

Needs Analysis for Offline Landslide Early Warning Educational Media for Mountain Communities in Latimojong

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Abstract. This study examines what offline landslide early warning education should offer mountain communities in Latimojong, Luwu Regency, Indonesia. We analysed daily rainfall records from 2008 to 2024, official disaster reports, terrain data, and assembly point suitability. Advisory-level rainfall occurred on 7.8% of days, and 93.8% of those days were driven by accumulated rather than single-day rain. Higher alert levels appeared on only five days, all between March and May. Only 3.2% of the district met every assembly point criterion, and 17 sites were recommended. The study specifies five offline learning modules and recommends an offline WebGIS.

Keywords: Needs Analysis; Disaster Education; Offline Learning Media; Landslide Early Warning; WebGIS.

1. Introduction

Rainfall-induced landslides rank among the deadliest natural hazards in tropical mountains. Between 2004 and 2016, Froude and Petley (2018) recorded 4,862 fatal landslides that killed 55,997 people worldwide, with Asia bearing the heaviest toll. Indonesia is particularly exposed because many rural settlements sit on steep slopes covered by thick weathered soil and receive heavy annual rainfall.

Luwu Regency in South Sulawesi illustrates this exposure. The floods and landslides of 3 May 2024, which began at 01:17 Central Indonesian Time (WITA), affected 13 districts (Badan Nasional Penanggulangan Bencana [BNPB], 2024a), and Latimojong District was hit hardest. The access road was severed, several village bridges collapsed, supplies for 12 villages had to be flown in by helicopter, and eight residents died (BNPB, 2024b). The Centre for Volcanology and Geological Hazard Mitigation (Pusat Vulkanologi dan Mitigasi Bencana Geologi [PVMBG], 2024) also recorded ground movements in five villages. Because the disaster struck at night and the area was then cut off, residents' chances of survival depended largely on what they understood and decided before dark.

Accurate forecasts alone do not make early warning work. Basher (2006) argued that warning systems must be people-centred, so that those at risk understand the message and act on it. The Protective Action Decision Model holds that people decide to evacuate only after they receive, notice, and comprehend a warning, and a failure to comprehend breaks the whole decision chain (Lindell & Perry, 2012). Fathani et al. (2016) set out seven subsystems for community-based landslide early warning, from risk assessment to community commitment, which were later adopted as ISO 22327:2018 (International Organization for Standardization [ISO], 2018). Intrieri et al. (2013) added

that warning systems should be simple, since confusion during an emergency only makes matters worse.

Education connects technical information with what residents actually do, but its effect depends on how well the content fits the learners. A systematic review by Seddighi et al. (2022) found that school-based disaster education raised awareness without necessarily producing preparedness. A mobile learning application improved primary school students' understanding of mitigation in Bengkulu (Winarni & Purwandari, 2018), and informal learning has proved effective in building preparedness outside schools (Pradhananga et al., 2022). However, most disaster applications are built without input from end users (Tan et al., 2017), even though ease of use determines whether people keep using them (Tan et al., 2020). How a mobile warning is worded also affects how long recipients wait before acting (Wood et al., 2018). Mountain areas add another difficulty, because warning technology can fail once power and communication networks go down (Intrieri et al., 2013).

The authors have studied disasters in this region for some years. Early work produced a community preparedness model for landslide risk reduction (Muis & Anwar, 2018) and a river-level monitor built on a microcontroller and short message service (Halim et al., 2019). In Luwu, the team has mapped land cover (Madung et al., 2023), located slip surfaces with geoelectrical surveys (Umar et al., 2023), analysed slopes in the Suso watershed (Nurfalaq, Manrulu, et al., 2024), mapped landslide-prone areas in Uluvalu Village (Nurfalaq, Muis, et al., 2024), and surveyed landslides and debris flows with uncrewed aerial vehicles (Muis et al., 2024). These results reached the community through the Disaster Resilient Village program (Desa Tangguh Bencana, hereafter Destana) in Latimojong (Iriansa et al., 2026; Muis et al., 2026). The team has also built technology-based learning media (Nur et al., 2024), web-based information systems (Hamza & Muis, 2025; Ramadhan et al., 2025), and a WebGIS calculator for agricultural losses (Rusmala et al., 2026).

Table 1 positions this study against 15 earlier studies, seven international and eight by the authors, using seven dimensions that early warning media for remote mountain areas require. Three gaps emerge. Nine studies used local hazard data, but none translated those data into educational content for residents. Only three studies touched on whether media can work without a network, and none dealt with it fully, even though mountain areas are easily isolated during disasters. Evacuation decision time appeared in just two studies and has never been linked to the suitability and accessibility of local assembly points.

Table 1. Positioning of the present study relative to previous research

Study	Local hazard data	Landslide early warning	Educational media	Village community	WebGIS or digital platform	Offline operation	Evacuation decision time
<i>International studies</i>							
Intrieri et al. (2013)	(√)	√	-	-	-	(√)	-
Fathani et al. (2016)	(√)	√	(√)	√	-	-	(√)
Tan et al. (2017)	-	-	(√)	-	√	-	-
Winarni & Purwandari (2018)	-	-	√	-	√	-	-
Wood et al. (2018)	-	(√)	-	(√)	(√)	-	√
Guzzetti et al. (2020)	√	√	-	-	(√)	-	-
Pradhananga et al. (2022)	-	-	√	√	-	(√)	-
<i>Studies by the authors</i>							
Muis & Anwar (2018)	(√)	-	(√)	√	-	-	-
Halim et al. (2019)	(√)	(√)	-	-	(√)	(√)	-

Nurfalaq, Muis, et al. (2024)	√	-	-	-	(√)	-	-
Muis et al. (2024)	√	-	-	-	(√)	-	-
Nur et al. (2024)	-	-	√	-	(√)	-	-
Hamza & Muis (2025)	-	-	(√)	(√)	√	-	-
Iriansa et al. (2026)	(√)	(√)	(√)	√	(√)	-	-
Rusmala et al. (2026)	(√)	-	-	(√)	√	-	-
Present study	√	√	√	√	(√)*	√	√

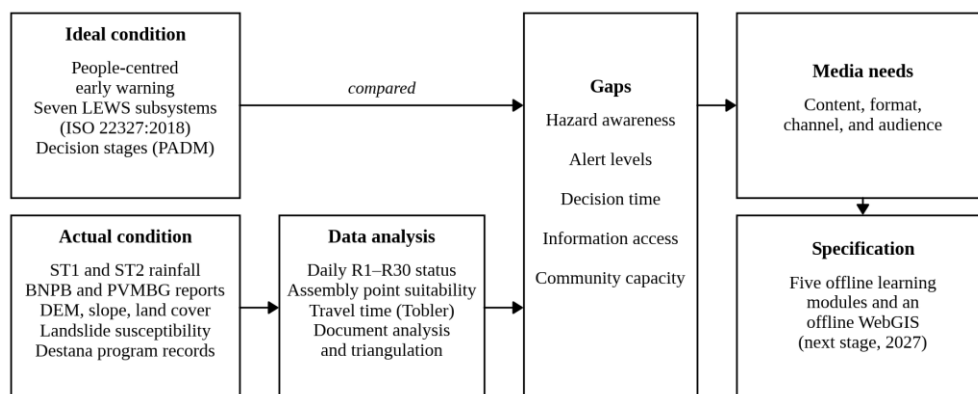
Note. √ = fully addressed; (√) = partially addressed; - = not addressed; * = WebGIS is proposed as a recommendation for the next stage—source: authors' analysis (2026) of the cited studies.

In short, data and institutions already exist, but there are no media that teach residents to read rainfall danger signs and to decide on evacuation without network access. Developing such media should start with a needs analysis, because the analysis phase sets the goals, content, and format of what will be designed (Branch, 2009). A needs analysis measures the gap between what should be and what is (Watkins et al., 2012). Surveys and interviews are the usual tools, yet repeated data collection can burden post-disaster communities in remote areas. This preliminary study therefore draws on existing data, and its findings will be checked directly with residents in the next stage.

The study aims to (1) describe the rainfall hazard that the Latimojong community needs to understand, (2) assess the suitability and accessibility of evacuation assembly points, (3) identify gaps between ideal and actual community-based early warning and specify requirements for offline educational media, and (4) recommend how these media can be developed as an offline WebGIS.

2. Method

We used a descriptive qualitative approach supported by descriptive statistics and spatial analysis. The work corresponds to the analysis phase of the ADDIE model (Branch, 2009), and its logic follows the discrepancy model, which compares ideal and actual conditions (Watkins et al., 2012). Figure 1 shows the analytical framework. Design and development lie outside the scope of this study and are presented as recommendations.



Source: authors' analysis (2026).

Figure 1. Analytical framework of the needs analysis for landslide early warning educational media

The study area is Latimojong District, Luwu Regency, which comprises 12 villages in the Latimojong Mountains. All data were secondary and available before the study began, so no interviews or questionnaires were used at this stage. Table 2 summarises the data types, sources, and uses.

Data were gathered through documentation and examined by document analysis (Bowen, 2009). Daily rainfall was first grouped into light (5 to 20 mm), moderate (20 to 50 mm), heavy (50 to 100 mm), very heavy (100 to 150 mm), and extreme (more than 150 mm) classes. We then computed

R1, the rainfall on a given day, and R30, the total over the 30 days ending on that day. R30 was calculated only where the preceding 30-day record was complete, which left 5,397 days for analysis. Each day was assigned to the Normal, Advisory (Waspada), Watch (Siaga), or Warning (Awas) level. Advisory applied when R1 was at least 70 mm with R30 of at least 400 mm or when R30 reached 500 mm; Watch when R1 was at least 90 mm and R30 at least 450 mm; and Warning when R1 was at least 130 mm and R30 at least 500 mm. These thresholds come from the ST1 record and serve as working thresholds for education, not as official ones.

Table 2. Types, sources, and uses of data

Data type	Source and period	Use in the analysis
Daily rainfall	Local observation stations ST1 (2008 to 2024) and ST2 (2022 to 2024)	Rainfall class frequency, R1, R30, and alert levels
Event reports	Official BNPB releases, 4 and 5 May 2024	Timing, impacts, and accessibility conditions
Ground movement records	PVMBG Geological Disaster Mitigation Portal (2024).	Distribution of affected villages
Terrain data	Digital elevation model, stream network, land cover, and the team's landslide susceptibility map on a 100 m grid	Slope gradient, assembly point suitability, and travel time
Program records	Research and community service publications of the team (2018 to 2026)	Institutional capacity and prior experience

Source: authors' analysis (2026).

Assembly point suitability was assessed on a 100 m grid against six criteria (Table 3), drawn from the systematic review by Soltani et al. (2014), which found accessibility, proximity to homes, site size, distance from hazards, geological hazards, and slope to be the most common criteria. Slope classes follow Van Zuidam (1985), the stream buffer follows the river setback rule for non-urban areas (Kementerian Pekerjaan Umum dan Perumahan Rakyat [PUPR], 2015), and the suitability classes follow the land evaluation framework of the Food and Agriculture Organization of the United Nations (FAO, 1976). Cells without elevation data were excluded. Cells meeting all criteria were merged into patches, and each village received the site with the lowest mean travel time from its settlement cells and village centre. Villages with more than 50 settlement cells received a second site when it cut the mean travel time by more than 15 minutes. This step was needed because no assembly point in Latimojong had yet been designated on the basis of suitability.

Table 3. Suitability criteria for evacuation assembly points

Criterion	Threshold	Basis
Slope gradient	Class S1 (highly suitable) for 0 to 8°; class S2 (moderately suitable) for more than 8 to 16°	Van Zuidam (1985); Soltani et al. (2014)
Landslide susceptibility	Very low or low class (index below 0.4)	Soltani et al. (2014)
Distance from streams	At least 100 m	PUPR (2015)
Position relative to very steep slopes	No cell steeper than 35° within a 200 m radius	Van Zuidam (1985); authors' working assumption
Land cover	Not forest or dense vegetation	Soltani et al. (2014)
Accessibility	Lowest mean travel time from the village settlement cells	Soltani et al. (2014)

Source: authors' analysis (2026), adapted from Van Zuidam (1985), Soltani et al. (2014), and PUPR (2015).

Walking time was modelled as the least-cost path over the digital elevation model with eight movement directions. Speed at each step followed Tobler's (1993) hiking function with a factor of 0.6 for off-path travel, and the results were summarised for the whole district and for settlement

cells. The position of this study relative to earlier work was mapped with a seven-dimension matrix, and all findings were organised into a gap matrix and translated into media requirements. Source triangulation, such as comparing the ST1 and ST2 records on the day of the event and matching the rainfall chronology with the BNPB reports, supported the credibility of the data.

3. Results

Rainfall characteristics and alert levels

Station ST1 recorded 5,752 days between 1 January 2008 and 20 November 2024. Mean annual rainfall is about 3,290 mm, and at least 1 mm of rain fell on 55.5% of days. April is the wettest month (mean 434 mm), followed by March (386 mm), February (339 mm), and May (324 mm), while September is the driest (123 mm). Table 4 gives the distribution of days by intensity class.

Table 4. Distribution of ST1 observation days by daily rainfall intensity class, 2008 to 2024

Daily rainfall class	Range (mm/day)	Number of days	Percentage
Very light or no rain	less than 5	3,588	62.4%
Light	5 to 20	1,236	21.5%
Moderate	20 to 50	733	12.7%
Heavy	50 to 100	183	3.2%
Very heavy	100 to 150	10	0.2%
Extreme	more than 150	2	0.03%
Total		5,752	100%

Source: authors' analysis (2026) of station ST1 records.

Heavy to extreme rain fell on only 195 days (3.4%). Extreme rain was recorded twice: 160.0 mm on 5 February 2008 and 186.0 mm on 2 May 2024. The latter is the highest value on record, and ST2 measured 175.0 mm on the same day, so the two stations agree.

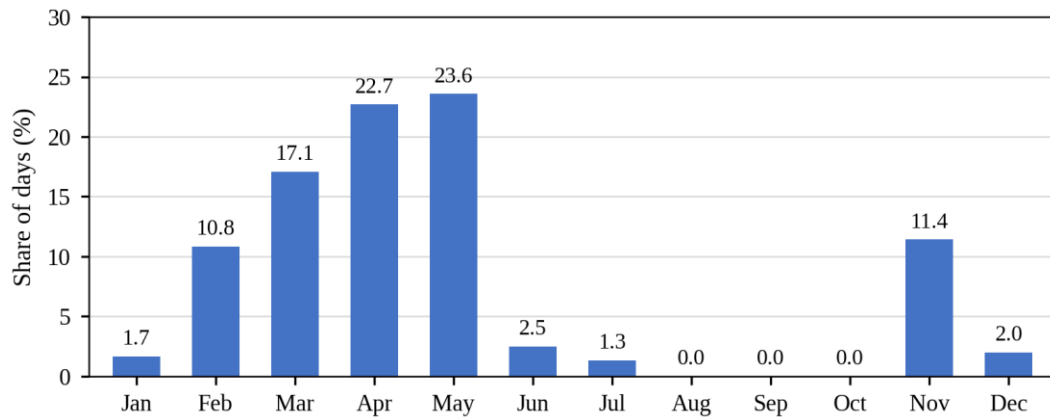
Of the 5,397 analysed days, 4,972 were Normal (92.1%), 420 Advisory (7.8%), 4 Watch (0.07%), and 1 Warning (0.02%). Over roughly 14.8 years, the Advisory level occurred on 28 days per year on average, with large year-to-year variation and a maximum of 82 days in 2010. Table 5 lists the Watch and Warning days.

Table 5. Watch and Warning days in the ST1 record

Date	R1 (mm)	R30 (mm)	Alert level
31 March 2017	116.1	498.0	Watch
17 March 2020	91.9	466.0	Watch
14 March 2022	131.0	463.0	Watch
8 May 2023	142.0	489.0	Watch
2 May 2024	186.0	680.5	Warning

Source: authors' analysis (2026) of station ST1 records.

All five high-level days fell between March and May. Figure 2 shows the same seasonality for days at the Advisory level or higher. Of these 425 days, 304 (71.5%) occurred from March to May, with the largest shares in May (23.6%) and April (22.7%). August to October never reached the Advisory level, while November formed a smaller second peak (11.4%).



Source: authors' analysis (2026) of station ST1 records.

Figure 2. Share of days at the Advisory level or higher by month at station ST1, 2008 to 2024

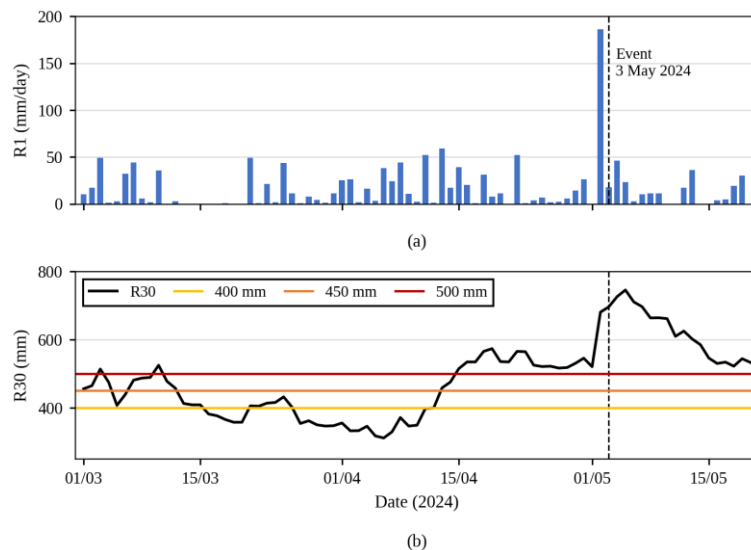
The yearly breakdown in Table 6 is uneven. The years 2010, 2013, 2016, 2023, and 2024 each had a month with more than 20 Advisory days, whereas some other years barely reached that level. In May 2024, every one of the 31 days was at the Advisory level or higher.

Table 6. Number of days at the Advisory level or higher per month at station ST1

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	n.a.	0	3	4	2	0	0	0	0	0	8	0
2009	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
2010	n.a.	n.a.	5	26	25	0	0	0	0	0	26	0
2011	0	0	0	3	13	0	0	0	0	0	13	2
2012	0	0	9	4	3	0	0	0	0	0	n.a.	0
2013	1	0	0	3	23	12	n.a.	n.a.	0	0	0	1
2014	n.a.	n.a.	n.a.	1	0	0	0	0	0	0	0	0
2015	0	17	0	0	0	0	0	0	0	0	0	0
2016	0	0	26	15	11	0	0	0	0	0	0	0
2017	0	0	2*	2	1	0	0	0	0	0	0	6
2018	0	n.a.	0	0	0	0	0	0	0	0	0	0
2019	0	7	14	0	1	0	0	0	0	0	0	0
2020	0	0	9*	12	0	0	6	0	0	0	0	0
2021	0	0	0	0	0	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
2022	0	15	7*	0	0	0	0	0	0	0	0	0
2023	0	0	2	22	7*	0	0	0	0	0	0	0
2024	0	1	2	16	31*	0	0	0	0	0	n.a.	n.a.

Note. Darker shading indicates more days; bold values marked with * denote months containing a Watch or Warning day; n.a. = fewer than 25 recorded days. Source: authors' analysis (2026) of station ST1 records.

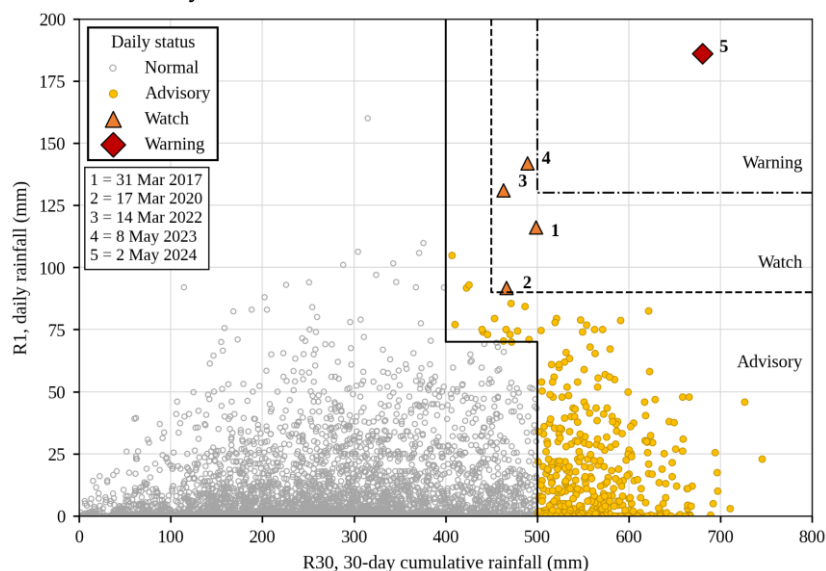
Figure 3 traces the rainfall leading up to 3 May 2024. R30 had exceeded 500 mm since 15 April 2024, so the Advisory level held for 17 consecutive days before 186.0 mm of rain on 2 May pushed the status to Warning. The disaster came a few hours later.



Note. (a) R1; (b) R30 with the working thresholds of 400, 450, and 500 mm. Source: authors' analysis (2026) of station ST1 records.

Figure 3. Daily rainfall (R1) and 30-day cumulative rainfall (R30) at station ST1, March to May 2024

Figure 4 plots all 5,397 days by R30 and R1. Of the 420 Advisory days, 394 (93.8%) had an R1 below 70 mm and 267 (63.6%) an R1 below 20 mm. The Advisory level was thus almost always produced by accumulated rain rather than by a single downpour. Conversely, half of the 62 days with an R1 of at least 70 mm stayed at the Normal level because R30 was still low.



Source: authors' analysis (2026) of station ST1 records.

Figure 4. Distribution of 5,397 ST1 observation days by R30 and R1 with alert-level boundaries

Suitability and accessibility of assembly points

Of the 31,163 cells with elevation data, 79.5% fall in the steep class (16 to 35°) and 11.7% in the very steep class (35 to 55°). Rolling terrain (8 to 16°) accounts for only 8.2%, and flat to gently rolling land for less than 1%. Once all six criteria were applied, only 1,001 cells, or 3.2% of the district, remained suitable. They form 267 patches, with 60 cells in class S1 and 941 in class S2. Slope was the main constraint, since only 8.8% of cells are 16° or flatter, followed by the distance from very steep slopes, which only 41.2% of cells satisfied.

From these patches, 17 recommended assembly points were selected in 12 villages (Table 7). Each village received one site, and five villages with scattered settlements, namely Boneposi, Buntu

Sarek, Pajang, Tabang, and Ulusalu, received a second. Only TK-16 in Ulusalu falls in class S1 (highly suitable), with a slope of 7.6°. The other 16 sites are class S2 (moderately suitable), with slopes of 9.4 to 15.4°, and need minor levelling. All sites lie in the very low (8 sites) or low (9 sites) susceptibility class, 187 to 1,250 m from streams, on patches of 1 to 10 ha.

Table 7. Evacuation assembly points recommended on the basis of the suitability analysis

Code	Village	Latitude (S)	Longitude (E)	Class	Slope (°)	Distance to stream (m)	Patch area (ha)	Susceptibility
TK-01	Boneposi	3.3662	120.1042	S2	10.7	315	3	low
TK-02	Boneposi	3.3752	120.1248	S2	13.5	669	3	low
TK-03	Buntu Sarek	3.4282	120.1222	S2	12.3	325	1	very low
TK-04	Buntu Sarek	3.4246	120.1114	S2	9.8	659	10	very low
TK-05	Kadundung	3.3742	120.1725	S2	15.4	256	1	low
TK-06	Lambanan	3.4561	120.1149	S2	13.5	522	7	very low
TK-07	Pajang	3.4183	120.1042	S2	12.9	502	1	very low
TK-08	Pajang	3.4201	120.1329	S2	12.9	1,053	1	low
TK-09	Pangi	3.2933	120.1338	S2	14.2	295	1	low
TK-10	Rante Balla	3.3428	120.0970	S2	9.4	886	3	very low
TK-11	Tabang	3.3158	120.0799	S2	13.5	394	2	low
TK-12	Tabang	3.3005	120.1195	S2	12.9	1,033	1	low
TK-13	Tibussan	3.4903	120.1393	S2	10.1	1,250	7	very low
TK-14	To'barru	3.3554	120.1635	S2	14.8	207	1	low
TK-15	To'lajuk	3.3733	120.0952	S2	15.1	896	1	very low
TK-16	Ulusalu	3.3986	120.0862	S1	7.6	728	2	very low
TK-17	Ulusalu	3.4039	120.1158	S2	15.1	187	1	low

Note. S1 = highly suitable; S2 = moderately suitable. Source: authors' analysis (2026).

Figure 5 maps walking time to the recommended sites. Areas within 30 minutes cluster around the suitable patches, whereas walks of more than two hours occur mostly along the steep, almost uninhabited margins of the district. Only 0.3% of the cells beyond two hours are settlement cells.

Figure 6 shows the walking time classes. Of the settlement cells, 32.8% can reach a site within 30 minutes and 42.4% within 30 to 60 minutes, with a median of 41 minutes. The remaining 24.8% need more than an hour, mostly where a valley separates them from suitable land. For the whole district, the median is 78 minutes, because much of the area consists of steep, sparsely settled slopes. These are model estimates, and every site still needs checking in the field. The message is nonetheless clear. For some residents, deciding to evacuate only once very heavy rain is already falling would be too late.

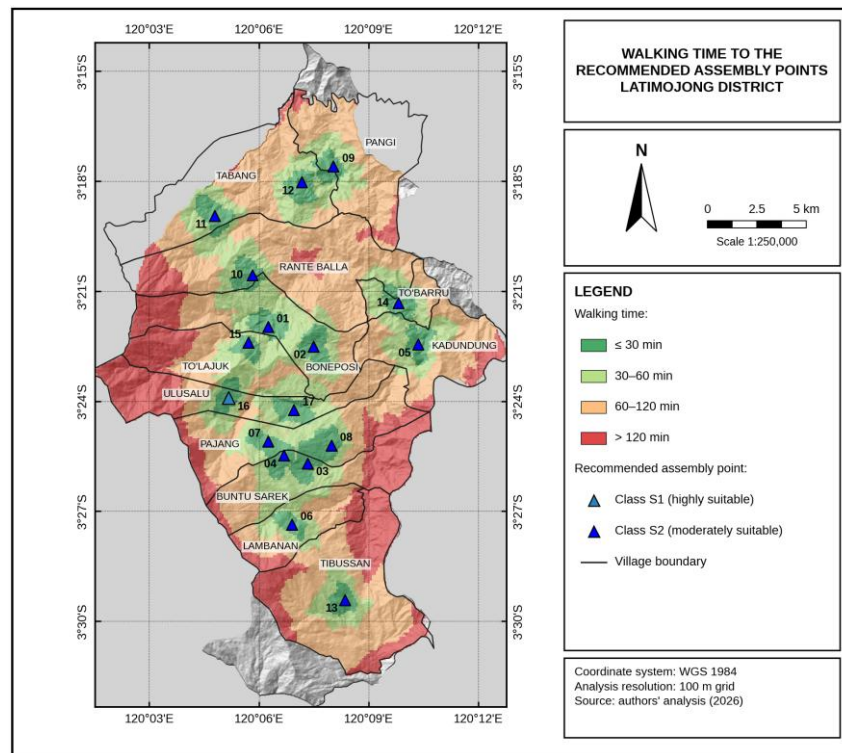
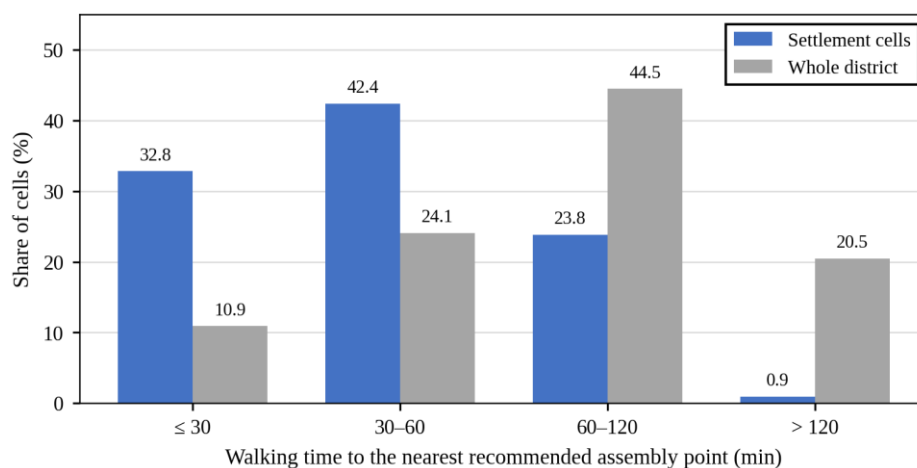


Figure 5. Walking time to the recommended assembly points in Latimojong District



Source: authors' analysis (2026).

Figure 6. Walking time classes to the nearest recommended assembly point for settlement cells and the whole district

Event impacts and institutional capacity

The BNPB reports (2024a, 2024b) point to three conditions that matter for education. The disaster struck in the early morning while most residents were asleep. Road access was cut, so residents had to rely on themselves during the first hours. Moderate to heavy rain also continued for several days and set off new landslides. The PVMBG (2024) records show ground movements in five villages, namely Boneposi, To'lajuk, Ulusalu, Pajang, and Pangi, so the hazard was not confined to one place.

On the institutional side, the Destana program has been running in Latimojong within a community-based disaster risk reduction framework (Iriansa et al., 2026) and alongside livelihood support (Muis et al., 2026). Its forums, volunteers, and links with village governments could carry

educational media. The program documents, however, contain nothing yet on reading rainfall, interpreting alert levels, or the time limits for evacuation decisions.

3.4 Gaps and media requirements

Comparing ideal and actual conditions revealed five gaps, which are summarised with the corresponding media requirements in Table 8.

Table 8. Gap and needs matrix for educational media

Aspect	Ideal condition	Actual condition	Media requirement
Hazard awareness	Residents understand that landslides are triggered by both daily and accumulated rainfall	93.8% of Advisory days resulted from accumulated rainfall, and the 2024 event was preceded by 17 Advisory days	Content on R1 and R30 and on reading a simple rain gauge
Alert levels	The four alert levels are understood and linked to actions	No materials explain the action required at each level	Illustrated alert levels with one key action per level
Decision time	Evacuation to a safe assembly point takes place before conditions become critical	No assembly points designated on suitability criteria, suitable land covers only 3.2% of the district, and the event occurred at night	Map of recommended assembly points and early evacuation messages at the Watch level before nightfall
Information access	Information remains available when networks fail	Road access was cut off, and the area was isolated after the event	Media that run offline can be shared between phones and can be printed
Community capacity	Residents and volunteers actively monitor and report	Destana institutions exist but lack rainfall monitoring materials	Guide for village rainfall observers and a simple reporting format

Source: authors' analysis (2026).

These requirements were then translated into five modules (Table 9). Every module is meant to be learned without internet access, uses plain language and pictures, and suits both community meetings and self-study.

Table 9. Initial specification of the offline landslide early warning learning modules

Module	Expected learning outcome	Presentation format
1. Rainfall that triggers landslides	Residents can explain the difference between daily and 30-day cumulative rainfall	Illustrations, the May 2024 case, and a short quiz
2. Reading a rain gauge	Residents can build and read a funnel gauge and record the reading every morning	Illustrated guide and daily record cards
3. Four alert levels	Residents can state the action required at the Normal, Advisory, Watch, and Warning levels	Colour-coded alert cards with pictograms
4. Natural warning signs and assembly points	Residents can recognise early signs of landslides and identify the nearest recommended assembly point	Illustrated checklist and village map
5. Reporting and sharing information	Village observers can report rainfall and natural signs to the Destana forum	Short report format that can be sent by text message

Source: authors' analysis (2026).

4. Discussion

The rainfall hazard in Latimojong has two sides. Advisory-level rain is fairly common, about 28 days a year, whereas Watch and Warning days are rare. Such a pattern can easily breed warning fatigue, as residents who hear repeated Advisory alerts without a major event may stop taking them seriously. However, the 3 May 2024 disaster followed 17 Advisory days caused by accumulated rain, and 93.8% of Advisory days in the record had less than 70 mm of daily rainfall (Figure 4). People who judge the danger only by how hard it is raining that day are likely to let their guard down. Guzzetti et al. (2020) likewise noted that regional landslide early warning systems generally consider rain accumulated over several days to weeks. Educational media should therefore make clear that the Advisory level is a time to get ready, not just a notice.

Timing offers a practical lesson as well. All Watch and Warning days fell between March and May, so education, rainfall observer training, and evacuation drills are best scheduled for January and February. This fits the view of Fathani et al. (2016) that dissemination and training are subsystems to be repeated periodically. The time of the event, 01:17 WITA, suggests that the decision to evacuate or stand by should be made before nightfall once the alert level is high. Lindell and Perry (2012) explained that protective decisions depend on how people understand the threat and the options open to them, so this message needs to be stated plainly.

Assembly points are a harder problem than they first appear. Only 3.2% of the district meets every safety criterion, so sites cannot be chosen simply for being close to homes. A site whose suitability has not been assessed may even lead people to the foot of a steep slope or to a stream bank exposed to debris flows. Soltani et al. (2014) identified accessibility, proximity to homes, and distance from hazards as the criteria used most often, and this study combines all three quantitatively. Even with the 17 recommended sites, a quarter of settlement cells need more than an hour to reach one, so evacuation cannot be left to the last minute. Wood et al. (2018) found that people tend to seek confirmation before acting, which narrows the window further. Educational media should reduce the decision to one key action per alert level and show the nearest assembly point clearly (Intrieri et al., 2013).

The need for offline media shapes their form more than any other finding. The area was isolated after the event (BNPB, 2024b), so media that rely on the internet cannot be counted on. The media must be accessible without a signal, pass from phone to phone, and be available in a printed version for residents without smartphones. Text messaging as a reporting channel has already been tested by the team for early flood detection (Halim et al., 2019).

The Destana institutions are an asset that can be used right away. Seddighi et al. (2022) warned that disaster education often stalls at awareness because of limited facilities, funding, and policy support. In Latimojong, the Destana forums and volunteers (Iriansa et al., 2026) can act as both a delivery channel and a practice ground. Informal learning in community meetings, as recommended by Pradhananga et al. (2022), suits mountain farming communities better than long formal training.

The contribution of this study lies in how media requirements are derived. Table 1 shows that earlier studies were usually strong in one or two dimensions only. Development studies of disaster media typically elicit needs through questionnaires or interviews, as Winarni and Purwandari (2018) did with primary school students. This study derives them from local hazard data, namely more than a decade of rainfall records, assembly point suitability, and evacuation walking time. The result is measurable content, such as R1 and R30 thresholds, high-risk months, suitable assembly point locations, and time limits for evacuation decisions. It also addresses the criticism by Tan et al. (2017) that disaster applications often ignore user conditions.

Our main recommendation is to develop these media as an offline WebGIS application that the team has designed as the target of its 2027 research stage. The application is not yet in use. WebGIS suits the task because most requirements, such as assembly point locations and walking times, are spatial and easier to grasp on a map. The team also has experience with web-based systems and WebGIS (Hamza & Muis, 2025; Rusmala et al., 2026) and holds slope and susceptibility data from earlier studies (Nurfalaq, Manrulu, et al., 2024; Nurfalaq, Muis, et al., 2024). Table 10 links the gaps, modules, and recommended features.

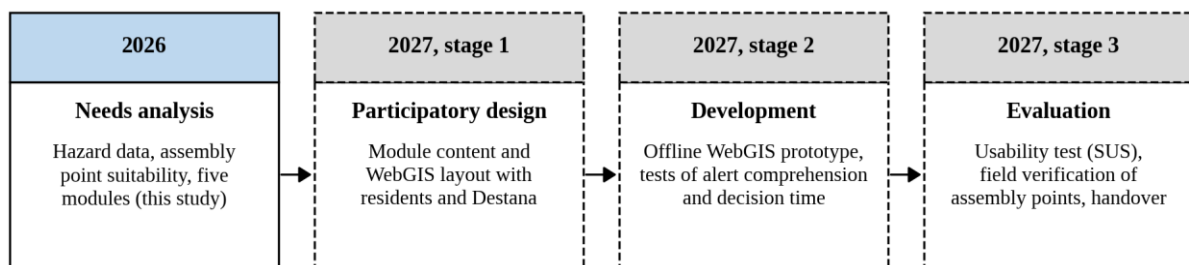
Table 10. Links between gaps, modules, and recommended offline WebGIS features

Gap	Related module	Recommended WebGIS feature
Information access	All modules	Offline mode, in which maps and content are stored on the phone after the first visit
Hazard awareness	Modules 1 and 2	Entry of daily readings from a simple rain gauge and on-device calculation of R1 and R30
Alert levels	Module 3	Automatic Normal, Advisory, Watch, and Warning status with one key action
Decision time	Modules 3 and 4	Susceptibility map, the 17 recommended assembly points, and walking time from the user's location
Community capacity	Modules 4 and 5	Checklist of natural warning signs and text-message reports synchronised when a signal is available

Source: authors' analysis (2026).

The next stages follow the ADDIE sequence (Figure 7). The design will be developed with residents and Destana managers; the prototype will be tested for comprehension of each alert level and for the time residents take to decide on evacuation; and usability will be evaluated with the System Usability Scale (Brooke, 1996), since ease of use determines whether disaster applications remain in use (Tan et al., 2020). In the same stage, the 17 recommended assembly points will be verified in the field with village governments before formal designation.

Several limitations should be noted. The needs were derived from secondary data without direct input from residents, so phone ownership, literacy, and everyday language remain unknown. The alert thresholds come from a single main station and may not represent villages at other elevations. The suitability and walking time analyses used a 100 m grid that may hide small flat areas, and footpaths, bridges, and river crossings were not modelled. Some settlements are also missing from the land cover data. Field verification and trials with the community are needed to address these limitations.



Source: authors' analysis (2026).

Figure 7. Subsequent research stages towards an offline WebGIS

5. Conclusion

Mountain communities in Latimojong need landslide early warning educational media that work without internet access. The review of 15 earlier studies showed that offline operation and evacuation decision time are the least addressed dimensions. Rainfall records from 2008 to 2024

show an average of 28 Advisory days per year, 93.8% of them driven by accumulated rain, while Watch and Warning occurred on only five days, all between March and May. Suitable land for assembly points covers only 3.2% of the district. On this land, 17 sites in 12 villages are recommended, which three-quarters of settlement cells can reach within an hour, with a median walking time of 41 minutes.

The media should teach daily and accumulated rainfall, the use of a simple rain gauge, the meaning of and response to each alert level, natural warning signs, suitable assembly points, and the value of early evacuation. We recommend developing the five modules into an offline WebGIS designed with residents and Destana managers, tested for warning comprehension and decision time, and then evaluated for usability. Education should take place in January and February, before the peak of the rainy season.

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