indonesia. Mediakom: Jurnal Ilmu Komunikasi, 3(1), 25–37. https://doi.org/10.35760/mkm.2019.v3i1.1980

Lai, C., Shao, Q., Chen, X., Wang, Z., Zhou, X., Yang, B., & Zhang, L. (2016). Flood risk zoning using a rule mining based on ant colony algorithm. Journal of Hydrology, 542, 268–280. https://doi.org/10.1016/j.jhydrol.2016.09.003

Larasati, Y., Utami, M. H., Pramita, R. D., Roisyah, & Surya, D. (2017). Tingkat pengetahuan masyarakat terhadap bencana banjir, gempa bumi, dan tanah longsor di Kecamatan Wonogiri. Prosiding Seminar Nasional Geografi UMS, 291–304.

Lee, D.-W. (2020). The expertise of public officials and collaborative disaster management. International Journal of Disaster Risk Reduction, 50(June), 101711. https://doi.org/10.1016/j.ijdrr.2020.101711

Li, A. C. Y., Nozick, L., Xu, N., & Davidson, R. (2012). Shelter location and transportation planning under hurricane conditions. Transportation Research Part E: Logistics and Transportation Review, 48(4), 715–729. https://doi.org/10.1016/j.tre.2011.12.004

Lin, L. (2018). Integrating a national risk assessment into a disaster risk management system: Process and practice. International Journal of Disaster Risk Reduction, 27, 625–631. https://doi.org/10.1016/j.ijdrr.2017.08.004

Liu, W., Dugar, S., Mccallum, I., Thapa, G., See, L., Khadka, P., Budhathoki, N., Brown, S., Mechler, R., Fritz, S., & Shakya, P. (2018). Integrated participatory and collaborative risk mapping for enhancing disaster resilience. International Journal of Geo-Information, 7(2), 1–23. https://doi.org/10.3390/ijgi7020068

Liu, Y., Lu, X., Yao, Y., Wang, N., Guo, Y., Ji, C., & Xu, J. (2021). Mapping the risk zoning of storm flood disaster based on heterogeneous data and a machine learning algorithm in Xinjiang, China. Journal of Flood Risk Management, 14(1), 1–14. https://doi.org/10.1111/jfr3.12671

Maarif, S., Damayanti, F., Suryanti, E. D., & Wicaksono, A. P. (2012). Initiation of the Desa Tangguh Bencana through stimulus-response method. Indonesian Journal of Geography, 44(2), 173–182. https://doi.org/10.22146/indo.j.geog,2399

Mani, S., & Saranaathan, S. E. (2017). Landslide hazard zonation mapping on meso-scale in SH-37 ghat section, Nadugani, Gudalur, the Nilgiris, India. Arabian Journal of Geosciences, 10(7), 1–15. https://doi.org/10.1007/s12517-017-2932-1

Marshall, J. D., Lang, A. F., Baldridge, S. M., & Popp, D. R. (2011). Recipe for disaster: Construction methods, materials, and building performance in the January 2010 haiti Harthquake. Earthquake Spectra, 27(S1), S323–S343. https://doi.org/10.1193/1.3637031

Martini. (2011). Identifikasi sumber bencana alam dan upaya penanggulangannya di Sulawesi Tengah. Infrastruktur, 1(2), 96–102. http://jurnal.untad.ac.id/jurnal/index.php/JTSI/article/view/689/593

Melati, P. M., & Jatipaningrum, M. T. (2018). Prediksi bencana alam di wilayah Kabupaten Wonogiri dengan konsep Markov Chains. Jurnal Statistika Industri Dan Komputasi, 3(1), 63–70.

Meyer, M. A., Hendricks, M., Newman, G. D., Masterson, J. H., Cooper, J. T., Sansom, G., Gharaibeh, N., Horney, J., Berke, P., Zandt, S. van, & Cousins, T. (2018). Participatory action research: tools for disaster resilience education. International Journal of Disaster Resilience in the Built Environment, 9(4–5), 402–419. https://doi.org/10.1108/IJDRBE-02-2017-0015

Mileski, J., Gharehgozli, A., Ghoram, L., & Swaney, R. (2018). Cooperation in developing a disaster prevention and response plan for Arctic shipping. Marine Policy, 92(February), 131–137. https://doi.org/10.1016/j.marpol.2018.03.003

Mishra, V., Fuloria, S., & Bisht, S. S. (2012). Enhancing disaster management by mapping disaster proneness and preparedness. Disasters, 36(3), 382–397. https://doi.org/10.1111/j.1467-7717.2011.01269.x

Munthali, K. G., Irvine, B. J., & Murayama, Y. (2011). Reservoir sedimentation and flood control: Using a geographical information system to estimate sediment yield of the Songwe River watershed in Malawi. Sustainability, 3(1), 254–269. https://doi.org/10.3390/su3010254

Neuhold, C. (2013). Identifying flood-prone landfills at different spatial scales. Natural Hazards, 65(3), 2015–2030. https://doi.org/10.1007/s11069-012-0459-z

Neuhold, C., & Nachtnebel, H. P. (2011). Assessing flood risk associated with waste disposals: Methodology, application and uncertainties. Natural Hazards, 56(1), 359–370. https://doi.org/10.1007/s11069-010-9575-9

Ni, H., Zheng, W., Song, Z., & Xu, W. (2014). Catastrophic debris flows triggered by a 4 July 2013 rainfall in Shimian, SW China: formation mechanism, disaster characteristics and the lessons learned. Landslides, 11(5), 909–921. https://doi.org/10.1007/s10346-014-0514-9

Noone, M. (2017). How to Become an International Disaster Volunteer. Butterworth-Heinemann. https://www.bloomberg.com/news/features/2017-03-09/how-to-become-an-international-gold-smuggler

Odiase, O., Wilkinson, S., & Neef, A. (2020). Urbanisation and disaster risk: the resilience of the Nigerian community in Auckland to natural hazards. Environmental Hazards, 19(1), 90–106. https://doi.org/10.1080/17477891.2019.1661221

Oktari, R. S. (2019). Peningkatan kapasitas Desa Tangguh Bencana. Jurnal Pengabdian Kepada Masyarakat (Indonesian Journal of Community Engagement), 4(2), 189–197. https://doi.org/10.22146/jpkm.29960

Oliver, M. C., Jesús, L. de la C., Ian, P., Martinez-Preciado, M. A., Manuel, U. R. J., Edwards, R. M., Ivan, R. L. C., Pedro, R. A., & Velazco-Cruz Jorge, A. (2019). Disaster risk resilience in colima-villa de Alvarez, Mexico: Application of the resilience index to flash flooding events. International Journal of Environmental Research and Public Health, 16, 1–12. https://doi.org/10.3390/ijerph16122128

Osofsky, H., Osofsky, J., Hansel, T., Lawrason, B., & Speier, A. (2018). Building resilience after disasters through the youth leadership program: The importance of community and academic partnerships on youth outcomes. Progress in Community Health Partnerships: Research, Education, and Action, 12(Special Issue 28), 11–21. https://doi.org/10.1353/cpr.2018.0013

Pahleviannur, M. R. (2019). Edukasi sadar bencana melalui sosialisasi kebencanaan sebagai upaya peningkatan pengetahuan siswa terhadap mitigasi bencana. Jurnal Pendidikan Dan Ilmu Sosial, 29(1), 49–55.

Parkash, S. (2015). Cooperation, coordination and team issues in disaster management: The need for a holistic and integrated approach. Geological Society Special Publication, 419(1), 57–61. https://doi.org/10.1144/SP419.5

Phillips, B. D. (2020). Disaster Volunteers. Butterworth-Heinemann.

Prasetyo, I. A. (2020). Usulan Peningkatan Efektivitas Mitigasi Bencana oleh Badan Penanggulangan Bencana Daerah Surakarta dengan Menggunakan Metode House of Risk. Universitas Muhammadiyah Surakarta.

Pratama, A., Nugraha, A. L., & W., A. P. (2014). Pemodelan kawasan rawan bencana erupsi gunung api berbasis data penginderaan jauh (studi kasus di Gunung Api Merapi). Jurnal Geodesi Undip, 3(4), 117–123.

Pratamaningtyas, A. B., Jayanti, S., & Wahyuni, I. (2016). Analisis kesiapsiagaan RSUD dr. Soediran Mangun Sumarso Wonogiri dalam penanggulangan bencana. Jurnal Kesehatan Masyarakat, 4(1), 293–303. www.journal.uta45jakarta.ac.id

Pratiwi, R. D., Nugraha, A. L., & Hani'ah. (2016). Pemetaan multi bencana Kota Semarang. Jurnal Geodesi Undip, 5(4), 122–131.

Pujawan, I. N., & Geraldin, L. H. (2009). House of risk: a model for proactive supply chain risk management. Business Process Management Journal, 15(6), 953–967. https://doi.org/10.1108/14637150911003801

Purwanto, A., Rustam, R., Andrasmoro, D., & Eviliyanto, E. (2022). Flood risk mapping using GIS and Multi-Criteria Analysis at Nanga Pinoh West Kalimantan area. Indonesian Journal of Geography, 54(3), 463–470. https://doi.org/10.22146/ijg.69879

Purworini, D., Purnamasari, D., & Hartuti, D. P. (2019). Crisis communication in a natural disaster: A chaos theory approach. Jurnal Komunikasi: Malaysian Journal of Communication, 35(2), 35–48. https://doi.org/10.17576/JKMJC-2019-3502-03

Rahman, A. Z. (2015). Kajian mitigasi bencana tanah longsor di Kabupaten Banjarnegara. Gema Publika, 1(1), 1–14.

Sakurai, M., & Thapa, D. (2017). Building resilience through effective disaster management. International Journal of Information Systems for Crisis Response and Management, 9(1), 11–26. https://doi.org/10.4018/ijiscram.2017010102

Saroji, Mahdi, S., & Srimulyani, E. (2016). Kajian empiris program Desa Tangguh Bencana (DESTANA) terhadap ketangguhan masyarakat pesisir dalam menghadapi bencana tsunami: studi kasus di dua Gampong Pesisir Kabupaten Aceh Besar. Jurnal Ilmu Kebencanaan (JIKA), 3(4), 142–148.

Scott, Z., & Few, R. (2016). Strengthening capacities for disaster risk management I: Insights from existing research and practice. International Journal of Disaster Risk Reduction, 20, 145–153. https://doi.org/10.1016/j.ijdrr.2016.04.010

Scott, Z., Wooster, K., Few, R., Thomson, A., Tarazona, M., Scott, Z., Wooster, K., Few, R., Thomson, A., & Tarazona, M. (2016). Monitoring and evaluating disaster risk management capacity. Disaster Prevention and Management, 25(3), 412–422.

Sekretariat Negara RI. (2007). Undang-Undang Republik Indonesia Nomor 24 Tahun 2007 tentang Penanggulangan Bencana. In Lembaran Negara Republik Indonesia Tahun 2007 Nomor 66 (p. 50). Sekretariat Negara RI.

Setiawan, E., Liu, J., & French, A. (2019). Resource location for relief distribution and victim evacuation after a sudden-onset disaster. IISE Transactions, 51(8), 830–846. https://doi.org/10.1080/24725854.2018.1517284

Sharma, L. P., Patel, N., Debnath, P., & Ghose, M. K. (2012). Assessing landslide vulnerability from soil characteristics-a GIS-based analysis. Arabian Journal of Geosciences, 5(4), 789–796. https://doi.org/10.1007/s12517-010-0272-5

Shaw, R., Takeuchi, Y., Gwee, Q. R., & Shiwaku, K. (2011). Disaster Education: An Introduction. In R. Shaw, K. Shiwaku, & Y. Takeuchi (Eds.), Disaster Education (p. xvi + 162). Emerald Group Publishing Limited. https://doi.org/10.1108/s2040-7262(2011)0000008018

Sherly, M. A., Karmakar, S., Parthasarathy, D., Chan, T., & Rau, C. (2015). Disaster vulnerability mapping for a densely populated coastal urban area: An application to Mumbai, India. Annals of the Association of American Geographers, 105(6), 1198–1220. https://doi.org/10.1080/00045608.2015.1072792

Suciana, F., & Permatasari, D. (2019). Pengaruh edukasi audio visual dan role play terhadap perilaku siaga bencana pada anak Sekolah Dasar. Journal of Holistic Nursing Science, 6(2), 44–51. https://doi.org/10.31603/nursing.v6i2.2543

Sufa, M. F., & Khoiriyah, U. (2017). Manajemen risiko proses produksi gula dengan metode Failure Mode Effect and Analysis. PERFORMA: Media Ilmiah Teknik Industri, 16(1), 72–76. https://doi.org/10.20961/performa.16.1.12756

Suhardjo, D. (2011). Arti penting pendidikan mitigasi bencana dalam mengurangi resiko bencana. Cakrawala Pendidikan, XXX(2), 174–188. https://doi.org/10.21831/cp.v0i2.4226

Suharini, E., S, D. L., & Kurniawan, E. (2015). Pembelajaran kebencanaan bagi masyarakat di daerah rawan bencana banjir DAS Beringin Kota Semarang. Forum Ilmu Sosial, 42(2), 184–195.

Sulistyo, B., Suhartoyo, H., Adiprasetyo, T., Hindarto, K. S., & Noviyanti. (2021). Accuracy of the level of critical water catchment area for flood mitigation around Bengkulu City, Indonesia. Indonesian Journal of Geography, 53(2), 226–235.

Sun, Z., Zhang, J., Zhang, Q., Hu, Y., Yan, D., & Wang, C. (2014). Integrated risk zoning of drought and waterlogging disasters based on fuzzy comprehensive evaluation in Anhui Province, China. Natural Hazards, 71(3), 1639–1657. https://doi.org/10.1007/s11069-013-0971-9

Suyanto, S., & Hartono, H. (2019). Pengaruh penggunaan panduan tanggap bencana terhadap strategi koping keluarga dalam menghadapi kerentanan bencana tsunami di Desa Gunturharjo Kabupaten Wonogiri. Interest: Jurnal Ilmu Kesehatan, 8(1), 67–74. https://doi.org/10.37341/interest.v8i1.119

Theodora, Y. (2020). Natural hazards: key concerns for setting up an effective disaster management plan in Greece. Euro-Mediterranean Journal for Environmental Integration, 5, 1–10. https://doi.org/10.1007/s41207-020-00174-y

Thi, T., & Shaw, R. (2016). School-based disaster risk reduction education in primary schools in Da Nang City, Central Vietnam. Environmental Hazards, 15(4), 356–373. https://doi.org/10.1080/17477891.2016.1213492

Torani, S., Majd, P. M., Maroufi, S. S., Dowlati, M., & Sheikhi, R. A. (2019). The importance of education on disasters and emergencies: A review article. Journal of Education and Health Promotion, 8(85), 1–6. https://doi.org/10.4103/jehp.jehp

Tran, P., Shaw, R., Chantry, G., & Norton, J. (2009). GIS and local knowledge in disaster management: a case study of flood risk mapping in Viet Nam. Disasters, 33(1), 152–169. http://web.a.ebscohost.com.recursosbiblioteca.eia.edu.co/ehost/pdfviewer/pdfviewer?vid=5&sid=4156fa22-6825-43ac-add7-495761bf50ba%40sdc-v-sessmgr01

Tuladhar, R. M. (2019). Towards effective and sustainable disaster risk management in Nepal: challenges and gaps. Journal of Nepal

Geological Society, 59, 39–48. https://doi.org/10.3126/jngs.v59i0.24984

UNDRR. (2015). Sendai Framework for DRR (p. 25). UNDRR. http://www.unisdr.org/we/inform/terminology

UNDRR. (2021). Understanding Risk. https://www.undrr.org/building-risk-knowledge/understanding-risk

Wahyuningtyas, A., & Pratomo, R. A. (2015). Identifikasi potensi multi-bencana di Kabupaten Landak Kalimantan Barat. Geoplanning: Journal of Geomatics and Planning, 2(1), 10–21.