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Community leaders' knowledge and practices in landslide management: A case study from Indonesia

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Community leaders play a crucial role in reducing disaster risk and enhancing preparedness at the community level. However, despite their importance, research on the role of community leaders in the context of landslide risk management, particularly in relation to the implementation of emergency response plans (ERP), remains limited. The study aimed to assess the associations between socio-demographic, natural hazards and landslides knowledge, early warning systems (EWS), and ERP with community leaders' practice in landslide management (pre, during and post). A cross-sectional design was utilised among 137 respondents residing in landslide-prone areas. Results showed that gender and educational attainment were both significantly associated with community leaders' landslide management practices. Knowledge of natural hazards and landslides also had a positive influence on their practices. In contrast, EWS showed no significant effect on landslide management practice ($p > 0.05$). Community leaders with an ERP were found to be 11.6 times more likely to implement the practices compared with those without one. It is recommended that community leaders develop an ERP specifically to strengthen landslide preparedness.

Contribution: The research assessed the knowledge and practice of community leaders in landslide management. It is necessary to provide an emergency response plan for community leaders to enhance landslide preparedness, particularly for vulnerable groups.

Keywords: landslide; knowledge; practice; community leaders; emergency response plan.

Introduction

Landslides pose a major geohazard worldwide, causing widespread destruction, thousands of fatalities and substantial property damage each year (Schuster & Highland 2021). Globally, landslides account for approximately 17% of annual deaths from natural hazards (Aristizábal & Sánchez 2020). The earliest recorded landslide disaster dates to 1767 BC in Honan Province, China, where an earthquake-triggered slide formed a landslide dam (Schuster 1996). Indonesia, frequently affected by a wide range of natural hazards, is recognised as one of the most disaster-prone countries in the world. The risk indices for tsunamis, floods, landslides, droughts and forest fires are significantly higher than the global average. Between January 2024 and October 2024, 1512 natural hazards were reported nationwide, with floods (766 cases), extreme weather (262 cases), and landslides (91 cases) being the most prevalent (Geoportal of Indonesian Disaster 2024).

Several regions are particularly vulnerable to landslides, including Bogor Regency, Depok City and parts of Jakarta. Landslide research in Jakarta, Depok and Bogor is crucial for reducing the risk and mitigating the impact of landslides in these vulnerable areas. Although Jakarta is not a mountainous region, it still has significant landslide potential, particularly in specific vulnerable areas. Depok has a varied topography with several hilly areas and river basins prone to landslides. Bogor is known to have a high risk of landslides, mainly because of high rainfall, steep slopes and unstable soil conditions. These regions, characterised by rapid urban development, varied topography and seasonal heavy rainfall, are particularly susceptible to landslide hazards National Disaster Management Authority (*BNPB* 2024). In Bogor Regency, 10 of 20 disaster events between December 2022 and January 2023 were landslides, and another landslide in November 2023 damaged 497 buildings (Rostanti 2023). Bogor is thus categorised as having a high landslide risk index (*BNPB* 2024). Depok City has 10 landslide-prone villages situated near riverbanks and road cliffs (Rajaguguk 2024), while Jakarta still contains 16 landslide-prone sub-districts based on hazard overlays from the Meterology, Climatology, and Geophysics Agency (BMKG) (Bustomi & Sari 2024).

To achieve sustainable and environmentally sound development, the paradigm of disaster risk reduction needs to be strengthened at the community level through community leaders. Local communities stand at the forefront, becoming increasingly aware of both the immediate impacts and root causes of emerging challenges. They play a pivotal role as advocates for risk reduction, translating this awareness into tangible, small-scale interventions. They serve as key mobilisers and decision-makers at the local level who can greatly influence disaster risk reduction efforts. Empowering community leaders in disaster risk reduction is an integral part of the Community-Based Disaster Risk Reduction (CBDRR) Programme, which is designed to empower communities to actively participate in all phases of disaster risk management. By doing so, the programme aims to enhance community preparedness, reduce vulnerabilities and minimise losses arising from disasters. This approach aligns with international standards in disaster risk reduction, particularly the Sendai Framework for Disaster Risk Reduction (2015–2030), which emphasises strengthening resilience at the community level. Improving community preparedness through the active involvement of community members and leaders is closely tied to the strengthening of social capital (Ruslanjari, Wahyunita & Permana 2018), including a culture of cooperation, togetherness and leadership. The programme also draws on the principles of participatory risk management (Pramono & Suranto 2021) and collaborative governance (Amil 2025), ensuring that disaster risk management is inclusive, locally driven and sustainable.

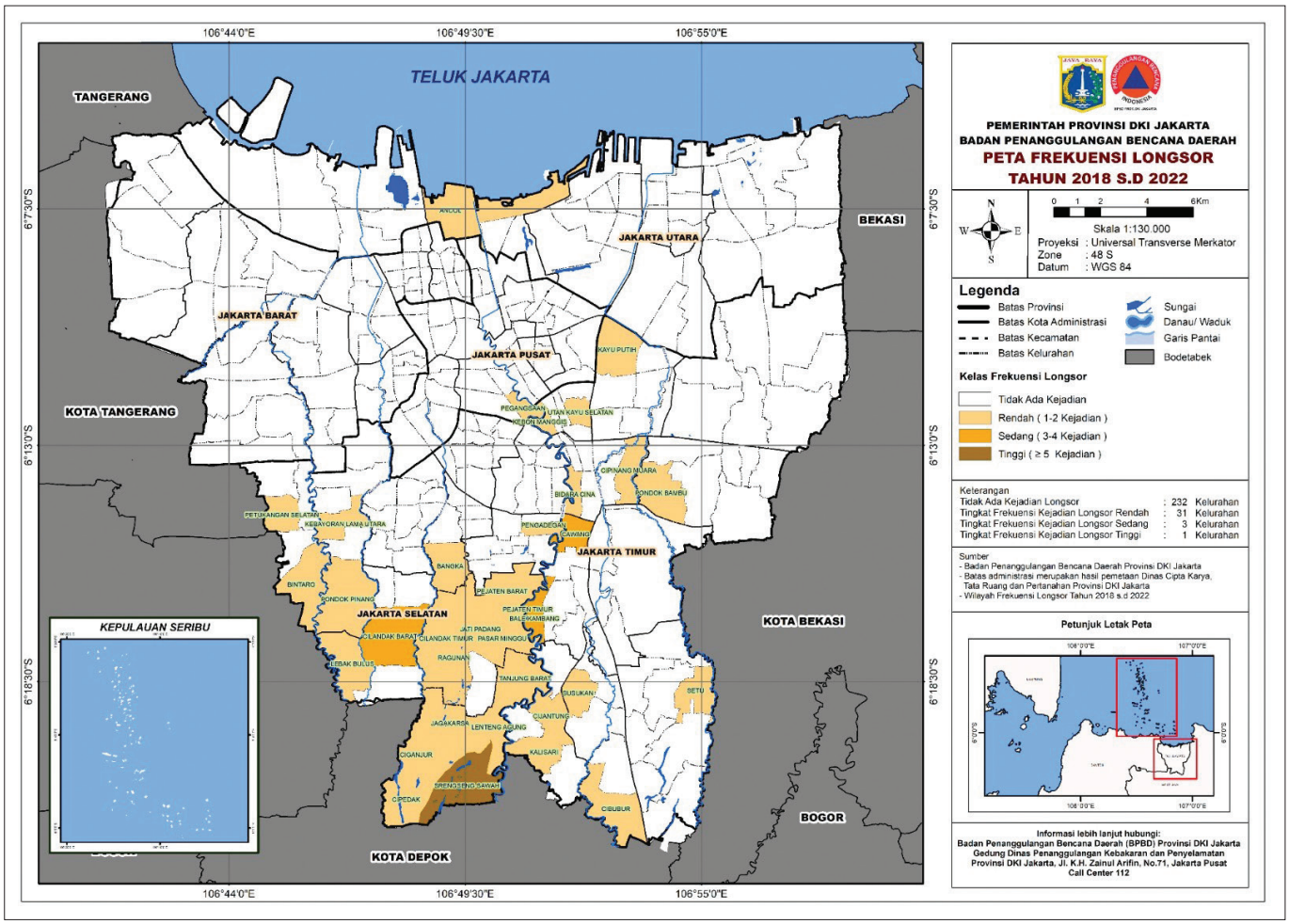
Key indicators for measuring disaster preparedness include community leaders' knowledge about natural hazards, the existence and quality of emergency response plans (ERP), and the availability and effectiveness of early warning systems (EWS). These elements are critical in assessing a community's ability to anticipate, respond to and recover from disaster events like landslides (Granberg 2013). Factors influencing landslide management practices are knowledge, EWS, ERP and socio-demographic characteristics (educational attainment, gender and income). Knowledge and attitude are associated with landslide preparedness practices (Indriani et al. 2023). Early Warning Systems enable community leaders to help initiate early evacuations, mobilise emergency resources and implement risk mitigation strategies. Early warning system is a key tool in enhancing preparedness, strengthening community resilience and supporting informed decision-making in all phases of landslide disaster management (Trogrlic et al. 2022). Emergency Response Plans offer a structured framework for managing disaster events across all phases– before, during, and after a landslide. A well-designed ERP not only improves the efficiency of emergency operations but also strengthens community resilience by promoting preparedness, minimising confusion and accelerating recovery (Ardiansyah et al. 2024). Educational attainment affects disaster management practice. Several studies have shown that final education is related to the level of community preparedness in natural hazards preparedness (Hoffmann & Blecha 2020). Gender plays a significant role in disaster management, and gender-inclusive practices are essential for effective disaster risk reduction (Hedriyanti & Syamsudin 2021). Socio-economics, represented by monthly income, is essential in explaining behaviour after natural hazards. High income is associated with relatively high-risk perception (Fussell, Sastry & VanLandingham 2009).

Cadres are community members or community leaders who are trained to enhance preparedness, lead prevention and mitigation measures and facilitate rapid response, particularly in the health sector (Zuliani & Hariyanto 2021), and vulnerable groups such as pregnant women during landslide emergencies (Maharani 2021). Several studies have examined the role of community leaders in disaster management, including research on landslide mitigation in Sukoharjo Regency (Dahroni & Subadi 2017), the influence of local opinion leaders on shaping community attitudes towards disaster mitigation in North Lombok Regency (Ain, Hadi & Teluma n.d.), the effectiveness of landslide mitigation in Bogor Regency (Ulvia n.d.), and the role of community leaders in coronavirus disease 2019 (COVID-19) mitigation in Padang City (Fahzima 2021). In addition, four other studies have quantitatively explored the roles of community leaders in disaster mitigation outside the selected areas of Jakarta, Bogor and Depok. However, despite these contributions, there remains little evidence on the knowledge and practice of community leaders in landslide management, specifically within Jakarta and Bogor areas that are increasingly vulnerable to landslides because of urban expansion, environmental degradation and climate variability. This knowledge gap limits the ability of disaster management agencies and local governments to design interventions that fully harness local leadership capacities. This study aims to assess the associations in community leaders' socio-demographic, natural hazards and landslides knowledge, EWS and ERP in landslide management practice (pre, during and post). The hypothesis in the study was developed from the formulation of the first problem, namely that there are significant differences in community leaders' practices in landslide management according to the socio-demographic characteristics, knowledge about natural hazards and landslides, EWS and ERP.

Research methods and design

Study design

This study employed a cross-sectional study design, with a sample size of 137 participants distributed across 17 selected villages in Jakarta, Bogor and Depok (Figure 1, Figure 2, Figure 3).



Source: DKI Jakarta Province Disaster Management Agency, 2018, *Map of landslide frequency 2018-2022*, DKI Jakarta Province Disaster Management Agency, DKI Jakarta Province

FIGURE 1: Map of Jakarta's landslide-prone area.

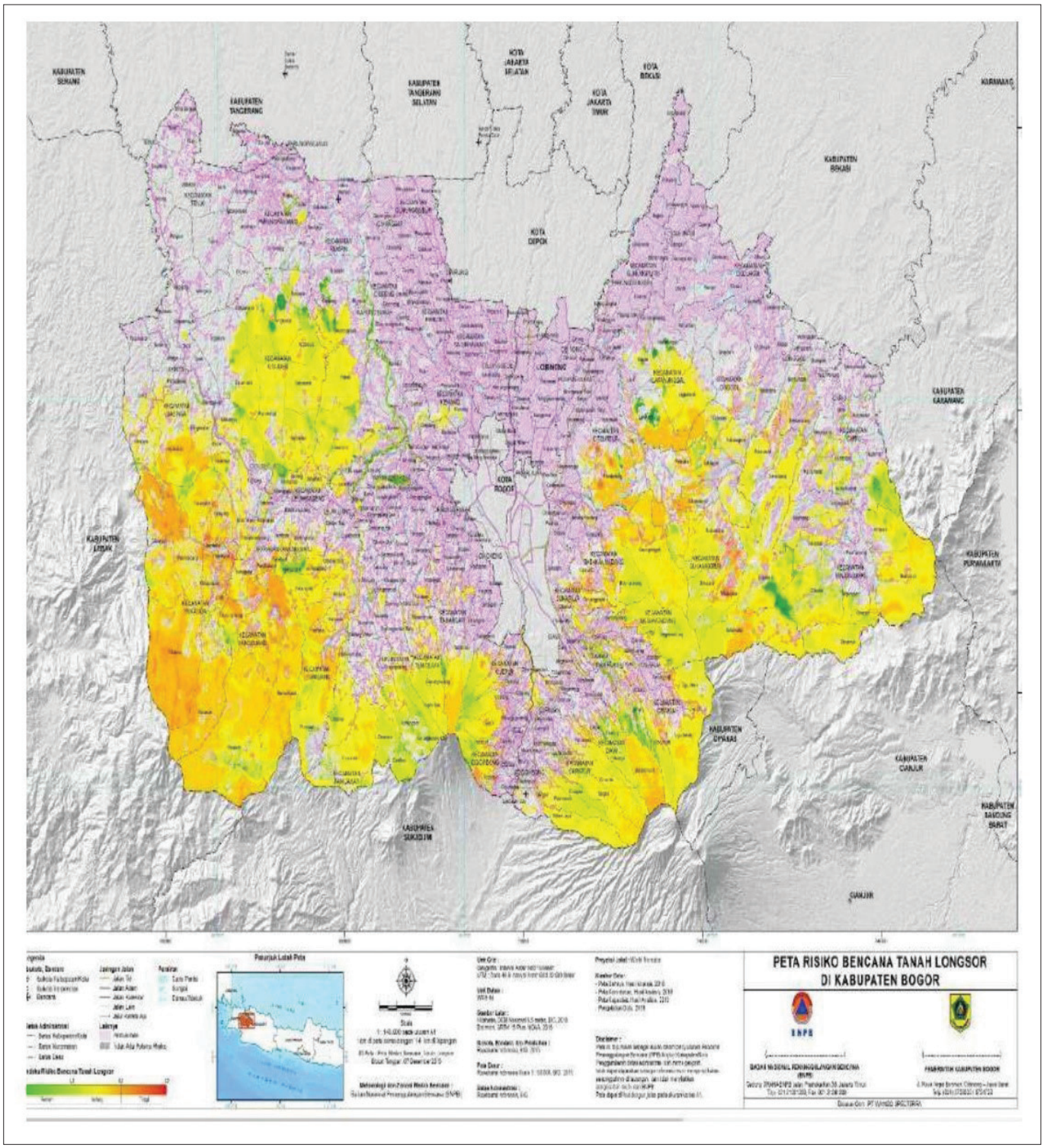
Population and sample

The research included all communities impacted by landslides over the past decade in 17 chosen villages in Jakarta City (Ancol, Kembangan and Pejaten Timur Villages), Bogor Regency (Sentul, Sukamulih, Cimandala and Limusnunggal Villages) and Depok City (Cilangkap, Jatijajar, Tugu, Pasir Gunung Selatan, Sukmajaya, Abadi Jaya, Cisalak, Mekarjaya, Ratu Jaya and Pasir Putih Villages). Seventeen villages and sub-districts were selected for inclusion in the study based on records of landslide-prone areas covering the period 2010–2025 (*BNPB* 2019). A total of 137 participants who met the inclusion criteria, that is, both male and female individuals, community leaders or the integrated community post cadres, and those who had experienced a landslide disaster in the last 10 years, were involved in the study. The participants were chosen using purposive sampling because only those with specific characteristics aligned with the research objectives were selected, so the findings are highly relevant to that group. However, as a result, the study's conclusions cannot be generalised to the broader population or to the entire city level. The sample size was calculated using Slovin's formula to ensure a representative sample of respondents (Tejada & Punjalan 2012). By entering the relevant values into Slovin's formula and adding 10%, the estimated sample size was determined to be 137 people, where n represents the sample size, N represents the total people affected by natural hazards in 2024 (4649403 people) (Nua 2024), and e represents the 9% error margin (Equation 1):

$$n = \frac{N}{(1 + N.e^2)} \quad \text{[Eqn 1]}$$

Study variables and instruments

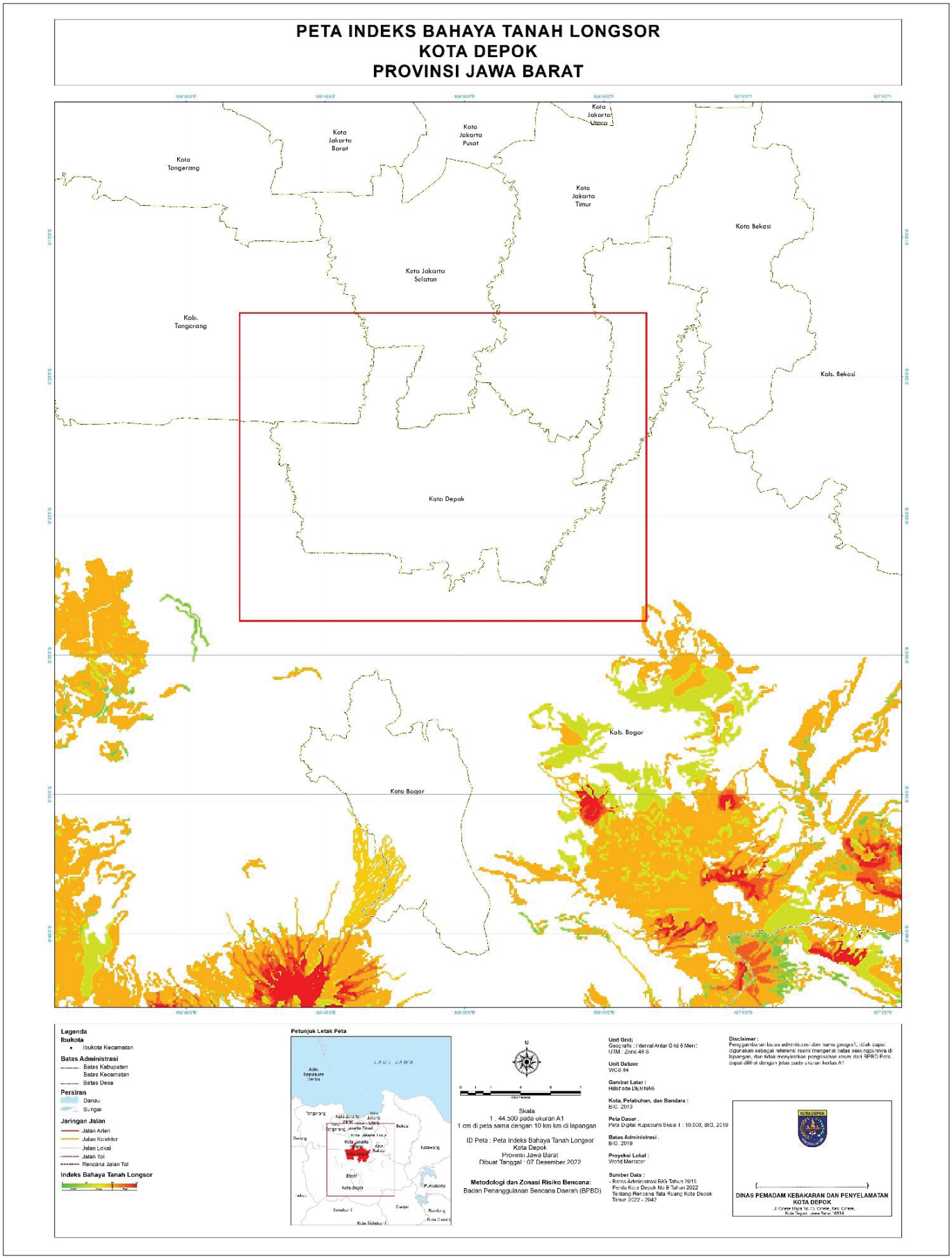
Independent variables (Figure 4) included participants' socio-demographic attributes (marital status, age, latest education, main occupation, residence, number of biological children, monthly income, length of time as a community leader); knowledge of natural hazards (meaning, types, impacts, disaster-prone groups and mitigation efforts) and landslide (definition, causes, signs, impacts); and ERPs influencing the landslide management practice of community leader and cadres as the dependent variable. Landslide management practices were categorised into three phases: pre-landslide, during the landslide and post-landslide. The total knowledge score was 16, with a minimum score of zero. Subsequently, the knowledge level was categorised as either low (i.e. below the mean score) or medium (i.e. equal to or above the mean score).



Source: Bogor District Disaster Management Agency (BPBD Bogor District), 2018, *Disaster Risk Assessment for Bogor District West Java Province, 2019-2023*, p. 40, BPBD Bogor District, Bogor District, West Java Province

FIGURE 2: Map of Bogor's landslide-prone area.

The level of the ERP was established based on the mean score, which was categorised into two groups: low (less than the mean score) and medium (greater than or equal to the mean score). A total of 14 questions were answered with a score of 1 for a positive response and 0 for a negative response. The respondents' practices were evaluated in three phases: before, during and after the landslide. Each phase was assessed using a different set of questions. The knowledge level of landslide management practices was determined by categorising responses into two groups: those deemed to demonstrate a good understanding of the subject matter if the score was equal to or greater than the mean score, and those indicating a poor understanding if the score was less than the mean score.



Source: Depok City Fire and Rescue Service (DFRS), 2022, *Depok City risk assessment, Depok City Fire and Rescue Service (DFRS)*, p. 83, Depok City, West Java Province

FIGURE 3: Map of Depok's landslide-prone area.

Data analysis

The analysis involved examining the frequency distribution of different variables, such as socio-demographic characteristics, knowledge of natural hazards and landslides, EWS practices, ERPs and landslide management practices (before, during and after). IBM® SPSS® Statistics software for Windows 24 was used to conduct the analysis. Univariate analysis included reviewing the mean, minimum and maximum values distribution. Bivariate data analysis was performed to determine if there was a correlation between independent variables such as socio-demographic characteristics, knowledge about natural hazards and landslide, EWS, ERP and the practice of landslide management. The Chi-Square test was used for bivariate analysis, with the relationship criteria based on the value (probability) generated with a 95% confidence interval. The study utilised logistic regression as a multivariate analysis method to evaluate the determining factors affecting landslide management practices. The equation model (Equation 2) is described below:

X1: *Socio-demographic characteristics*

$$Y = \alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 3X4 + \varepsilon$$

X2: *Knowledge about natural hazards and landslides*

X3: *The Early Warning System (EWS)*

X4: *The Emergency Response Plan (ERP)* [Eqn 2]

Ethical considerations

Ethical clearance to conduct this study was obtained from the Ethics Commission for Health Research and Development of STIKES Sint Carolus Jakarta on 22 July 2024 (No. 107/KEPPKSSTIKSC/VII/2024).

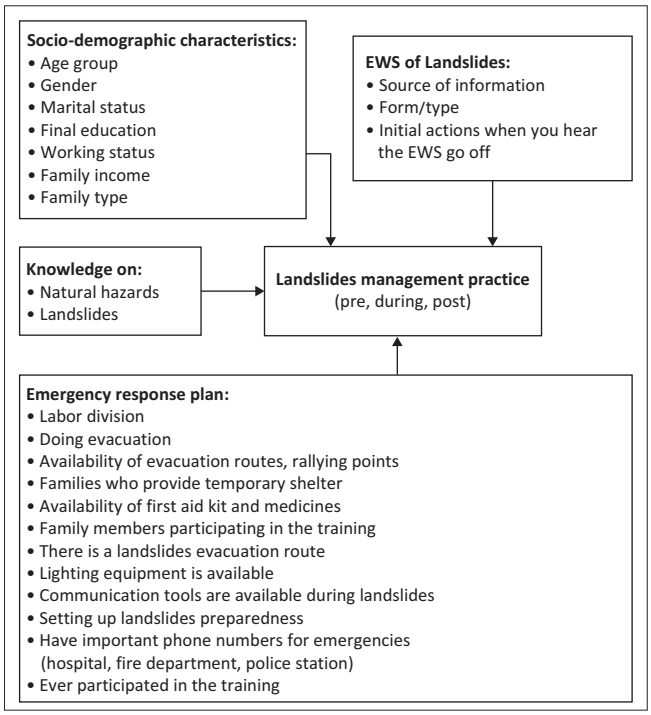
Results

Factors influencing the landslide management practice

Socio-demographic characteristics

The socio-demographic characteristics of the respondents, including age group, gender, marital status, highest level of education attained, current employment status, family income, family structure, number of biological children, status as a community leader and willingness to become a disaster preparedness cadre are described in Table 1. Most respondents were 50 years or above, with a mean age of 45.6 years. Many respondents were male and married. Most respondents had received an education at the secondary level, holding either a high school diploma or a bachelor's degree. The proportion of employed respondents was approximately double that of those who were not employed. One-third of the total respondents reported a monthly income of approximately $193.5, with most of these individuals belonging to nuclear families comprising a father, mother and children. A more significant proportion of the total respondents (more than one-third) identified as community leaders in their respective neighbourhoods. During the interview, it was established that approximately 50% of the respondents had fewer than two biological children.

Knowledge of natural hazards and landslides began with questions on the definition, types, examples and impacts of natural hazards. More than half of the respondents knew the



EWS, early warning systems.

FIGURE 4. Conceptual framework of factors affecting community leaders' practice on landslide management.

TABLE 1: Socio-demographic characteristics.

Variable	People (*n*)	Proportion (%)
Age group (years old)		
20–39	42	30.7
40–59	80	58.4
60–75	15	10.9
Gender		
Male	77	56.2
Female	60	43.8
Marital status		
Married	116	84.7
Single (widow/widower)	21	15.3
Last education		
Less than 12 years of schooling	59	43.1
More than or equal to 12 years of schooling	78	56.9
Working status		
Yes	86	68.6
No	51	37.2
Monthly income ($)		
< 193.5	44	32.1
193.5–322.6	60	43.8
> 322.6	33	24.1
Family type		
Nuclear	108	78.8
Extended	29	21.2

Note: Age group Mean ± standard deviation = 45.6 ± 11.8.
s.d., standard deviation.

TABLE 2: Frequency distribution of knowledge about natural hazards and landslides, landslide management knowledge and landslide management practices.

Variable	People (*n*)	Proportion (%)
Knowledge about natural hazards		
Definition	94	68.6
Types	127	92.7
Examples	137	100
Impact	137	100
Landslide-prone group		
Older people	94	68.6
Children	77	6.2
Under-five children	64	46.7
Pregnant women	31	22.8
People with disabilities	12	8.8
The need for vulnerable groups to prepare for landslide	67	48.9
Knowledge of landslides		
Definition	115	83.9
Causal factors	130	94.9
Impact	134	97.8
Signs of landslide	120	87.6
Knowledge about landslide management		
Preparedness mitigation definition	50	36.5
Types of landslide mitigation	40	29.2
Level of knowledge about natural hazards and landslides		
Poor	76	55.5
Good	61	29.2
Practice of landslide management		
Pre-landslide:		
Learning and practising evacuation routes	32	23.4
Discussing countermeasures with family members	34	24.8
Self-preparation habits before a landslide		
Preparing a preparedness bag	20	14.6
Planning or placing items in a relatively safe place	19	13.9
Disrupting daily life	68	49.6
Early signs of a landslide	130	94.9
At – landslide		
Evacuate landslide-prone family members to a safe place	68	49.6
Source of landslide information from:		
social media	53	38.7
mosque bell	19	81
Inform the public of the landslide and update the information	81	59.1
Feeling anxious when a landslide occurs	105	76.6
Evacuation site during landslide:		
Mosque/church	25	18.2
Safer relative/neighbour's home	38	27.7
Field	7	5.1
EWS of landslide		
Availability of EWS landslide	49	35.8
The information sources:		
WhatsApp Group	46	33.6
Mosque/*musholla* speakers	22	16.1
Neighbours	27	19.7
Kentongan/electricity pylons	85	62
First action when community leaders heard the landslide EWS:		
Pick up the disaster preparedness bag	12	8.8
Rush to the evacuation centre	90	65.7
Assist vulnerable groups to safer places	43	31.4
Calm down and do not panic	33	24.1
EWS of landslide level		
Poor	84	61.3
Good	53	38.7

Table 2 continues on the next page →

TABLE 2 (Continues ...): Frequency distribution of knowledge about natural hazards and landslides, landslide management knowledge and landslide management practices.

Variable	People (*n*)	Proportion (%)
ERP of the landslide		
Tasks division in flood emergency rescue	14	10.2
Something is being undertaken for landslide evacuation	72	52.6
Maps, places, evacuation routes, assembly points are available	5	3.6
There were relatives/families providing shelter	70	51.1
There was first aid medicine when there was a landslide	56	49.9
There were family members who had taken part in training	2	1.5
There are evacuation routes in case of a landslide	9	6.6
Family lighting equipment available in emergency	119	86.9
Family communication tools are available during a landslide	126	92
Have prepared a disaster preparedness	11	8
Have an important phone number (hospital, police office firefighter) in the emergency	34	24.8
Have ever received landslide preparedness training	2	1.5
Level of emergency response plan parameter		
Poor	79	57.7
Good	58	42.3

Note: *Level of knowledge about natural hazards and landslides* - Mean ± s.d. = 37.4 ± 12.1; *EWS of landslide level* - Mean ± s.d. = 28.5 ± 22.5; *Level of emergency response plan parameter* - Mean ± s.d. = 35.9 ± 13.6.

s.d., standard deviation; EWS, early warning systems; ERP, emergency response plans.

meaning of natural hazards, and all respondents could mention the types, examples and effects. Older people were part of the most disaster-prone groups, as respondents expressed, followed by children and toddlers. This group needs to prepare for a landslide, according to most respondents. Although nearly all respondents could accurately describe a landslide, its definition, causes, impacts and hallmarks, their overall understanding of natural hazards and landslide-specific knowledge remained low (mean score = 37.4). This shortfall is primarily driven by limited awareness of which population groups are most vulnerable during disasters and by gaps in knowledge about landslide management (Table 2).

Practices for managing landslides commence during the pre-landslide phase, identified by a few participants through early detection of landslide signs, family conversations about landslide management and assembling disaster preparedness kits. Nearly half of the respondents relocated family members at risk of landslide to a secure location. The primary sources of landslide information are mainly social media. Most respondents shared the latest landslide developments with other community members. Feeling anxious during a landslide, they typically evacuate to the safer homes of relatives or neighbours. Following a landslide, the most common actions include ensuring no further landslides and cleaning the house and surroundings if the house remains intact (undamaged). Landslide management practices still need to be increased based on the above practices. One-third of the total survey participants already possess a landslide EWS in the form of bells, electric poles and a WhatsApp group. The most common response to the landslide EWS sounding was rushing to the evacuation site, while the least common action was taking a disaster preparedness bag. It is evident that the landslide EWS still needs improvement. The level of preparedness in the ERP could be higher, particularly in the pre-landslide actions, which are seldom carried out except during an actual landslide (Table 2).

Significant variations in landslide management practices are based on age, educational attainment, working status, monthly income, EWS, ERP of landslide and knowledge about natural hazards and landslides. These are presented in Table 3. The variables of age, educational attainment, monthly income, EWS level, ERP level, level of knowledge about natural hazards and landslides, and level of landslide management practices were significantly different from genders. Males rather than females dominate the age group above 50 years. The proportion of male respondents with senior high school education is twice that of females. Similarly, a monthly income above $322.6, the position of community leader, a good level of EWS, a good level of the ERP, a level of knowledge about natural hazards and landslides, and a good level of landslide management practices are owned mainly by male respondents. Landslide management practices (pre, during, post) of a community leader with a good level of ERP are 11.6 times higher than that of a community leader with a low level (Table 4). Table 4 explained that the Hosmer–Lemeshow test yielded a Chi-Square value of 1.737 with a *p*-value of 0.973 (> 0.05). This indicates that the logistic regression model fits the data well, as there is no significant difference between the observed and predicted values. The −2 Log Likelihood value of the logistic regression model is 102.758, which is smaller than the Chi-Square table value (degrees of freedom [*df*] = 132) of 159.814. This indicates that the logistic regression equation meets the test requirements and shows good overall model fit. The Omnibus Test shows a Chi-Square value of 85.929 with a *p*-value < 0.05. This means that the independent variables: gender, number of biological children, ERP, and knowledge about natural hazards and landslide have a simultaneous, statistically significant effect on the community leaders' practice in landslide management. The Nagelkerke R Square value is 0.623, indicating that the four independent variables listed above together explain 62.3% of the variation in the community leaders' practice in landslide management, while the remaining 37.7% of the variation is because of other factors not included in the model.

TABLE 3: Analysis of the differences in the proportion of sociodemographic characteristics, knowledge of natural hazards and landslide, emergency response plans with landslide management practices.

Variable	*n*	Practice before the landslide						Practice at the landslide						Practice post-landslide						Practice of landslide management					
		Poor		Good		OR (95% CL)	*p*-value	Poor		Good		OR (95% CI OR)	*p*-value	Poor		Good		OR (95% CI OR)	*p*-value	Poor		Good		OR 5% CI OR	*p*-value
		n	%	*n*	%			*n*	%	*n*	%			*n*	%	*n*	%			*n*	%	*n*	%		
Gender																									
Women	60	39	65.0	21	35.0	1	-	43	71.7	17	28.3	1	-	38	63.3	22	36.7	1	-	40	66.7	20	33.3	1	-
Men	77	40	51.9	37	48.1	1.7	0.125	43	55.8	34	44.2	2.0	0.047	41	53.2	36	46.8	1.5	0.236	35	45.5	42	54.5	2.4	*0.000
	-	-	-	-	-	(0.9–3.4)	-	-	-	-	-	(19–4.1)	-	-	-	-	-	(0.8–3.0)	-	-	-	-	-	(1.2–4.8)	-
Marital status																									
Single/widow/widower	21	12	57.1	9	42.9	1	0.958	15	71.4	6	28.6	1	0.373	12	57.1	9	42.9	1	0.958	13	61.9	8	38.1	1	0.400
Married	116	67	57.8	49	42.2	0.9	-	71	61.2	45	38.8	1.6	-	67	57.8	49	42.2	0.9	-	62	53.4	54	46.6	1.4	-
	-	-	-	-	-	(1.4–2.5)	-	-	-	-	-	(0.6–4.4)	-	-	-	-	-	(0.4–2.5)	-	-	-	-	-	(0.5–3.7)	-
Age group (years old)																									
< 40	42	22	52.4	20	47.6	1	-	27	64.3	15	35.7	1	-	22	52.4	20	47.6	1	-	21	50.0	21	50.0	1	-
40–50	47	31	66.0	16	34.0	0.6	0.194	33	70.2	14	2.9.8	0.8	0.552	30	63.8	17	36.2	0.6	0.623	31	66.0	16	34.0	0.5	0.100
	-	-	-	-	-	(0.2–1.3)	-	-	-	-	-	(0.3–1.9)	-	-	-	-	-	(0.3–1.5)	-	-	-	-	-	(0.2–1.2)	-
> 50	48	26	54.2	22	45.8	0.9	0.865	26	54.2	22	45.8	1.5	0.331	27	56.3	21	43.8	0.9	0.713	23	47.9	25	52.1	1.1	-
	-	-	-	-	-	(0.4–2.1)	-	-	-	-	-	(0.7–3.6)	-	-	-	-	-	(0.4–1.9)	-	-	-	-	-	(0.5–2.5)	-
Final education																									
Completed secondary education or less	71	55	77.5	16	22.5	1	-	62	87.3	9	12.7	1	-	53	74.6	18	25.4	1	-	55	77.5	16	22.5	1	0.800
High school graduates and above	66	24	36.4	42	63.6	6.0	*0.001	24	36.4	42	63.6	12.1	*0.001	26	39.4	40	60.6	4.5	*0.001	20	30.3	46	69.7	7.9	*0.000
	-	-	-	-	-	(2.8–12.7)	-	-	-	-	-	(5.1–28.5)	-	-	-	-	-	(2.2–9.4)	-	-	-	-	-	(3.7–1.70)	-
Working status																									
No	51	32	62.7	19	37.3	1	-	37	72.5	14	27.5	1	-	32	62.7	19	37.3	1	-	32	62.7	19	37.3	1	-
Yes	86	47	54.7	39	45.3	1.4	0.354	49	57.0	37	43.0	2.0	0.068	47	54.7	39	45.3	1.4	0.354	43	50.0	43	50.0	1.7	0.100
	-	-	-	-	-	(0.7–1.8)	-	-	-	-	-	(0.9–4.2)	-	-	-	-	-	(0.7–2.8)	-	-	-	-	-	(0.8–3.4)	-
	108	58	63.0	40	37.0	1	0.500	68	63.0	40	37.0	1	0.930	64	59.3	44	40.7	1	0.466	63	58.3	45	41.7	1 0.1	-
Extended family	29	11	37.9	18	62.1	2.8	-	18	62.1	11	37.9	1.0	-	15	51.7	14	48.3	1.4	-	12	41.4	17	58.6	1.9	-
	-	-	-	-	-	(1.2–6.5)	-	-	-	-	-	(0.4–2.4)	-	-	-	-	-	(1.6–3.1)	-	-	-	-	-	(0.9–4.6)	-
Number of biological children																									
> 2	76	48	63.2	28	36.8	1	-	50	65.8	26	34.2	1	-	47	61.8	29	38.2	1	-	47	61.8	29	38.2	1	0.100
1–2	61	31	50.8	30	49.2	1.7	0.146	36	59.0	25	41.0	1.3	0.415	32	52.5	29	47.5	1.5	0.269	28	45.9	33	54.1	1.9	-
	-	-	-	-	-	(0.8–3.2)	-	-	-	--		(0.7–2.3)	-	-	-	-	-	(0.7–2.9)	-	-	-	-	-	(0.9–3.8)	-
Monthly family income (USD)																									
< 193.5	47	37	78.7	10	21.3	1	-	41	87.2	6	12.8	1	-	33	70.2	14	29.8	1	*0.046	37	78.7	10	21.3	1	-
193.5–322.6	58	32	55.2	26	44.8	3.0	*0.013	32	55.2	26	44.8	5.6	*0.001	30	5.17	28	48.3	2.2.	-	27	46.6	31	53.4	4.2	*0.013
	-	-	-	-	-	(1.3–7.2)	-	-	-	-	-	(2.0–15.1)	-	-	-	--		(0.9–4.9)	-	-	-	-		(1.8–10.1)	-
> 322.6	32	10	31.3	22	68.8	8.1	*0.011	13	40.6	19	59.4	9.9	*0.001	16	50.0	16	50.0	2.4	*0.032	11	34.4	21	65.6	7.1	-
	-	-	-	-	-	(2.9–22.6)	-	-	-	-	-	(2.9–22.6)	-	-	-	-	-	(0.9–4.9)	-	-	-	-	-	(2.6–19.4)	-
EWS of landslide																									
Poor	84	50	59.5	34	40.5	1	-	55	65.5	29	34.5	1	-	53	63.1	31	36.9	1	-	53	63.1	31	36.9	1	-
Good	53	29	54.7	24	45.3	1.2	0.579	31	58.5	22	41.5	1.3	0.410	26	49.1	27	50.9	1.8	0.105	22	41.5	31	58.5	2.4	*0.013
	-	-	-	-	-	(0.6–2.4)	-	-	-	-	-	(0.7–2.3)	-	-	-	-	-	(0.9–3.6)	-	-	-	-	-	(1.2–4.9)	-

Table 3 continues on the next page →

TABLE 3 (Continues ...): Analysis of the differences in the proportion of sociodemographic characteristics, knowledge of natural hazards and landslide, emergency response plans with landslide management practices.

Variable	*n*	Practice before the landslide						Practice at the landslide						Practice post-landslide						Practice after the landslide					
		Poor		Good		OR (95% CL)	*p*-value	Poor		Good		OR (95% CI OR)	*p*-value	Poor		Good		OR (95% CI OR)	*p*-value	Poor		Good		OR (95% CI OR)	*p*-value
		n	%	*n*	%			*n*	%	*n*	%			*n*	%	*n*	%			*n*	%	*n*	%		
Emergency response plan																									
Poor	79	61	77.2	18	22.8	1	-	65	82.3	14	17.7	1	-	59	74.7	20	25.3	1	-	63	79.7	16	20.3	1	-
Good	58	18	31.0	40	69.0	7.5	*0.001	21	36.2	37	63.8	8.2	*0.001	20	34.5	38	65.3	5.6	*0.001	12	20.7	46	79.3	15.1	*0.000
	-	-	-	-	-	(3.5–16.2)	-	-	-	-	-	(3.7–17.9)	-	-	-	-	-	(2.7–11.8)	-	-	-	-	-	(6.5–34.9)	-
Knowledge about natural hazards and landslide																									
Poor	76	59	77.6	17	22.4	1	-	60	86.8	10	13.2	1	-	57	75.0	19	25.0	1	-	62	81.6	14	18.4	1	-
Good	61	20	32.8	41	67.2	7.2	*0.001	20	32.8	41	67.2	13.5	*0.001	22	36.1	39	63.9	5.3	*0.001	13	21.3	48	78.4	16.4	*0.000
	-	-	-	-	-	(3.3–15.2)	-	-	-	-	-	(5.8–31.8)	-	-	-	-	-	(2.5–11.1)	-	-	-	-	-	(7.0–38.0)	-

OR, odds ratio; CI, confidence interval; USD, United States Dollar; EWS, emergency warning system.
*, $p < 0.005$.

TABLE 4: Logistic regression analysis of gender, number of biological children, emergency response plans, knowledge about natural hazards and landslides with practice of landslide management.

Variable	*B*	SE	Wald	*df*	*p*-value	OR	Lower	Upper
Gender (men vs women)	1.273	0.534	5.669	1	0.017	3.6	1.3	10.2
Number of biological children (1–2 vs > 2)	1.160	0.537	4.664	1	0.031	3.2	1.1	9.1
ERP (good vs poor)	2.454	0.537	20.836	1	0.000	11.6	4.1	33.3
Knowledge about natural hazards and landslide (good vs poor)	2.443	0.523	21.798	1	0.000	11.1	4.1	32.1
Constant	3.623	0.682	28.223	1	0.000	0.0	-	-

Note: Chi-Square Hosmes andLemeshow 1 737; –2 Lokehood = 102 758; Chi-quare Omnibus Test = 85 929 dan Nagelkerke *R* Square –0.623.
SE, standard error; OR, odds ratio; CI, confidence interval; *df*, degrees of freedom; ERP, emergency response plan.

Discussion

In Indonesia, Community-Based Disaster Management (CBDM) is a critical strategy for preparedness and response, utilising local knowledge and resources to strengthen resilience. Given the country's high vulnerability to natural hazards such as earthquakes, volcanic eruptions and floods, CBDM is essential for risk mitigation and fostering community self-reliance through community participation, local knowledge, resource mobilisation and capacity building. A key objective of CBDM is to enhance community leaders' knowledge of disasters, EWS and ERP in the context of landslide management (Ali et al. 2019). Landslide management practice of community leaders influenced by socio-demographic characteristics (gender, education attainment, and monthly income); knowledge about natural hazards and landslides; EWS and ERP. This section highlights the role of four factors affecting landslide management practice and the current research's role in enriching the landslide disaster management research repertoire in Indonesia.

Socio-demographic characteristics such as gender, educational attainment, and monthly income exhibit notable variances in community leaders' practices in landslide management. The study showed that the proportion of men is slightly higher than that of women. Many respondents in the study were male community leaders. The Indonesian culture of appointing a community leader in Indonesia is male, and the patriarchal culture encourages many men to become community leaders today. Community leaders are agents of change in changing the disaster preparedness behaviour of the community.

Landslide management practices show significant gender disparities. Compared to adult men, women are at a 14 times higher risk of being victims of disasters. The level of good landslide management practices was found to be higher among men than among women. This difference appears to be influenced by the fact that most men had at least a high school education, were employed, had a monthly income above $322.6, possessed good knowledge about natural hazards and landslides, and had prepared a good contingency plan. This reinforces that women play essential roles across all phases of disaster management. In emergency response, women frequently assist the injured before official responders arrive and contribute significantly to search and rescue operations. During reconstruction and recovery, they organise community celebrations of survival, fostering solidarity and social cohesion (Enarson, Fothergill & Peek 2017).

The management of landslides varies significantly depending on the level of education achieved. This means that educational attainment influences community leaders' practice of landslide management. Respondents who had completed high school or a higher level of education demonstrated significantly better landslide management practices compared with those who had only completed secondary education or less. This finding is supported by Cahyani and Suharini (2021), and Haristiani et al. (2023), who found that education level influenced preparedness for landslide disasters. High-level education graduates were expected to be more prepared because of their exposure to emergency systems, and education may influence the degree to which individuals process risk mitigation information (Menard, Slater & Flaitz 2011).

Family income influences landslide management practices. Community leaders with monthly incomes between $193.5 and $322.6 exhibited better landslide management practices compared with those whose monthly incomes were below $193.5. This study is consistent with the Zamboni and Martin (2020), which showed that higher income increases the likelihood that households will be prepared and evacuate when necessary. This strengthens the amount of family income supports families in providing items needed to prepare for disasters, such as food reserves, savings, insurance and others that cause families to be better prepared for the impacts that will occur because of disasters (Rohman & Suroso 2013).

The understanding of natural hazards and landslides differs significantly from implementing landslide management based on gender. The proportion of respondents with good knowledge about natural hazards and landslides was higher among men compared to women. The level of good landslide management practices is higher among men than women. This condition is influenced by most men having at least a high school education, working status, a monthly income above $322.6, good knowledge about natural hazards and landslides and a good contingency plan. This conclusion aligns with the findings of Fatmah, Fitrinitia and Ambran (2025), who reported that earthquake preparedness is associated with knowledge. Similarly, Fatmah (2024) found that knowledge about floods correlates with effective flood management. This strengthens that the local community possesses indigenous knowledge to reduce the impacts of landslide disasters (Cahyono, Wuryanta & Lastiantoro 2021). Men's contingency plans are also better than women's because men are more responsive to natural hazards, including a quicker response attitude in disaster mitigation efforts than women (Sari & Ridwan 2019). Knowledge plays a crucial role in the preparedness of a community, which shapes an individual's readiness. Knowledge is the outcome of perception, an individual's comprehension of objects through their senses, which include sight, hearing, smell, taste and touch (Notoatmodjo 2010).

The EWS does not have any influence on the practices of community leaders in managing landslides. The EWS for landslide primarily relies on a WhatsApp group-based disaster information system. Effective communication and information distribution are essential in reducing the impact of landslide disasters. Initially, the communities used *kentongan* for communication, but it could have been more effective and efficient, so they switched to WhatsApp. This finding is different from Wardyaningrum (2014), who found that the relationships in a centralised communication

network among stakeholders in this area significantly reduce disaster risk by utilising local capabilities. This reinforces that EWS affect community preparedness in landslide disasters. Disaster early warnings that are built or available and affordable to the community can increase community preparedness in dealing with landslide disasters (Suparji, Nugrogo & Surtinah 2022).

Emergency response plans impact the community leaders' approach to landslide management. The management of landslides differs significantly from efforts to build a disaster-resilient community, as the integration of emergency response planning within landslide management remains relatively low. Respondents with low levels of ERP tended to exhibit poorer landslide management practices. This gap indicates a need to strengthen the role of preparedness and coordinated response in overall landslide risk reduction strategies. This finding aligns with research on the factors influencing volunteer willingness in China, which is at 14.65% (Ma et al. 2021). This is reinforced by emergency response is critical to disaster management practices (before, during and after). Managing disasters and responding to emergencies require efficient coordination and preparedness to mitigate the impacts of disasters and protect human lives (Ardiansyah et al. 2024). Emergency response plans involve aspects of emergency relief skills that significantly affect community preparedness for disasters.

The current research has enriched previous research results on factors related to landslide management practices of community leaders, such as socio-demographic characteristics, knowledge about natural hazards and landslides, EWS, and ERP, but a study on the development of a landslide risk reduction model in landslide-prone areas does not exist yet. Therefore, the research results can be the basis for forming a Community-Based Risk Reduction (CBRR) model of community leaders to improve landslide management practices through ERP, for example, Disaster Prepared Village (KSBs) and *Destana* Programme.

At the policy level, the *CBRR* empowerment programme in emergency response parameters in landslide-prone areas can be developed by the provincial, district and city of the Local Disaster Management Authority (*BPBDs*) in collaboration with the Ministry of Social Affairs, and provincial, city and district social services. In addition, disaster training, including landslide emergency response, landslide mitigation and evacuation simulation, must be provided to *KSB* members to improve their knowledge, attitudes and skills in dealing with landslides.

Conclusion

Firstly, the limitations of the study are the small sample size, which resulted in an insufficient representation of landslide management approaches among community leaders in the study's geographic locations. Secondly. The use of purposive sampling limits the external validity of the findings; therefore, the results cannot be generalised to the broader population or to district- and provincial-level contexts.

The study results indicate that gender and educational attainment were both significantly associated with community leaders' landslide management practices. Knowledge of natural hazards and landslides had a positive influence on the implementation of good landslide management practice. In this study, it was also found that the presence of an EWS showed no significant effect on landslide management practices. Community leaders who had an ERP were 11.6 times more likely to implement good landslide management practices compared with those without such a plan.

Additional research is needed to investigate the knowledge and landslide management practices of various vulnerable populations – including children, pregnant and breastfeeding women, older adults and individuals with disabilities – regarding landslide disasters. Extending this line of inquiry to other types of disasters is also essential. Intervention studies focusing on landslide management training for both the broader community and vulnerable groups should be conducted, with assessments of changes in management practices following the interventions. In addition, proper implementation of landslide management strategies underscores the need for wider adoption of preparedness and mitigation measures. Such strategies include assembling disaster preparedness kits and participating in training sessions, simulations, seminars and webinars to enhance readiness and mitigation efforts among vulnerable groups and their families.

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Competing interests

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CRediT authorship contribution

Fatmah Fatmah; Visualisation; Data curation, Writing – original draft, Writing – review & editing. Rachmadhi Purwana; Writing – original draft. Khamarrul A. Bin Razak; Writing - review & editing.

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Data availability

The data that support the findings of this study are available from the corresponding author, F.F., upon reasonable request.

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