

CLIMATE CHANGE ADAPTATION AND DISASTER MANAGEMENT EFFECTIVENESS IN ACEH PROVINCE

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Abstract

Climate change has intensified the frequency and magnitude of disasters, creating complex challenges for local governments in developing regions. This study aims to examine the influence of climate change adaptation on the effectiveness of local disaster management in Aceh Province. A quantitative approach was employed using data collected from 124 respondents, including government officials, community leaders, and disaster management practitioners. Data analysis utilized Structural Equation Modeling–Partial Least Squares (SEM-PLS) to assess the relationship between adaptation strategies and disaster management outcomes. The results reveal that climate change adaptation has a positive and significant effect on disaster management effectiveness, explaining 60.3% of the variance. These findings indicate that well-planned and participatory adaptation strategies enhance local governments' capacity to respond effectively to disaster risks. The study highlights Aceh's distinctive position as a province with special authority to implement Islamic law, where moral values such as amanah, 'adl, and maslahah align with the goals of sustainable development.

Keywords: climate change; disaster management; Aceh; sustainable development; SEM-PLS

INTRODUCTION

Climate change has emerged as one of the defining challenges of the twenty-first century, amplifying the frequency and magnitude of disasters and placing increasing pressure on governance systems across the world. The intensification of extreme events—such as floods, droughts, and coastal inundations—has revealed the inadequacy of reactive disaster responses and highlighted the need for proactive, adaptive, and integrated approaches to resilience. Over the past decade, scholars have increasingly emphasized the role of climate change adaptation (CCA) in fostering sustainable resilience and reducing disaster risks. Empirical evidence demonstrates that adaptation measures—particularly nature-based solutions such as mangrove restoration, watershed rehabilitation, and agroforestry—are effective in mitigating climate impacts and protecting vulnerable communities (Genç & Genç, 2025; Van Niekerk et al., 2018). However, the successful implementation of these strategies requires institutional commitment, cross-sectoral coordination, and participatory engagement to achieve long-term success (Atkin, 2024; Bormann et al., 2015).

Globally, the Paris Agreement and the United Nations Sustainable Development Goals (SDGs) have accelerated the transition toward climate-resilient governance. Theoretical developments indicate that adaptation and disaster management should be

integrated rather than treated as separate domains, with local institutions playing a critical role in ensuring the effectiveness of disaster risk reduction (Le Dé, 2017; Van Niekerk et al., 2018). Recent studies highlight that countries with strong local adaptation capacity tend to exhibit better preparedness, faster recovery, and improved governance outcomes in disaster response (Atkin, 2024; Lukito et al., 2019). Nevertheless, the extent to which local adaptation efforts translate into effective disaster management remains underexplored, particularly in developing regions constrained by limited institutional capacity and resources (Dwirahmadi et al., 2023; Yoseph-Paulus & Hindmarsh, 2018).

Beyond technical and institutional frameworks, recent scholarship underscores the relevance of Islamic social finance and philanthropic governance in strengthening disaster resilience and community empowerment. Iskandar et al. (2025) emphasize that effective management and strategic application of Islamic social finance can enhance public welfare and serve as a model for Muslim-majority regions seeking to promote philanthropy-based economic empowerment. In parallel, Iskandar et al. (2025) explain that Islamic philanthropic mechanisms—particularly zakat- and waqf-based initiatives—contribute meaningfully to disaster response and post-crisis recovery by ensuring sustainable funding for resilience and rehabilitation programs. Collectively, these perspectives reinforce the view that the effectiveness of disaster management depends not only on technical capacity but also on governance structures rooted in ethical values, distributive justice, and community participation—principles that are crucial for long-term resilience building.

In Indonesia—a country highly exposed to natural hazards such as floods, landslides, and tsunamis—the link between climate adaptation and disaster management effectiveness has become an urgent research agenda. Among its regions, Aceh Province holds a distinctive position due to its historical exposure to large-scale disasters and its ongoing vulnerability to climate-related hazards. Located at the northern tip of Sumatra, Aceh frequently experiences coastal flooding, saltwater intrusion, and agricultural droughts, all of which threaten community livelihoods and ecosystem stability (Gunawan et al., 2025; Narendr et al., 2024; Roza et al., 2025). Since the devastating 2004 Indian Ocean tsunami, Aceh has become a focus of national and international initiatives to strengthen disaster preparedness and community resilience. Empirical research demonstrates that community-based adaptation programs, including mangrove rehabilitation and integrated agriculture, have yielded measurable environmental and social benefits (Gunawan et al., 2025; Roza et al., 2025).

Beyond institutional efforts, local communities in Aceh have developed indigenous systems of disaster adaptation rooted in cultural wisdom. Traditional knowledge—such as the *smong* oral tradition on Simeulue Island—has been instrumental in saving lives during tsunamis and remains central to disaster preparedness education (Kasih & Ramli, 2022). Similarly, Mukim-based social structures function as local governance units that integrate environmental protection with customary authority, facilitating collective adaptation to ecological vulnerability (Al-Fairusy, 2019). These community-driven mechanisms illustrate that local knowledge and social capital are vital components of climate resilience, complementing formal government interventions.

However, significant disparities in disaster preparedness persist between urban and rural areas, and early warning systems—although improved—often lack multi-hazard integration and comprehensive vulnerability assessments (Desdiani et al., 2022; Sufri et al., 2020). Despite considerable progress, there is limited empirical evidence on how climate change adaptation directly influences the effectiveness of local disaster management. Previous studies have identified persistent governance challenges—such as fragmented coordination, limited financial resources, and weak monitoring mechanisms—that hinder the translation of adaptation policies into practical outcomes (Dwirahmadi et al., 2023; Setiawati et al., 2023; Sufri & Elvin, 2025). Moreover, the absence of quantitative assessments examining the causal relationship between adaptation practices and institutional performance has restricted the formulation of evidence-based disaster management reforms. This research gap is particularly relevant in Aceh, where local governments must balance technical adaptation measures with sociocultural and institutional realities to achieve sustainable resilience.

Aceh possesses a distinctive social and institutional context in disaster management and climate change adaptation, as highlighted by various studies. Adiyoso & Kanegae (2013) emphasize the role of social structures and local value systems in supporting disaster risk reduction efforts in Banda Aceh, particularly through enhancing public awareness of preparedness. Salleh (2011) demonstrates that post-tsunami development strategies in Aceh emphasize the integration of social, institutional, and community dimensions to strengthen adaptive capacity against disaster threats. Similarly, Hirdayadi et al. (2022) explains that environmental management practices in Aceh reflect a synergy between local norms and institutional governance in responding to climate change dynamics. Meanwhile, Fatimahsyam (2024) highlights the importance of community participation and local leadership in fostering preparedness and social resilience to disaster risks. These findings provide empirical evidence that the effectiveness of disaster management in Aceh is strongly influenced by the adaptive capacity embedded within the region's social and institutional systems.

Theoretically, this study contributes to the evolving discourse on climate resilience by integrating global adaptation theory with localized empirical analysis. It advances understanding of how well-designed adaptation strategies enhance the effectiveness of disaster management through improved coordination, resource utilization, and community participation. Empirically, the study provides evidence from a climate-vulnerable region, offering insights for policymakers and practitioners on how adaptation can strengthen local disaster management performance.

Accordingly, this study examines the influence of climate change adaptation on the effectiveness of local disaster management in Aceh Province. Using a quantitative approach with Structural Equation Modeling–Partial Least Squares (SEM-PLS), this research empirically evaluates how adaptation strategies enhance local governments' capacity to respond effectively to disaster risks. The study contributes both theoretically and practically by linking adaptation policy with disaster management outcomes in one of Indonesia's most climate-sensitive regions.

METHOD

Research Design

This study employed a quantitative explanatory design to examine the influence of climate change adaptation on the effectiveness of disaster management in Aceh Province, Indonesia. The explanatory design was selected because it enables the testing of causal relationships between independent and dependent variables through statistical modeling (Creswell & Creswell, 2018). The quantitative approach was considered appropriate for identifying relationships among constructs using standardized indicators and numerical data (Saunders et al., 2009). Data were analyzed using structural equation modeling–partial least squares (SEM–PLS), a variance-based analytical technique suitable for exploratory and predictive studies involving latent constructs and relatively small sample sizes (Hair Jr et al., 2021; Sarstedt & Christian M. Ringle, 2017). SEM–PLS was chosen for its ability to assess both the measurement and structural models simultaneously, making it particularly suitable for social science research in developing-country contexts.

Participants and Data Sources

The study involved 124 respondents, comprising government officials, community leaders, and disaster management practitioners from several districts in Aceh Province. Participants were selected using a purposive sampling technique to ensure the inclusion of individuals directly engaged in climate adaptation and disaster response (Etikan & Bala, 2017). The sample included representatives from the Aceh Regional Disaster Management Agency (BPBD), the Environmental and Forestry Agency (DLHK), non-governmental organizations (NGOs), and local community resilience groups. All data were primary, collected through a structured questionnaire administered both online and in person. This approach enabled broad coverage across administrative levels and geographical areas, ensuring that perspectives from local institutions, practitioners, and communities were adequately represented. The exclusive use of primary data provided direct insights into stakeholders' perceptions of adaptation and disaster management effectiveness within the Aceh context.

Data Collection Procedures

Data collection was carried out between March and May 2025 through survey administration. The questionnaire employed a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) to capture respondents' perceptions (Joshi et al., 2015).

Before distribution, the research instrument underwent expert validation by three specialists in accounting and disaster governance to ensure conceptual clarity, indicator relevance, and contextual appropriateness. The validation process aimed to evaluate whether each questionnaire item accurately represented the research constructs and aligned with institutional practices in Aceh. Revisions to item wording and terminology were made based on expert feedback to ensure that the questionnaire was contextually suitable for public policy and disaster management frameworks in Aceh Province.

The finalized questionnaire was distributed through two channels: direct field visits to institutional offices and community organizations, and digital dissemination via secure online platforms (e.g., Google Forms). Respondents were provided with clear instructions to minimize response bias and enhance data quality. Instrument reliability and validity were subsequently confirmed statistically during the SEM–PLS analysis, including the evaluation of factor loadings, composite reliability, and average variance extracted (Hair Jr et al., 2021).

Operational Definitions and Measurement

This study examined two main constructs: climate change adaptation (CCA) and disaster management effectiveness (DME). Each construct was operationalized through measurable indicators adapted from validated international and local studies. All items were rated on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree), indicating respondents' level of agreement.

Disaster management effectiveness (DME) refers to the capacity of local governments to provide rapid and coordinated responses, ensure interagency collaboration, and facilitate post-disaster recovery effectively and participatively (Dzigbede et al., 2020; Rahmayanti, 2021). The construct was measured using seven indicators reflecting local government performance: (1) speed of response during disasters, (2) timeliness of relief distribution, (3) coordination across agencies, (4) collaboration with NGOs and the private sector, (5) speed of post-disaster recovery, (6) community participation, and (7) clarity of recovery planning.

Climate change adaptation (CCA) represents the capacity of local governments and communities to adjust to the impacts of climate change through risk awareness, adaptive policymaking, and the strengthening of socioeconomic resilience (Cinner et al., 2022; Dwirahmadi et al., 2019). It was measured through indicators capturing (1) awareness of climate risks, (2) implementation of adaptive policies, (3) infrastructure readiness, (4) community capacity building, (5) integration of adaptation into local planning, (6) livelihood diversification, and (7) dissemination of climate information.

These operationalizations ensured that both constructs captured the multidimensional aspects of institutional performance and social engagement relevant to local adaptation and disaster governance.

Data Analysis Techniques

Quantitative data were analyzed using SmartPLS 4.0, following the two-step approach proposed by Hair Jr et al. (2021). The first step assessed the measurement model to evaluate construct validity and reliability through factor loadings, composite reliability (CR), and average variance extracted (AVE). Discriminant validity was confirmed using the Fornell–Larcker criterion. The second step assessed the structural model to test the hypothesized causal relationship between climate change adaptation and disaster management effectiveness. The significance of path coefficients was examined through bootstrapping with 5,000 subsamples, while model strength and predictive accuracy were determined using R^2 , Q^2 , and f^2 effect sizes (Hair et al., 2022; Hair Jr et al., 2021). Path coefficients with t -values greater than 1.96 ($p < .05$) were considered statistically significant. This analytical approach provided a rigorous basis for testing the proposed model, ensuring that the findings reflected both theoretical

validity and empirical robustness within the socio-institutional context of Aceh Province.

FINDINGS

This section presents the empirical findings of the study derived from the Partial Least Squares Structural Equation Modeling (SEM–PLS) analysis. The results address the research hypothesis formulated earlier: *climate change adaptation positively and significantly influences disaster management effectiveness in Aceh Province*. The findings are discussed in three parts: (1) measurement model evaluation, (2) structural model evaluation, and (3) summary of findings.

Measurement Model Evaluation

The measurement model was assessed to evaluate indicator reliability, internal consistency, and validity before proceeding to the structural model. The initial model included several indicators for each construct, as shown in Table 1.

Table 1. Outer Loadings (Before Deletion of Low-Loading Indicators)

Construct	Indicator	Outer Loading	Validity Status
Climate Change Adaptation (ADP)	ADP1	0.672	Below 0.70 threshold → <i>to be removed</i>
	ADP2	0.722	Accepted
	ADP3	0.802	Accepted
	ADP4	0.823	Accepted
	ADP5	0.681	Below 0.70 threshold → <i>to be removed</i>
	ADP6	0.731	Accepted
	ADP7	0.802	Accepted
Disaster Management Effectiveness (EPB)	EPB1	0.837	Accepted
	EPB2	0.872	Accepted
	EPB3	0.654	Below 0.70 threshold → <i>to be removed</i>
	EPB4	0.820	Accepted
	EPB5	0.855	Accepted
	EPB6	0.753	Accepted
	EPB7	0.691	Below 0.70 threshold → <i>to be removed</i>

Four indicators (ADP1, ADP5, EPB3, and EPB7) exhibited outer loading values below the recommended threshold of 0.70 (Hair Jr et al., 2021) and were subsequently removed from the model. This refinement improved the model’s reliability and validity indices.

Table 2. Outer Loadings, Reliability, and Convergent Validity (Final Model)

Construct	Indicator	Outer Loading	Cronbach’s Alpha	Composite Reliability	AVE
Climate Change Adaptation (ADP)	ADP2	0.722	0.804	0.871	0.629

	ADP3	0.802			
	ADP4	0.823			
	ADP6	0.731			
	ADP7	0.802			
Disaster Management Effectiveness (EPB)	EPB1	0.837	0.902	0.925	0.672
	EPB2	0.872			
	EPB4	0.820			
	EPB5	0.855			
	EPB6	0.753			

(Source: Author's SEM-PLS output, 2025)

All remaining indicators exhibited satisfactory loading values (> 0.70), confirming indicator reliability. The internal consistency of each construct was verified, as both Cronbach's Alpha (CA) and Composite Reliability (CR) exceeded 0.70 (Nunnally & Bernstein, 1994). The Average Variance Extracted (AVE) values were also greater than 0.50, demonstrating adequate convergent validity (Fornell & Larcker, 1981).

Discriminant validity was examined using the Fornell-Larcker Criterion, as presented in Table 3. The square root of the AVE for each construct exceeded its inter-construct correlation, confirming distinctiveness between the two latent variables (Henseler et al., 2015).

Table 3. Discriminant Validity (Fornell-Larcker Criterion)

Construct	ADP	EPB
ADP	0.793	
EPB	0.544	0.820

(Source: Author's SEM-PLS output, 2025)

These results confirm that both constructs are statistically valid, internally consistent, and free from multicollinearity issues.

Structural Model Evaluation

The structural model was evaluated to test the hypothesized causal relationship between *climate change adaptation* (ADP) and *disaster management effectiveness* (EPB). The model demonstrated substantial explanatory power, with an R^2 value of 0.603, indicating that adaptation explained 60.3% of the variance in disaster management effectiveness (Chin, 1998).

Table 4. Structural Model Results (Path Coefficient and Determination)

Path	β (Path Coefficient)	t-value	p-value	R^2	f^2	Q^2
ADP \rightarrow EPB	0.276	3.188	0.002	0.603	0.154	0.388

(Source: Author's SEM-PLS output, 2025)

The path coefficient ($\beta = 0.276$, $p = 0.002$) indicates that climate change adaptation has a positive and statistically significant effect on disaster management effectiveness. The effect size ($f^2 = 0.154$) represents a moderate influence, while the Stone-Geisser Q^2 value (0.388) demonstrates strong predictive relevance (Hair Jr et al., 2021). These findings suggest that local adaptation practices—such as policy

integration, community engagement, and institutional coordination—substantially enhance the speed, coordination, and responsiveness of local governments in disaster management.

DISCUSSION

Interpretation of Results and Comparison with Previous Studies

The study's results indicate that climate change adaptation has a positive and significant effect on disaster management effectiveness in Aceh Province. The path coefficient ($\beta = 0.276$; $p = 0.002$) indicates a strong and directional causal relationship, while the R^2 value of 0.603 denotes that more than half of the variance in disaster management effectiveness can be explained by adaptation factors. These findings empirically support the study hypothesis that the higher a region's adaptive capacity to climate change, the more effective its disaster management system will be.

Theoretically, this relationship aligns with resilience theory, which emphasizes that adaptive capacity is a core component of social and institutional system resilience to external shocks (Simonovic, 2018). Adaptation is not merely a reactive response to risk but an institutional and social learning process that enables communities and governments to adjust strategies under climatic uncertainty. In the Acehese context, this implies that planned adaptation strategies—comprising institutional capacity strengthening, cross-sectoral coordination, and increased public awareness—are prerequisites for building sustainable disaster management effectiveness. The results also corroborate the adaptive governance framework articulated by Krause et al. (2015), which posits that disaster governance effectiveness is determined not only by the availability of physical resources but also by institutions' ability to adapt to changing risk dynamics. Here, adaptation is understood as an iterative process linking policy, action, and continuous learning. Local governments that successfully integrate adaptation into development planning display superior capacity to respond to complex environmental and social changes. This corresponds with the model described by Rahman et al. (2024), in which institutional learning serves as the main mechanism for strengthening disaster policy effectiveness.

Empirically, the positive relationship shows that adaptation directly contributes to enhancing institutional capacity and community preparedness. Improvements in early-warning systems, emergency drills, and synergy between government and communities have been shown to accelerate response and post-disaster recovery. Decentralized adaptation programs in Aceh illustrate how local policies can strengthen effectiveness without full reliance on central interventions. This phenomenon supports Tota et al. (2025) argument that decentralizing adaptation expands policy innovation space and permits more context-sensitive responses to local risks. The results further indicate that adaptation plays a structural role in improving disaster management effectiveness by affecting three main performance dimensions: (1) response speed, (2) inter-agency coordination, and (3) efficiency in resource use. These three are principal effectiveness indicators in the disaster risk management literature (Padlee et al., 2021). When adaptation is implemented systematically and based on risk data, institutional capacity increases and cross-sectoral communication channels become more efficient.

Moreover, the findings show that adaptation functions as a mechanism shaping social behaviors that support collective preparedness. As Dwirahmadi et al. (2023) argue, participation-based adaptation strengthens ownership of public policy, increases compliance with safety standards, and accelerates the dissemination of critical information during disasters. In Aceh, adaptation success is evident in community involvement in risk mapping and monitoring of environmental rehabilitation activities, which enhance the overall effectiveness of the disaster management system.

Thus, the results not only confirm acceptance of the main hypothesis but also assert that adaptation is a decisive factor operating via two pathways: first, by strengthening institutional capacity and government coordination; second, by shaping adaptive social behavior that supports effective disaster response. These two pathways reinforce one another to create a responsive, efficient, and sustainable disaster management system. The findings reinforce the theoretical position that disaster management effectiveness is a direct function of a region's adaptive capacity at both institutional and social levels.

The study's findings are consistent with international studies that emphasize climate adaptation as a principal determinant of disaster management effectiveness. Several empirical studies in Southeast Asia and other developing countries show a similar directional relationship between these variables (Padlee et al., 2021; Tota et al., 2025). This consistency strengthens the generalization that adaptation is not only a climate response strategy but a policy mechanism that directly affects local disaster management performance. It also reflects the external validity of the model used. Rahman et al. (2024) show that the success of adaptation at the regional level correlates strongly with disaster response effectiveness, especially when adaptation policies are integrated into regional development plans. A similar pattern is visible in Aceh, where adaptation forms part of risk-informed disaster governance. Therefore, this study reinforces the view that disaster management effectiveness heavily depends on how far adaptation is embedded in planning and public decision-making processes.

However, there are contextual differences that refine theoretical understanding. Padlee et al. (2021) note that adaptation effectiveness in Malaysia and Brunei improved due to more stable fiscal support and inter-agency coordination. In contrast, Aceh's context demonstrates that effectiveness can be achieved despite relatively limited fiscal capacity, provided there is strong synergy between government and communities. This implies that the adaptation-effectiveness relationship is not solely determined by resource magnitude but also by the intensity of collaboration and policy commitment. This extends Tota et al. (2025) conclusion that social and institutional factors are as important as technical ones for adaptation success. Comparison with Dwirahmadi et al. (2023) shows that community-based adaptation programs play a strategic role in enhancing social preparedness and response effectiveness. That study emphasizes that active citizen participation strengthens public trust in institutions and speeds emergency information flows. In Aceh, this pattern appears through community involvement in risk mapping and early-warning system management. Hence, this study adds empirical evidence that the social dimension of adaptation contributes directly to disaster management effectiveness. Furthermore, the results expand (Krause et al., 2015) argument on the importance of institutional learning in adaptive governance. Findings from Aceh show that effectiveness increases when government institutions convert past

experiences into new policy learning. Such institutional learning reinforces adaptive capacity and allows the disaster management system to evolve sustainably. In adaptation theory, this demonstrates that effectiveness is not the product of static policy but of continuous learning processes.

Conceptually, the results assert that disaster management effectiveness cannot be fully explained by structural or financial capacity alone; rather, it should be understood as the outcome of interactions among institutional adaptation, social learning, and local values. The principal contribution of this study is the assertion that climate adaptation is a universal factor in improving disaster management effectiveness, while its form and strength are greatly influenced by each locality's social and cultural context.

From an institutional perspective, the findings reflect Aceh's transitional process toward an adaptive governance model of disaster management. Adaptation is pursued through improved inter-agency coordination, integration of risk data into regional planning, and regulatory adjustments to evolving environmental dynamics. These efforts demonstrate implementation of policy-learning principles, where past experiences become the basis for improving future responses (Rahman et al., 2024). Thus, the significance of the observed relationship arises not solely from technical policy measures but from the bureaucracy's ability to adapt decision-making processes continuously to changing risks. Social factors also contribute substantially to strengthening the adaptation–effectiveness relationship. In Aceh, communities possess strong social structures based on communal ties, reflected in mutual aid and post-disaster solidarity. Participatory adaptation—such as preparedness training, coastal ecosystem management, and village-based risk mapping—has increased community capacity to identify and respond to threats. This aligns with Dwirahmadi et al. (2023), who state that active public participation in adaptation programs enhances disaster management effectiveness by strengthening public trust in government institutions and accelerating emergency information flows.

Local culture likewise plays a significant role in explaining the link between adaptation and effectiveness. Before the tsunami era, Acehese communities were familiar with adaptation mechanisms grounded in local wisdom—such as the *Mukim* institution that governs cross-village natural resource management and the *Hikayat Smong* tradition in Simeulue that functions as a collective memory of tsunamis. These wisdoms bolster preparedness through intergenerational social learning. As Al-Fairusy (2019) explains, such local values serve not only as means of information dissemination but also as social devices for building community resilience to natural hazards. Integrating this local wisdom into modern adaptation policy helps explain why disaster management effectiveness in Aceh has risen significantly despite relatively limited fiscal capacity.

From a normative perspective, the significant effect of adaptation on effectiveness can also be understood through the internalization of Islamic values in disaster governance. The principles of *amanah* (honesty and responsibility), *‘adl* (justice), and *maṣlahah* (public welfare) serve as an ethical framework guiding government and community behavior in risk management. As (Niara et al., 2025) and Iskandar et al. (2025) observe, applying Islamic values in public policy in Aceh increases social accountability and policy legitimacy, thereby strengthening public trust

in disaster institutions. In adaptation, *amanah* promotes transparency in resource management, *‘adl* ensures equitable distribution of adaptation benefits across regions, and *maṣlahah* focuses policy orientation on collective well-being. Together, these principles create synergy between religious ethics and modern governance effectiveness.

Another strengthening factor is the successful integration of adaptation policy into regional development planning. The Aceh government has prioritized climate change in the Regional Medium-Term Development Plan (RPJMD). This integration demonstrates that adaptation has moved beyond reactive activities to become part of a sustainable development strategy. This aligns with Tota et al. (2025), who assert that adaptation sustainability depends on the extent to which policies are formally institutionalized within regional government structures. Aceh’s implementation shows a progressive institutionalization process, though it still faces human resource and financial constraints. By combining institutional, social, cultural, and normative-value dimensions, the adaptation–effectiveness relationship in Aceh can be interpreted as the outcome of hybrid disaster governance—merging scientific-modern approaches with socio-religious principles and local wisdom. This approach creates an adaptation system that is not only functional but also contextual and rooted in community identity. Its success reinforces the theory that disaster governance effectiveness is determined not solely by technical capacity but also by value coherence and social legitimacy (Padlee et al., 2021; Simonovic, 2018).

Theoretical and Practical Implications

This study contributes significantly to theory development in climate change adaptation and disaster management, particularly within regions that have strong socio-religious characteristics such as Aceh. Theoretically, the findings expand understanding of the direct relationship between adaptive capacity and disaster management effectiveness as formulated in resilience theory and adaptive governance frameworks.

First, the study asserts that adaptation is not merely a technical or administrative function but a dynamic process involving interactions among institutional capacity, social learning, and the legitimacy of local values. This strengthens the theories of Simonovic (2018) and Krause et al. (2015), which posit that system resilience to disasters depends on actors’ ability to adjust to uncertainty through policy innovation and cross-sectoral coordination. By presenting empirical evidence from Aceh, this study adds a new dimension to those theories: normative and cultural values can act as reinforcing factors of adaptation policy effectiveness.

Second, the study extends the adaptive governance framework toward a more contextual perspective by introducing the concept of “value-based adaptive governance.” In Aceh, adaptation is implemented through Islamic principles such as *amanah*, *‘adl*, and *maṣlahah*, which not only guide policy actors’ behavior but also create moral legitimacy in public decision-making (Iskandar et al., 2025; Niara et al., 2025). Integrating Islamic ethics into disaster adaptation provides a new theoretical contribution by showing that value-based adaptive governance can strengthen social trust and institutional effectiveness, especially in religious societies.

Third, the study enriches academic discourse on the synergy between global adaptation theory and local wisdom. Evidence from Aceh shows that an effective adaptation system is formed not only by modern policies but also by traditional social mechanisms such as *Mukim* and *Hikayat Smong*, which serve as channels for transmitting disaster knowledge across generations (Al-Fairusy, 2019) Thus, the findings affirm that resilience in developing countries has distinct characteristics: it does not always rely on high technology but can stem from institutionalized local culture.

Overall, the study's theoretical contribution lies in asserting that disaster management effectiveness results from a combination of adaptive capacity, institutional learning, and cohesion of socio-religious values. These findings broaden the conceptual terrain of climate adaptation theory by positioning public morality and community participation as structural elements in building sustainable disaster resilience.

From a practical perspective, the study offers a set of policy recommendations for local governments, disaster agencies, and communities to strengthen disaster management effectiveness through sustainable adaptation. First, for local governments, the study emphasizes the importance of institutionalizing adaptation within the development planning system. Adaptation should not be treated as an add-on program but must become part of strategic regional plans (RPJMD and Renstra SKPA). This integration aligns with Rahman et al. (2024), who argue that adaptation is effective when it functions as a cross-sectoral policy instrument accompanied by long-term budgeting. Governments should develop measurable adaptation performance indicators—for example, the number of climate-resilient villages, local institutional capacity, and community preparedness levels. Second, for disaster management agencies (BPBA and district/city BPBD), the findings underscore the importance of institutional learning and policy innovation. A system for routine documentation and evaluation of emergency response experiences is necessary to provide a foundation for future policy improvements. In line with Tota et al. (2025), disaster agencies should adopt an adaptive management cycle approach—planning, implementation, evaluation, and policy revision continuously based on field learning.

Third, for communities and customary institutions, the study indicates the need to strengthen community participation in adaptation. Meaningful participation can be implemented through the development of village-based disaster resilience forums, local-wisdom-based training, and revitalization of social solidarity values. Consistent with Dwirahmadi et al. (2023), community involvement accelerates the dissemination of risk information and enhances public policy legitimacy. Therefore, successful adaptation policies are those that emerge from participation and collective awareness, not merely from bureaucratic instruction. Fourth, from the perspective of Islamic values and public morality, the study stresses the importance of applying *amanah* (responsibility and transparency) in disaster fund management, *'adl* (justice) in aid distribution, and *maṣlahah* (public welfare) in prioritizing adaptation programs. This ethical approach can strengthen policy accountability, reduce potential social conflict, and foster trust between government and society (Niara et al., 2025).

Fifth, for national policy development, Aceh's findings can serve as a model to strengthen interregional policy learning. The central government may adopt Aceh's best practices—such as integrating local wisdom into adaptation and involving religious

institutions in risk communication—as references for other regions with similar social structures. This aligns with Padlee et al. (2021), who contend that successful local-level adaptation can act as a policy laboratory for national replication. In summary, the practical implications of this study assert that disaster management effectiveness is built not only through formal regulation but through synergy among adaptive policy, institutional learning, community participation, and ethical values. The Aceh adaptation model can serve as an example for other regions seeking to develop sustainable disaster management systems rooted in local socio-cultural values.

CONCLUSION

This study affirms that climate change adaptation is a determining factor that has a positive and significant effect on disaster management effectiveness in Aceh Province. The empirical analysis shows that adaptive capacity—developed through local government policies, institutional strengthening, and community participation—significantly improves the performance of the disaster management system. Theoretically, these findings extend the frameworks of resilience theory and adaptive governance by incorporating the dimensions of social values, local wisdom, and Islamic ethics as reinforcing elements of institutional resilience. Practically, the study provides a foundation for local governments to integrate adaptation into development planning, strengthen institutional learning, and actively engage communities in disaster risk mitigation. However, this research is limited by its geographical scope, which is confined to the Aceh region, and by the use of only two-dimensional variables. Therefore, generalization of the results should be approached with caution. Future studies are recommended to expand the research context to other provinces and to include mediating variables such as public trust, policy innovation, or institutional learning to deepen the understanding of the mechanisms linking adaptation and disaster management effectiveness. Overall, the findings of this study contribute to strengthening both the scientific and practical foundations for developing an adaptive, ethical, and sustainable disaster management system in regions vulnerable to climate change.

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