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The Effect of Collaborative Leadership and Early Warning System on Community Preparedness Response through Community Participation in Madiun Regency

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Abstract

Disaster risks in Madiun Regency, particularly floods, landslides, and tornadoes, underscore the need for preparedness strategies that integrate early warning systems, stakeholder coordination, and community involvement. This study examined the effects of collaborative leadership and early warning systems on community preparedness response, including indirect effects through community participation. A quantitative explanatory design involved 400 respondents from purposively selected areas. Data were collected using a five-point Likert-scale questionnaire and analyzed through partial least squares structural equation modeling (PLS-SEM) using SmartPLS 4. The structural model identified significant paths from collaborative leadership and early warning systems to both preparedness response and community participation. Community participation was positively and significantly associated with preparedness response and partially mediated the relationship between each predictor and preparedness response. These findings identify community participation as an intermediary linking collaborative leadership and early warning systems to preparedness. The study concludes that disaster preparedness efforts should integrate collaborative governance, warning systems, and community participation. The findings provide evidence to inform the strengthening of participatory disaster management policies in Madiun Regency.

Keywords: Collaborative Leadership; Early Warning Systems; Community Participation; Disaster Preparedness; Disaster Risk Reduction

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INTRODUCTION

Indonesia is highly exposed to disaster risks due to its complex geographical, geological, hydrological, and demographic conditions. These vulnerabilities involve not only geological hazards but also increasingly complex hydrometeorological disasters associated with environmental changes and climatic conditions. Such circumstances indicate that disaster management should not focus solely on emergency response after a disaster occurs, but should also strengthen preparedness before hazards escalate into disasters. In this context, community preparedness represents a critical component of disaster risk reduction because communities are directly exposed to hazards and often become the first actors required to recognize risks, interpret warnings, and undertake protective actions (Marinda & Muttaqin, 2025).

Madiun Regency is one of the areas facing diverse disaster risks associated with its geographical characteristics. Lowland areas crossed by river systems are exposed to flooding, while hilly areas and mountain slopes are vulnerable to landslides, particularly during the rainy season (Kurnianto et al., 2021). These conditions require stronger local capacity to enable communities to recognize hazards, understand warning information, and undertake appropriate preparedness measures. The Disaster Resilient Village (Desa Tangguh Bencana/Destana) program represents a community-based approach intended to strengthen village capacity to manage disaster risks and recover from their impacts (Manuhua, 2024). However, the effectiveness of such an approach depends not only on program availability but also on the quality of coordination and engagement among the actors responsible for its implementation.

This context highlights collaborative leadership as an important factor in strengthening community preparedness. Collaborative leadership emphasizes the ability of leaders to connect governments, communities, volunteers, and other stakeholders through communication, coordination, trust-building, and participatory decision-making (Sulistiawati & Handoko, 2026). Such an approach is particularly relevant to disaster management because complex risks cannot be effectively addressed by a single organization acting independently (Royani & Agusna, 2025). Collaboration enables stakeholders to integrate resources, knowledge, responsibilities, and perspectives in order to develop responses that are more adaptive to local conditions (Nadifah et al., 2023). Accordingly, leadership in disaster

management should be understood not merely as the exercise of authority but as a process of facilitating collective action.

Alongside leadership, the availability of timely and actionable information is essential for effective preparedness (Romadi et al., 2025). An Early Warning System (EWS) is designed to detect hazards, assess risks, disseminate warnings, and encourage appropriate protective actions (Amin & Burhan, 2025). Its effectiveness, however, is not determined solely by technological performance. The Socio-Technical Systems Theory emphasizes that technical systems must interact effectively with their social environment (Wijanarko et al., 2026). Meaning that technologies such as sensors, warning devices, and digital communication platforms require public understanding, acceptance, and readiness to translate information into action (Kasmawati, 2021). EWS should therefore be viewed as an integrated mechanism connecting technology, institutions, information, and communities.

The importance of this integration becomes apparent when warning information does not automatically result in adequate preparedness actions (Mujahidin & Murdhani, 2025). Public understanding of risk, information clarity, transmission speed, and trust in information sources can influence whether a warning is effectively received and acted upon. High-quality information that is accurate, relevant, clear, and accessible can strengthen people's ability to determine appropriate preparedness measures (Agbehadji et al., 2023). Similarly, disaster education and simulation can improve public knowledge and preparedness for emergency situations (Rahmawati & Hensa, 2025). These findings suggest that an effective EWS must be accompanied by social capacity that enables communities to interpret and utilize warnings appropriately.

Community participation is therefore particularly important because communities should not be positioned merely as recipients of government policies or warning information (Akbar et al., 2025). Instead, they should participate in planning, implementation, monitoring, and evaluation of disaster-related programs. Participation can strengthen community ownership while enabling local actors to contribute knowledge and decisions based on their own environmental conditions (Mahlella, 2025). From the perspective of Participatory Development Theory, community involvement constitutes a process through which people actively contribute to decisions and collective actions affecting their interests (Kasmawati, 2021). Participation may consequently serve as an important mechanism

through which leadership and warning systems are translated into stronger preparedness capacity.

Previous studies have established the relevance of these individual factors, yet their relationships have not been sufficiently examined within an integrated model. Nadifah et al. (2023) identified a positive relationship between EWS mitigation and volunteer preparedness, but the study did not incorporate collaborative leadership or the broader community as central actors. Manuhua (2024) demonstrated that the Destana program can support community preparedness through socialization, training, and disaster simulations, although its implementation remained constrained by limited resources. Meanwhile, Royani & Agusna (2025) highlighted the importance of collaboration between disaster-management authorities and communities, while also showing that collaborative practices had not yet been fully institutionalized at the local level.

Research focusing on EWS has also tended to emphasize technological performance, particularly hazard detection and information transmission. Waluyo & Putra (2024), for instance, demonstrated that an IoT-based EWS could accelerate flood-warning dissemination through sensor technology and digital communication. Although such findings demonstrate the technological value of EWS, they provide limited insight into how leadership and community involvement contribute to transforming warning information into actual preparedness responses. Therefore, the research gap addressed by this study concerns the limited empirical investigation of how collaborative leadership and EWS jointly influence community preparedness response while positioning community participation as an intervening mechanism, particularly in the context of Madiun Regency.

This study draws primarily on Collaborative Governance Theory to explain the relationships among leadership, coordination, and stakeholder involvement in disaster-risk management. This perspective is complemented by Socio-Technical Systems Theory, which explains the interaction between early warning technologies and communities' social capacity to use warning information, and Community Resilience Theory, which conceptualizes preparedness as part of a community's capacity to anticipate, respond to, and adapt to disasters. The integration of these theoretical perspectives provides a broader explanation of preparedness by connecting institutional capacity, technological-information systems, and community participation.

The novelty of this study lies in its empirical model linking collaborative leadership and EWS to community preparedness response through community participation as an intervening mechanism. This approach integrates institutional, technological, and social dimensions within a single analytical framework rather than examining them as isolated determinants. Accordingly, this study aims to describe collaborative leadership, EWS, community participation, and community preparedness response and to examine both the direct and indirect relationships among these constructs in Madiun Regency. The study is expected to strengthen empirical understanding of community-based disaster preparedness while providing a basis for developing disaster governance that is more collaborative, responsive, and oriented toward strengthening community capacity.

METHODS

This study employed a quantitative approach with an explanatory research design using a survey method (Sofya et al., 2024). The design was selected to examine the relationships and effects among collaborative leadership, the early warning system (EWS), community participation, and community preparedness response in addressing disaster risks in Madiun Regency. The study adopted a non-experimental design because no treatment or manipulation of the research variables was performed (Ramadhani & Albina, 2025). Instead, the study examined naturally occurring conditions by measuring community perceptions through a structured questionnaire. Primary data were collected using closed-ended statements measured on a five-point Likert scale.

The research model comprised collaborative leadership (X1) and the early warning system (X2) as independent variables, community preparedness response (Y) as the dependent variable, and community participation (Z) as the mediating variable. Collaborative leadership was operationalized through five indicators: clarity of objectives and policy direction, communication, trust, coordination and collaboration, and collaborative decision-making. The early warning system was assessed through risk knowledge, information quality, speed and accessibility, system effectiveness, and system facilities and operations. In this study, the early warning system represents an integrated process involving threat detection, risk analysis, timely dissemination of warnings, and the promotion of appropriate community responses (Royani & Agusna, 2025). Community participation was measured through opportunities for participation, partnership, transparency, voluntarism, alignment between

programs and community aspirations, and self-reliance. Community preparedness response was assessed through disaster knowledge, preparedness planning, evacuation readiness, resource readiness, and response to early warnings.

The study population comprised residents of five subdistricts in Madiun Regency, namely Balerejo, Dagangan, Kare, Wungu, and Madiun. Based on data from the Statistics of Madiun Regency for 2025, the populations of these five subdistricts were 44,865, 53,081, 34,732, 59,070, and 38,865 residents, respectively. The sample size was determined using the Slovin formula, resulting in 400 respondents. Respondents were drawn from the five selected subdistricts because they constituted the geographical scope of the study and provided the population context required to assess collaborative leadership, early warning systems, community participation, and disaster preparedness response.

The study utilized both primary and secondary data. Primary data were collected through an online questionnaire distributed using Google Forms. The instrument consisted of closed-ended statements measured on a five-point Likert scale ranging from strongly disagree to strongly agree (Maskhuliah et al., 2025). The questionnaire was developed according to the operational indicators of each research variable and the conditions of the selected study areas. Secondary data were obtained from existing documents, reports, articles, and institutional data relevant to the research (Susanto et al., 2024).

Data analysis was conducted using Structural Equation Modeling–Partial Least Squares (SEM-PLS) with SmartPLS. The analytical procedure consisted of descriptive statistical analysis, measurement model evaluation, and structural model evaluation (Hair et al., 2019). The outer model was assessed through convergent validity using outer loadings and Average Variance Extracted (AVE), discriminant validity using cross-loadings and AVE, and reliability using Cronbach's Alpha and Composite Reliability. The inner model was subsequently evaluated using R-Square, predictive relevance (Q^2), and effect size (f^2). Hypothesis testing was performed through bootstrapping at a 5% significance level by examining the t-statistic, p-value, and path coefficient to determine the significance and direction of relationships among the constructs (Sarstedt & Liu, 2024). The research was conducted within the research period specified in the original thesis.

RESULTS

Descriptive Statistics Analysis

The descriptive statistical analysis indicates that the four research variables, namely Collaborative Leadership, Early Warning System (EWS), Community Participation, and Community Preparedness Response, received generally positive assessments from the respondents. The analysis was based on the mean scores of each indicator from 400 respondents in Madiun Regency.

Table 1. Descriptive Statistics of the Research Variables

Variable	Mean	Category
Collaborative Leadership	3.81	High
Early Warning System	3.72	High
Community Participation	3.37	Relatively adequate
Community Preparedness Response	3.71	High

Source: Compiled by the researcher (2026)

Table 1. Descriptive Statistics of Research Variables shows that collaborative leadership had the highest mean score, while community participation had the lowest. At the indicator level, collaborative decision-making was the highest aspect of collaborative leadership (3.82), information quality was the lowest aspect of the early warning system (3.71), active involvement was the lowest aspect of community participation (3.36), and response to early warnings was the highest aspect of community preparedness response (3.73).

Measurement Model Evaluation (Outer Model)

The outer model was evaluated using SmartPLS 4 to assess construct validity and reliability through convergent validity, discriminant validity, and reliability tests.

a. Convergent Validity

Convergent validity was assessed based on the outer loading values. An indicator was considered valid when its outer loading exceeded 0.70.

Table 2. Convergent Validity Test

Variable	Indicator	Outer Loading	Conclusion
Collaborative Leadership (X1)	X1.1	0,925	Valid
	X1.2	0,926	Valid
	X1.3	0,926	Valid
	X1.4	0,933	Valid
	X1.5	0,935	Valid

Variable	Indicator	Outer Loading	Conclusion
	X1.6	0,923	Valid
	X1.7	0,905	Valid
	X1.8	0,921	Valid
	X1.9	0,929	Valid
	X1.10	0,934	Valid
	X1.11	0,930	Valid
	X1.12	0,910	Valid
Early Warning System (X2)	X2.1	0,923	Valid
	X2.2	0,911	Valid
	X2.3	0,914	Valid
	X2.4	0,927	Valid
	X2.5	0,925	Valid
	X2.6	0,909	Valid
	X2.7	0,926	Valid
	X2.8	0,914	Valid
	X2.9	0,924	Valid
	X2.10	0,925	Valid
	X2.11	0,921	Valid
	X2.12	0,919	Valid
Community Participation (Y)	Y1.1	0,893	Valid
	Y1.2	0,891	Valid
	Y1.3	0,877	Valid
	Y1.4	0,907	Valid
	Y1.5	0,871	Valid
	Y1.6	0,876	Valid
	Y1.7	0,880	Valid
	Y1.8	0,889	Valid
	Y1.9	0,878	Valid
	Y1.10	0,899	Valid
	Y1.11	0,850	Valid
	Y1.12	0,878	Valid
Community Preparedness Response (Z)	Z1.1	0,847	Valid
	Z1.2	0,850	Valid
	Z1.3	0,858	Valid
	Z1.4	0,878	Valid
	Z1.5	0,860	Valid
	Z1.6	0,860	Valid
	Z1.7	0,876	Valid
	Z1.8	0,884	Valid
	Z1.9	0,866	Valid
	Z1.10	0,848	Valid
	Z1.11	0,838	Valid
	Z1.12	0,864	Valid

Source: Compiled by the researcher (2026)

Table 2. Convergent Validity Test shows that all indicators obtained outer loading values above 0.70. Therefore, all indicators met the convergent validity criterion and were retained for further analysis.

b. Discriminant Validity

Discriminant validity was assessed using Cross Loading, the Fornell-Larcker Criterion, and the Heterotrait-Monotrait Ratio (HTMT).

Table 3. Cross Loading Results

Item	X_1	X_2	Y	Z
$X_{1.1}$	0,925	-0,013	0,642	0,679
$X_{1.2}$	0,926	-0,019	0,638	0,684
$X_{1.3}$	0,926	-0,014	0,646	0,684
$X_{1.4}$	0,933	0,010	0,678	0,707
$X_{1.5}$	0,935	-0,027	0,648	0,687
$X_{1.6}$	0,923	0,011	0,670	0,707
$X_{1.7}$	0,905	0,012	0,653	0,670
$X_{1.8}$	0,921	0,004	0,666	0,701
$X_{1.9}$	0,929	0,011	0,673	0,705
$X_{1.10}$	0,934	-0,019	0,657	0,686
$X_{1.11}$	0,930	0,009	0,678	0,704
$X_{1.12}$	0,910	0,034	0,672	0,697
$X_{2.1}$	-0,009	0,923	0,528	0,483
$X_{2.2}$	0,003	0,911	0,523	0,482
$X_{2.3}$	-0,017	0,914	0,523	0,466
$X_{2.4}$	0,007	0,927	0,526	0,491
$X_{2.5}$	0,000	0,925	0,530	0,478
$X_{2.6}$	-0,016	0,909	0,521	0,449
$X_{2.7}$	0,020	0,926	0,553	0,492
$X_{2.8}$	0,027	0,914	0,544	0,490
$X_{2.9}$	0,002	0,924	0,545	0,479
$X_{2.10}$	-0,008	0,925	0,526	0,481
$X_{2.11}$	0,029	0,921	0,541	0,498
$X_{2.12}$	-0,046	0,919	0,489	0,433
$Y_{.1}$	0,642	0,490	0,893	0,779
$Y_{.2}$	0,632	0,494	0,891	0,775
$Y_{.3}$	0,643	0,494	0,877	0,764
$Y_{.4}$	0,617	0,545	0,907	0,765
$Y_{.5}$	0,606	0,518	0,871	0,760
$Y_{.6}$	0,637	0,516	0,876	0,773
$Y_{.7}$	0,649	0,497	0,880	0,761
$Y_{.8}$	0,611	0,517	0,889	0,763
$Y_{.9}$	0,634	0,495	0,878	0,777
$Y_{.10}$	0,619	0,532	0,899	0,756
$Y_{.11}$	0,629	0,502	0,850	0,771
$Y_{.12}$	0,643	0,497	0,878	0,757
$Z_{.1}$	0,644	0,450	0,748	0,847
$Z_{.2}$	0,668	0,413	0,743	0,850
$Z_{.3}$	0,646	0,433	0,744	0,858

Item	X_1	X_2	Y	Z
Z.4	0,641	0,450	0,743	0,878
Z.5	0,635	0,475	0,752	0,860
Z.6	0,660	0,460	0,764	0,860
Z.7	0,653	0,448	0,761	0,876
Z.8	0,676	0,403	0,759	0,884
Z.9	0,640	0,427	0,744	0,865
Z.10	0,608	0,492	0,750	0,848
Z.11	0,621	0,459	0,713	0,838
Z.12	0,642	0,451	0,749	0,864

Source: Compiled by the researcher (2026)

Table 3. Cross Loading Results shows that all indicators had the highest loading on their respective constructs compared with the other constructs, indicating that the Cross Loading criterion was satisfied.

Table 4. Discriminant Validity Based on the Fornell-Larcker Criterion

Variable	X_1	Z	Y	X_2
X_1	0,925			
Z	0,749	0,861		
Y	0,714	0,869	0,883	
X_2	0,000	0,519	0,576	0,920

Source: Compiled by the researcher (2026)

Table 4. Discriminant Validity Based on the Fornell-Larcker Criterion shows that most constructs met the Fornell-Larcker criterion. However, the correlation between Community Participation (Z) and Community Preparedness Response (Y) was 0.869, which was slightly higher than the √AVE of Community Participation (0.861).

Table 5. Discriminant Validity Based on HTMT

Variable	X_1	Z	Y	X_2
X_1				
Z	0,767			
Y	0,729	0,895		
X_2	0,025	0,531	0,588	

Source: Compiled by the researcher (2026)

c. Reliability Test

Construct reliability was assessed using Cronbach's Alpha, rho_A, Composite Reliability, and AVE.

Table 6. Reliability Test

Variable	Cronbach's Alpha	rho_A	Composite Reliability	AVE	Conclusion
Collaborative Leadership (X_1)	0,985	0,985	0,986	0,856	Reliable
Community Participation (Z)	0,968	0,968	0,972	0,741	Reliable
Community Preparedness Response (Y)	0,974	0,974	0,977	0,779	Reliable
Early Warning System (X_2)	0,983	0,984	0,985	0,846	Reliable

Source: Compiled by the researcher (2026)

Table 6. Reliability Test shows that all constructs had Cronbach's Alpha and Composite Reliability values above 0.70, with AVE values above 0.50. Therefore, all constructs were considered reliable and met the required measurement quality criteria.

Structural Model Evaluation (Inner Model)

a. Coefficient of Determination (R-Square)

The R-Square test evaluates the extent to which exogenous variables explain the variance of endogenous variables. R-Square values of 0.75, 0.50, and 0.25 indicate substantial, moderate, and weak explanatory power, respectively.

Table 7. Coefficient of Determination (R-Square)

Variable	R-Square	R-Square Adjusted	Category
Community Participation (Z)	0,830	0,829	Strong
Community Preparedness Response (Y)	0,848	0,847	Strong

Source: Compiled by the researcher (2026)

Table 7. Coefficient of Determination (R-Square) shows that Community Participation (Z) has an R-Square value of 0.830, indicating that 83.0% of its variance is explained by Collaborative Leadership (X1) and the Early Warning System (X2), while the remaining 17.0% is explained by factors outside the model. Community Preparedness Response (Y) has an R-Square value of 0.848, indicating that 84.8% of its variance is explained by X1, X2, and Z, while 15.2% is explained by other factors. Both values are categorized as strong (substantial).

b. Predictive Relevance Test

The predictive relevance test evaluates the model's ability to predict observed data using Q²predict values and comparisons between PLS-SEM and the Linear Model (LM) based on RMSE.

Table 8. Predictive Relevance Test

Item	Q²predict	PLS-SEM_RMSE	PLS-SEM_MAE	LM_RMSE	LM_MAE	IA_RMSE	IA_MAE
Y.1	0,649	0,377	0,308	0,393	0,323	0,635	0,547
Y.2	0,639	0,386	0,314	0,400	0,322	0,643	0,545
Y.3	0,654	0,366	0,298	0,382	0,313	0,622	0,525
Y.4	0,674	0,355	0,292	0,368	0,299	0,622	0,535
Y.5	0,632	0,374	0,304	0,391	0,316	0,616	0,533
Y.6	0,670	0,368	0,302	0,374	0,306	0,640	0,550
Y.7	0,666	0,362	0,297	0,371	0,301	0,627	0,540
Y.8	0,636	0,366	0,299	0,383	0,306	0,608	0,518
Y.9	0,644	0,381	0,312	0,399	0,325	0,638	0,552
Y.10	0,663	0,353	0,289	0,369	0,302	0,608	0,517
Y.11	0,645	0,390	0,317	0,409	0,332	0,655	0,555
Y.12	0,657	0,362	0,296	0,373	0,300	0,619	0,527
Z.1	0,614	0,354	0,290	0,368	0,301	0,570	0,525
Z.2	0,612	0,360	0,293	0,376	0,306	0,577	0,524
Z.3	0,600	0,362	0,295	0,375	0,305	0,573	0,523
Z.4	0,610	0,355	0,290	0,374	0,304	0,569	0,520
Z.5	0,625	0,360	0,292	0,372	0,303	0,587	0,531
Z.6	0,643	0,365	0,298	0,372	0,303	0,611	0,546
Z.7	0,625	0,354	0,291	0,370	0,302	0,579	0,530
Z.8	0,612	0,365	0,297	0,373	0,302	0,586	0,530
Z.9	0,587	0,356	0,290	0,370	0,298	0,553	0,512
Z.10	0,605	0,378	0,307	0,397	0,323	0,601	0,542
Z.11	0,593	0,370	0,297	0,383	0,307	0,580	0,519
Z.12	0,612	0,381	0,309	0,397	0,327	0,611	0,548

Source: Compiled by the researcher (2026)

Table 8. Predictive Relevance Test shows that all indicators have positive Q²predict values, ranging from 0.587 to 0.674. In addition, the PLS-SEM RMSE values are lower than the LM RMSE values for all indicators, indicating that PLS-SEM provides better predictive performance than the linear benchmark model. Therefore, the research model demonstrates good predictive relevance.

c. Effect Size (f^2) Test

The effect size test evaluates the contribution of each exogenous variable to the endogenous variables. Values of f^2 of 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively.

Table 9. Effect Size (f^2) Test

Relationship	f^2 Value	Category
$X_1 \rightarrow Z$	3,300	Large
$X_2 \rightarrow Z$	1,584	Large
$X_1 \rightarrow Y$	0,476	Large
$X_2 \rightarrow Y$	0,557	Large
$Z \rightarrow Y$	0,049	Small

Source: Compiled by the researcher (2026)

Table 9. Effect Size (f^2) Test shows that X1 → Z has an f^2 value of 3.300 and X2 → Z has an f^2 value of 1.584, both indicating large effects. The relationships X1 → Y and X2 → Y also show large effects, with values of 0.476 and 0.557, respectively. Meanwhile, Z → Y has an f^2 value of 0.049, indicating a small effect. Thus, the largest contributions in the model are found in the effects of Collaborative Leadership and the Early Warning System on Community Participation.

d. Hypothesis Testing

Hypothesis testing was conducted using bootstrapping in SmartPLS 4. A hypothesis is considered statistically supported when the T-Statistics value exceeds 1.96 and the P-Values value is below 0.05 at a 5% significance level.

Table 10. Hypothesis Testing

Hypothesis	Relationship	Original Sample (β)	T-Statistics	P-Values	Decision
H_1	X1 → Y	0,557	14,450	0,000	Accepted
H_2	X2 → Y	0,467	17,024	0,000	Accepted
H_3	X1 → Z	0,749	32,950	0,000	Accepted
H_4	X2 → Z	0,519	22,460	0,000	Accepted
H_5	Z → Y	0,209	4,960	0,000	Accepted
H_6	X1 → Z → Y	0,156	4,846	0,000	Accepted
H_7	X2 → Z → Y	0,108	4,811	0,000	Accepted

Source: Compiled by the researcher (2026)

Table 10. Hypthesis Testing shows that all hypotheses (H1–H7) are accepted. Collaborative Leadership and the Early Warning System have positive and significant effects on both Community Participation and Community Preparedness Response. Community Participation also has a positive and significant effect on Community Preparedness Response

and mediates the effects of Collaborative Leadership and the Early Warning System on Community Preparedness Response.

DISCUSSION

The findings demonstrate that all direct and indirect relationships examined in the model are positive and statistically significant. This pattern indicates that community preparedness response in Madiun Regency is not determined solely by individuals' capacity to respond to disasters, but is also associated with the quality of collaborative leadership, the effectiveness of the early warning system (EWS), and the extent to which communities participate in disaster risk reduction activities. Taken together, the structural relationships suggest that community preparedness is multidimensional and develops through interconnected institutional, informational, and social mechanisms. Collaborative leadership and early warning systems do not merely perform administrative or informational functions; their effects can also be strengthened through community participation, which translates institutional capacity and risk information into preparedness-related action.

The positive and significant effect of collaborative leadership on community preparedness response represents an important finding. The path coefficient of 0.557, accompanied by a t-statistic of 14.450 and a p-value of 0.000, indicates a substantial and statistically significant relationship. Substantively, this finding suggests that improvements in clarity of objectives and policy direction, communication, trust, coordination and collaboration, and collaborative decision-making are associated with stronger community preparedness responses. Collaborative leadership should therefore not be understood merely as the capacity of authorities to provide direction. Rather, it involves the ability to connect multiple actors so that information, responsibilities, and resources can be coordinated in pursuit of shared disaster-management objectives. In the context of Madiun Regency, such an arrangement is particularly relevant because effective preparedness requires interaction among local government, village authorities, BPBD, disaster volunteers, and community members.

This interpretation is reinforced by the particularly strong relationship between collaborative leadership and community participation. The path coefficient of 0.749 is the largest coefficient in the proposed model, with a t-statistic of 32.950 and a p-value of 0.000. This result indicates that collaborative leadership has the strongest association with

community participation among the relationships examined. Participation therefore appears not to emerge simply because disaster-related programs are available; rather, it is strongly connected to how communities are positioned within the governance process. Opportunities for participation, partnership, transparency, voluntarism, alignment between programs and community aspirations, and self-reliance can be strengthened when leadership creates meaningful opportunities for community involvement. The finding consequently suggests that communication, trust, coordination, and joint decision-making are not merely characteristics of leadership but also mechanisms capable of shaping community engagement.

The early warning system also demonstrates a positive and significant effect on community preparedness response, with a path coefficient of 0.467, a t-statistic of 17.024, and a p-value of 0.000. This result indicates that an EWS functions beyond the simple dissemination of hazard information. Its contribution to preparedness depends on whether risk information can be understood, accessed, and translated into appropriate action. This interpretation is consistent with the conceptualization of an early warning system as an integrated mechanism involving risk knowledge, threat assessment, warning dissemination, and the promotion of appropriate response actions (Royani & Agusna, 2025). Accordingly, the effectiveness of an EWS should not be assessed solely according to the availability of technological infrastructure. The quality of information, timeliness, accessibility, operational effectiveness, and system readiness are equally relevant to its contribution to community preparedness.

The positive and significant relationship between the early warning system and community participation, reflected in a path coefficient of 0.519, a t-statistic of 22.460, and a p-value of 0.000, further reveals an important mechanism. Timely and accessible disaster information can strengthen community understanding of the risks surrounding them. Such understanding may encourage individuals to participate in mitigation activities, disaster-awareness programs, training, and evacuation simulations. The EWS can therefore function as a catalyst for participation because risk information provides communities with a concrete basis for recognizing the relevance of preparedness activities. This finding extends the interpretation of early warning systems beyond a technology-centered perspective by positioning communities not merely as recipients of warnings but also as active actors within the preparedness process.

Community participation itself has a positive and significant effect on preparedness response, with a path coefficient of 0.209, a t-statistic of 4.960, and a p-value of 0.000. Although the coefficient is smaller than those observed for several other structural relationships, its statistical significance confirms that community involvement remains an important component of preparedness. Participation provides opportunities for communities to acquire knowledge, develop practical skills, and gain experience through direct involvement in disaster-related activities. Preparedness is therefore not solely the outcome of information received from authorities; it can also emerge through collective learning and practical experience generated through participation in disaster risk reduction activities.

The mediation findings provide further insight into how these relationships operate. Collaborative leadership has a significant indirect effect on community preparedness response through community participation, with an indirect coefficient of 0.156, a t-statistic of 4.846, and a p-value of 0.000. Because the direct relationship between collaborative leadership and preparedness response is also significant, community participation constitutes a partial mediator. A comparable pattern is observed for the indirect relationship between the early warning system and preparedness response, which produces an indirect coefficient of 0.108, a t-statistic of 4.811, and a p-value of 0.000. These findings are theoretically important because they demonstrate that preparedness does not develop through a single pathway. Collaborative leadership and early warning systems can directly contribute to preparedness, while their effects are additionally strengthened when communities are actively engaged. Participation thus represents a mechanism through which institutional capacity and disaster information can be converted into community response capacity.

From a theoretical perspective, this study contributes by demonstrating that collaborative leadership, early warning systems, and community participation should be understood as interconnected components of disaster preparedness rather than isolated determinants. The findings also support the application of SEM-PLS for examining relationships among latent constructs simultaneously, consistent with the analytical rationale described by Sarstedt & Liu (2024). More importantly, the empirical model extends the understanding of preparedness by demonstrating that the influence of collaborative leadership and EWS operates not only through direct pathways but also through community participation as a mediating mechanism. This perspective emphasizes that communities should not be conceptualized merely as passive recipients of disaster policies and warnings.

Instead, their participation forms part of the mechanism through which governance capacity and risk information become effective preparedness responses.

Practically, the findings have implications for BPBD, village governments, and other disaster-management stakeholders in Madiun Regency. Strengthening preparedness requires leadership practices that facilitate two-way communication, build trust, improve coordination, and provide meaningful opportunities for joint decision-making. At the same time, early warning systems need to ensure that warnings are timely, understandable, accessible, and operationally reliable. Programs such as the Disaster Resilient Village initiative can consequently be oriented not only toward information delivery but also toward expanding meaningful participation through training, evacuation simulations, joint planning, and community-based risk reduction activities. Such an approach may improve communities' ability to transform warnings and institutional guidance into concrete preparedness actions.

Several limitations should nevertheless be considered when interpreting these findings. First, the survey-based design relies primarily on respondents' perceptions and therefore does not fully capture the qualitative dynamics of collaboration, leadership practices, or community engagement. Second, the study was conducted among 400 respondents across five subdistricts in Madiun Regency; consequently, the generalizability of the findings should be considered in relation to the geographical and social characteristics of the study setting. Third, because the constructs were operationalized through questionnaire statements, differences in respondents' interpretation of individual items may have influenced the measurement process. These limitations do not diminish the empirical contribution of the study but indicate that its findings should be interpreted within the context in which the data were collected. Overall, the study demonstrates that strengthening community preparedness requires an integrated combination of collaborative leadership, effective early warning systems, and active community participation, with participation serving as an important mechanism through which institutional capacity and disaster information are translated into community response capability.

CONCLUSION

This study demonstrates that community preparedness response in Madiun Regency is positively and significantly associated with collaborative leadership, the early warning system (EWS), and community participation. Collaborative leadership contributes not only

directly to preparedness response but also emerges as the strongest factor in fostering community participation. Similarly, the early warning system contributes to preparedness both directly and indirectly through community involvement. Community participation itself significantly strengthens preparedness capacity and partially mediates the effects of both collaborative leadership and the early warning system on community preparedness response. These findings address the research objectives by demonstrating that community preparedness is not generated by a single determinant but by the interaction of leadership capacity, effective risk-information dissemination, and meaningful community involvement.

Theoretically, this study contributes to disaster preparedness research by positioning community participation as an important mechanism linking institutional capacity and information systems with community response capacity. This perspective highlights the importance of viewing communities not merely as recipients of disaster policies and warnings but as active actors within the preparedness process. Practically, the findings underscore the need to strengthen coordination among disaster-management stakeholders, improve the quality, accessibility, and effectiveness of early warning systems, and expand opportunities for community involvement in disaster risk reduction programs. These implications provide a basis for local governments, disaster-management agencies, village authorities, volunteers, and communities to develop more integrated preparedness strategies.

Future research should extend the geographical scope of investigation and consider areas with different disaster characteristics to enhance the transferability of the findings. Further studies may also incorporate additional explanatory variables and employ qualitative or mixed-methods designs to provide deeper insights into the mechanisms of collaboration, community participation, and the interpretation and use of early warning information in shaping community preparedness.

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