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EDUCATION FOR DISASTER RISK REDUCTION IN THE SEISMIC LANDSCAPE: CO-CREATING RESILIENCE THROUGH UNIVERSITY-SCHOOL NETWORKS IN NORTHERN THAILAND

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ABSTRACT

This study examined how university-school collaborations can serve as transformative platforms for building community resilience and promoting sustainable development in Chiang Rai Province, Northern Thailand, which was affected by the 2014 earthquake and is exposed to transboundary seismic risks from the 2025 Myanmar earthquake. The research investigated the role of educational partnerships in fostering long-term adaptive capacity. Adopting a qualitative exploratory design, the study was guided by a composite conceptual framework that integrates the Community of Practice, Social-Ecological System, and Education for Sustainable Development (ESD) perspectives. Data was gathered through in-depth interviews and content analysis involving purposively selected informants, including government officials, school principals, and educators. The study analyzed three core dimensions of school safety: institutional capacity, physical infrastructure, and external relationships. The findings revealed that resilience is not merely a product of engineering solutions or administrative mandates but emerges from deeply rooted knowledge and collaborative practices among diverse educational and community actors. The university-school network operates as a dynamic community of practice, facilitating mutual learning, cross-generational engagement, and participatory knowledge production. These networks strengthen the schools' roles as integral centers within a broader social-ecological risk governance system, fostering iterative adaptation and context-sensitive responses to disaster threats. Furthermore, the research demonstrates how such partnerships contribute to the realization of global sustainability goals, particularly SDG 4 (Quality Education), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action), by integrating disaster preparedness, ecological thinking, and civic responsibility into the educational system.

Keywords: Community of practice; social-ecological resilience; Education for Sustainable Development (ESD); university-school collaboration; earthquake; disaster risk governance

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1. INTRODUCTION

In recent decades, disaster risk has intensified in frequency, scale, and systemic complexity, prompting renewed scholarly and policy attention to how resilience is cultivated within communities (Shiel et al., 2016). Resilience is increasingly understood not merely as the capacity to recover after a shock, but also as the ability of institutions and social systems to anticipate risk, cultivate preparedness, and sustain adaptive capacity over time (Lin et al., 2021; Fu & Zhang, 2024). Within this evolving paradigm, education occupies a pivotal position. Schools and universities are not only sites of knowledge transmission but also institutional arenas where risk awareness, social trust, and adaptive practices can be embedded prior to disaster events.

International frameworks like the Hyogo Framework for Action (2005–2015) and the Sendai Framework for Disaster Risk Reduction (2015–2030) call for the integration of disaster risk knowledge into education systems at all levels to foster a "culture of safety" (Oktari et al., 2018). Education for Sustainable Development (ESD) emphasizes equipping learners with competencies to navigate environmental uncertainty and participate in resilience-building (UNESCO, 2017). Parallel scholarship highlights the role of universities as anchor institutions that can mobilize knowledge, technical expertise, and social capital to support community transformation (Stephens et al., 2008; Trencher et al., 2014; Galdames & Saracostti, 2024). Overall, these policies and academic discourses construct a normative expectation that educational institutions should function as proactive resilience nodes within broader socio-ecological systems (Rahman & Shaw, 2015).

However, empirical realities in disaster-prone regions frequently diverge from these expectations. Field evidence from earthquake-affected areas shows that school-based disaster preparedness often remains fragmented, reactive, and dependent on individual leadership rather than on institutionalized systems (Oktari et al., 2018; Fu & Zhang, 2024). Disaster risk reduction (DRR) initiatives may take the form of occasional drills or symbolic compliance measures without sustained curricular integration, continuity of professional development, or cross-sector coordination. Institutional memory is vulnerable to staff turnover, and collaboration between schools and external actors tends to be episodic rather than structurally embedded (Franco & Tracey, 2019; Oktari et al., 2015). In this way, the translation of global resilience commitments into everyday educational governance remains uneven.

This disjunction between normative expectations and authentic institutional conditions constitutes the research problem of this study. While universities are widely described as contributing to community resilience, there is limited empirical clarity about the mechanisms by which university engagement strengthens local adaptive capacity prior to disasters (Songlar et al., 2019). Much of the literature either emphasizes emergency response coordination during crisis situations or examines post-disaster reconstruction. By contrast, comparatively fewer studies analyze the preparatory and inter-disaster processes through which collaborative educational practices institutionalize DRR knowledge and sustain preparedness over time (Lin et al., 2021).

To address this gap, this study clarifies and examines a specific mechanism: the pre-disaster and inter-disaster adaptive learning processes through which university-school collaboration builds institutional capacity for disaster risk reduction (Oktari et al., 2015). This research does not focus on standard operating procedures for disaster response, or on crisis-stage command systems. Instead, it investigates how sustained collaboration—through curriculum co-design, professional mentoring, peer learning networks, and participatory knowledge production—functions as an institutionalized governance process that embeds preparedness within everyday education practices (Fu & Zhang, 2024).

This analytical focus is temporally significant. By situating resilience-building within the preparedness and inter-disaster phases of the disaster cycle, the study aligns conceptually with the Community of Practice (CoP) framework (Wenger, 1998). CoP theory emphasizes mutual engagement, shared repertoire, joint enterprise, and iterative identity formation—processes that unfold over time rather than during singular crisis events. Disaster resilience in educational settings is therefore understood as a relational and institutional achievement emerging from sustained collaborative practice, rather than as a product of emergency compliance alone.

The Socio-Ecological Systems (SES) perspective further strengthens this analysis by situating schools within broader governance and environmental structures. Resilience is disturbed across institutional capacity, infrastructural integrity, and external relationships, all of which interact within complex adaptive systems (Liu et al., 2023). When integrated with ESD principles, this perspective underscores that disaster education is not merely technical training but a transformative process that links knowledge production, institutional learning, and civic responsibility.

This study explores these dynamics through a case study of a university-school network in Chiang Rai Province, Northern Thailand. The region experienced a magnitude 6.3 earthquake in May 2014 (Pananont et al., 2017), which exposed significant institutional and infrastructural vulnerabilities in local schools. In the

subsequent years, efforts were made to strengthen disaster education and preparedness through collaborative initiatives between a regional university and affected schools. This context provides a grounded opportunity to analyze how university engagement may shift schools from reactive preparedness toward institutionalized adaptive learning.

This study addresses the following research question: "How do university-school networks function as pre-disaster adaptive learning systems that institutionalize disaster risk reduction practices and strengthen community resilience in earthquake-prone contexts?" By addressing this question, the study contributes to three areas of scholarship. First, it refines disaster education research by distinguishing between emergency response mechanisms and sustained institutional learning processes. Second, it advances theoretical discussions of resilience governance by demonstrating how educational collaboration operates as a localized adaptive mechanism within socio-ecological systems. Third, it offers empirical insight into how global development commitments, particularly SDG 4 (Quality Education), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action), are translated into everyday preparedness practices through sustained university, school partnerships (Galdames & Saracostti, 2024; Thomas, 2022).

2. LITERATURE REVIEW

2.1 Theoretical foundations of Community of Practice (CoP)

The Community of Practice (CoP) framework, initially conceptualized by Lave and Wenger (1991) and later refined by Wenger (1998), provides a compelling foundation for understanding collaborative, situated learning over time, particularly in contexts requiring shared knowledge, trust, and adaptive responses (Yamori, 2009). Within a CoP, individuals engaged in a common domain, such as disaster preparedness, mutually construct knowledge and reproduce practices through iterative social interaction (Choi & Choi, 2018). Wenger (1998) articulates three core dimensions of practice: mutual engagement, joint enterprise, and shared repertoire, which together form the internal structure of a CoP. Voluntary participation, common goals, and the continuous negotiation of meaning, identity, and experience characterize these communities. CoP theory has since evolved to include three structural components: domain (shared interest), community (social relationships), and practice (collective behaviors and routines), making it adaptable for diverse learning and governance settings (Choi & Choi, 2018; Sun et al., 2013).

In disaster education, CoPs are increasingly recognized as essential mechanisms for enhancing long-term collaborative learning, shifting disaster risk reduction (DRR) from passive, top-down transmission to active, community-engaged co-creation of knowledge. Rather than positioning learners as passive recipients, CoP-based disaster education promotes reciprocal learning, in which experts may integrate local knowledge, and community members participate in knowledge dissemination (Yamori, 2009). This transformation fosters proactive attitudes, intergenerational engagement, and socially feasible solutions. CoPs thus become not just learning spaces but social infrastructures of resilience, enabling communities to anticipate, absorb, and adapt to shocks over extended timeframes (Choi & Choi, 2018).

CoP theory also supports knowledge sustainability, especially in high-impact, low-frequency disasters like earthquakes. Unlike individual-centered approaches that often fade over time, CoPs preserve institutional memory, support continuity of practice, and nurture adaptive imagination through collective participation (Farley, 2020). In each stage of the crisis cycle—pre-crisis, crisis, and post-crisis—CoPs offer critical functions: relationship-building in anticipation, coordinated response during emergencies, and reflective transformation in recovery (Choi & Choi, 2018). These contributions are crucial for achieving social-ecological resilience, in which communities operate as complex adaptive systems, and resilience is co-produced through learning, feedback, and adaptation across scales (Paton, 2013).

Notably, several scholars advocate for expanding CoP theory in disaster contexts to explicitly include non-human actors, such as physical infrastructure, technologies, or institutions, which are referred to as "artifacts" (Sun et al., 2013). These artifacts shape how knowledge is practiced and maintained, influencing risk awareness and community behavior. In earthquake-prone areas, schools, emergency shelters, and hazard maps function not only as tools but also as material anchors of practice and identity (Choi & Choi, 2018). Their inclusion enhances the CoP framework by recognizing the interconnected relationships between people and their built environment.

However, CoP-based approaches are not without limitations. Empirical studies (e.g., the Okitsu case study) highlight challenges such as uneven participation, reliance on a few active members, and the entrenchment of rigid social identities (Miles et al., 2019). In some instances, community members may internalize overwhelming risk narratives, leading to apathy or denial of risk. These dynamics underscore the need for critical reflection within CoP structures to avoid reinforcing social exclusion or immobilization (Yamori, 2009). Furthermore, the distinction between genuine CoP-driven education and superficial

participatory models must be preserved. True CoPs demand structural transformation and shared authority, rather than tokenistic involvement under hierarchical paradigms.

2.2 Socio-Ecological Systems in disaster and education contexts

Resilience has emerged as a central concept in disaster studies, evolving across disciplines to reflect the dynamic interplay among systems, uncertainty, and adaptive capacity (Rahman & Shaw, 2015). Within this discourse, the Socio-Ecological Systems (SES) framework has gained prominence for its ability to conceptualize communities and ecosystems as interlinked and adaptive systems shaped by both human and environmental processes. Rooted in ecological theory but expanded to include social dimensions, SES defines resilience as the capacity of a system to absorb disturbances, reorganize, and sustain its core functions, structures, and feedback mechanisms (Fadli et al., 2018). This approach moves beyond linear recovery models, (by) emphasizing the need to "bounce forward" through iterative learning, cross-scale interaction, and self-organization. In disaster contexts, SES is particularly relevant for interpreting how risk is distributed across social groups, institutions, and infrastructures, as well as for evaluating the long-term implications of both natural hazards and human responses (Liu et al., 2023).

In the context of earthquake resilience, the SES framework broadens the analytical lens to include social capital, institutional capacity, ecological vulnerability, and the built environment (Fadli et al., 2018). In these settings, SES-based models have proven useful for assessing how infrastructural damage intersects with social fragmentation, policy discontinuities, and disrupted livelihoods, particularly during recovery and reconstruction phases (Modica & Zoboli, 2016). Importantly, SES approaches emphasize that resilience is not uniformly distributed; rather, it is shaped by power, history, and access to resources, underscoring the importance of place-based, equity-oriented interventions.

Within this framework, schools occupy a strategic position as institutional nodes embedded within socio-ecological networks. In the realm of earthquake disaster risk reduction (DRR), schools are increasingly recognized as key actors in promoting community resilience (de Oliveira et al., 2024). However, conceptual acknowledgement of the school's importance does not automatically clarify how its contribution to resilience should be assessed. If schools are to be treated as resilience actors, their institutional capacity must be operationalized.

Drawing on disaster resilience scholarship (Norris et al., 2008; Cutter et al., 2008; Twigg, 2009), this study interprets community resilience not as a binary condition but as a continuum of institutional embedding. Specifically, institutional capacity in educational settings is conceptualized across three preparedness dimensions: (1) planning and policy integration, (2) operational procedures and training systems, and (3) financial allocation and resource commitment. Furthermore, based on performance across these dimensions, school-level community resilience can be analytically categorized into three typologies: (1) strong resilience, where preparedness is institutionalized across planning, operations, and financial commitment, practices are systematic, documented, and sustained; (2) moderate resilience, in which preparedness mechanism exist but remain inconsistently embedded, dependent on leadership initiative of temporary projects; and (3) low resilience, where preparedness is reactive, informal, and unsupported by stable governance or resource allocation structures.

This typological approach aligns with SES understandings of resilience as adaptive capacity spread across institutional frameworks rather than defined solely by infrastructural robustness (Cutter et al., 2008; Ross & Berkes, 2014). It also addresses critiques that resilience discourse risks conceptual vagueness unless it is grounded in clear evaluative criteria (Fadli et al., 2018).

The integration of education within SES further strengthens this institutional interpretation. Education, particularly when aligned with Education for Sustainable Development (ESD), serves not only as a means of knowledge transfer but also as a mechanism for cultivating adaptive competencies, participatory governance, and collective agency (Servant-Miklos, 2022). Student-centered and problem-based pedagogies foster system thinking and cooperative capacities that are essential for navigating environmental uncertainty (Servant-Miklos, 2022). Evidence from crisis contexts, such as the COVID-19 pandemic, underscores the potential of education to sustain socio-ecological awareness and emotional resilience when it is embedded in community-oriented practices (Modica & Zoboli, 2016).

Thus, in earthquake-prone regions such as Northern Thailand, where environmental hazard intersects with governance fragmentation and educational inequality, the SES perspective provides both a theoretical and evaluative scaffold. It enables an analysis of how preparedness is institutionalized, how resilience varies across contexts, and how schools, when supported through participatory partnerships, contribute to adaptive governance and localized implementation of SDG 4, SDG 11, and SDG 13 (Galdames & Saracostti, 2024; Thomas, 2022). Figure 1 presents the conceptual framework derived from this integration.

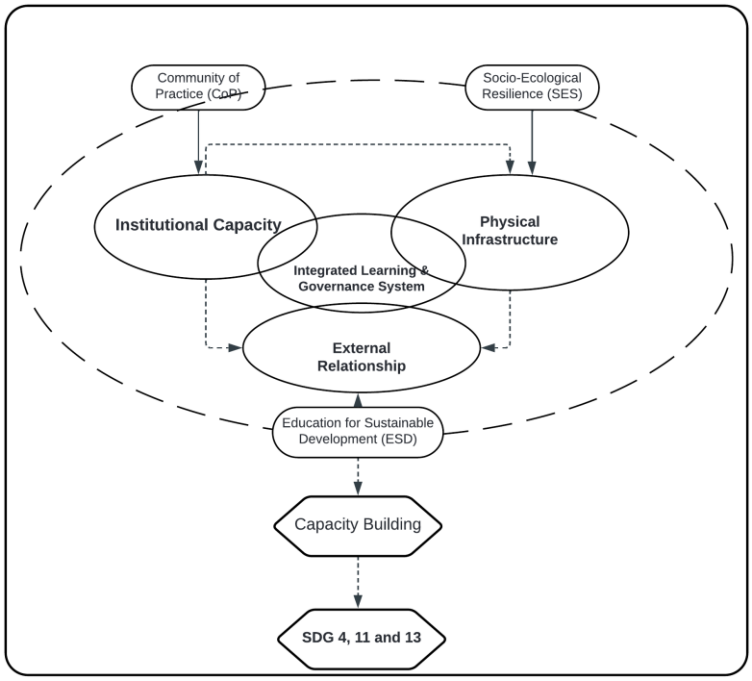

Figure 1: Conceptual framework: University–School collaboration for community resilience and sustainable development in an earthquake-prone context

This conceptual framework illustrates the dynamic interaction among theoretical foundations, Communities of Practice (CoP), Socio-Ecological Resilience (SES), and Education for Sustainable Development (ESD), together with three core operational domains: Institutional Capacity, Physical Infrastructure, and External Relationships (Tong et al., 2012; Dania et al., 2022), itself informed by disaster resilience indices and the Hyogo Framework for Action, this model provides a structured methodology to evaluate how educational institutions prepare for and respond to natural hazards.

Institutional Capacity refers to a school's internal management of disaster preparedness, encompassing planning processes, operational procedures, and budget allocation. It involves integrating disaster risk reduction (DRR) into school regulations and curricula, developing preparedness and recovery plans, and establishing trained disaster-response teams. Financial commitment to preparedness, such as funds for training, infrastructure repair, and support for vulnerable students, is particularly critical.

Physical Infrastructure focuses on the condition and safety of school buildings, facilities, and the surrounding environment. Key indicators include compliance with building safety codes, the presence of evacuation shelters and emergency supplies, and the maintenance of eco-friendly and hygienic conditions. Regular inspections and the ability to quickly repair damage are essential to ensure continuity of education following a disaster. Among the practitioners surveyed, environmental health campaigns and regular safety checks were emphasized as priorities for sustaining a safe school environment.

External Relationships examine the school's interaction with local communities, government agencies, and other support networks. This includes collaboration in disaster planning, communication with education authorities, access to early-warning systems, and community involvement in school-based DRR activities. The availability of external funding, whether from local government, parent associations, or NGOs, also plays a vital role.

These domains collectively shape the Integrated Learning and Governance System, serving as the central mechanism for co-producing disaster preparedness and sustainability practices. The framework highlights how educational partnerships foster capacity building, which in turn supports the achievement of the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action). Arrows indicate the flow of influence and feedback across theoretical inputs, systemic components, and development outcomes, underscoring the iterative and participatory nature of resilience-building in post-disaster educational governance.

3. RESEARCH METHODOLOGY

3.1 Research design

This study utilizes a qualitative case study approach to examine the role of a university-school partnership in promoting community resilience and supporting sustainable development in a disaster-prone educational context. Given the complex interaction(s) among institutional structures, stakeholder relationships, and contextual vulnerability, the case study method provides the most suitable framework for examining these dynamics in depth. As an exploratory inquiry, this research emphasizes rich, contextual understanding over generalization, aiming to uncover the nuanced mechanisms through which localized educational governance contributes to adaptive capacity in areas exposed to environmental risks in which to illuminate broader theoretical debates on Community of Practice (CoP), socio-ecological resilience, and Education for Sustainable Development (ESD) (Baškarada, 2014; Yin, 2018; Stake, 2005). Consistent with Baškarada (2014), the case study enables an in-depth analysis of complex social systems guided by theoretical propositions. In this study, the three preparedness dimensions—planning and policy integration, operational procedures, and financial commitment—served as analytical propositions structuring the inquiry. The goal is not statistical generalization but analytic generalization, contributing to theories on institutionalized preparedness and adaptive governance (Yin, 2018).

3.2 Research setting and context

The empirical investigation took place in Chiang Rai Province, which is located in Northern Thailand. This region experienced a magnitude 6.3 earthquake in May 2014, marking a pivotal moment in local disaster preparedness efforts. The 2014 earthquake caused significant structural damage to more than fifteen schools across Chiang Rai Province, with the most severe impacts concentrated in the districts of Mae Lao, Mae Suai, and Phan. Facilities such as classrooms, administrative offices, and science laboratories experienced extensive damage, including cracked walls, collapsed ceilings, and compromised foundations (Ornthammarath et al., 2023). As a result, many schools were forced to suspend regular classes and relocate students to temporary learning spaces, such as makeshift classrooms and open-air shelters. This disruption not only undermined educational continuity but also exposed the critical weakness of school infrastructure, particularly in rural areas where seismic retrofitting had long been neglected. Moreover, the event underscored the absence of a coordinated disaster preparedness framework within the education system, revealing critical gaps in risk governance and institutional readiness (Laosunthara et al., 2025). More recently, concerns have grown about the potential impacts of the 2025 Myanmar earthquake, including cascading risks across regional fault lines. Thus, Chiang Rai represents a strategically important setting for understanding how educational institutions, especially in post-disaster environments, collaborate to enhance resilience and embed sustainability into community development.

3.3 Participant selection and sampling

A purposive sampling strategy was employed to select participants with direct experience and expertise in disaster education and university-community collaboration. The sample comprised ten key informants from three primary stakeholder groups: (1) school leaders (e.g., principals and deputy principals), (2) primary and secondary school teachers involved in disaster preparedness or related curriculum delivery, and (3) local government officials and university personnel engaged in risk reduction and outreach activities. This selection provides a diverse yet targeted representation of the actors shaping the university-school partnership in Chiang Rai.

3.4 Data collection procedures

Two principal methods were utilized to collect qualitative data: (1) semi-structured interviews served as the primary mode of data collection, and (2) document analysis served as a secondary data source. These interviews were conducted in person using a guide aligned with the study's three analytical indicators: institutional capacity, physical infrastructure, and external relationships. Questions focused on planning and policy integration, referring to updating of disaster preparedness plans, curriculum integration of disaster risk reduction (DRR), mechanisms for transferring institutional knowledge, and coordination with district-level education authorities, following the operational procedures and training system, and financial allocation and resource commitment. Additionally, the questions focused on participants' experiences with inter-institutional collaboration and community engagement, as well as their perceptions of resilience. Document analysis complemented the interviews by reviewing a variety of institutional materials, including school emergency plans, local disaster response protocols, university outreach reports, and training documentation. These documents helped to contextualize the interview findings and added additional insights into the formal and informal mechanisms governing disaster education. All interviews were conducted with informed consent, recorded, transcribed verbatim, and anonymized to ensure the ethical integrity of the research.

3.5 Data analysis approach

The qualitative data were analyzed using thematic content analysis, guided by Neuendorf's methodological approach in 2018. Consistent with Yin (2018)'s case study logic, a pattern-matching strategy was employed to compare empirical observations with the operationalized preparedness dimensions and resilience typology. This approach enabled systematic alignment between theoretical propositions and field-based evidence. The process included, (1) an initial phase of immersion in the data through repeated reading of transcripts and documents, (2) generation of codes both inductively from participants' narratives and deductively from the theoretical framework, (3) organization of codes into broader themes aligned with the three operational domains (institutional, infrastructural, relational), (4) mapping of emergent patterns onto the guiding concepts of CoP, SES, and ESD, (5) interpretation of findings with attention to their implications for community resilience and contributions to the SDGs, and (6) triangulation of data sources ensured analytical robustness, while demoing during coding facilitated reflexivity and transparency throughout the process. To ensure methodological rigor, the study adhered to qualitative standards of credibility, dependability, and confirmability (Yin, 2018; Baškarada, 2014). Credibility was strengthened through data triangulation between interview findings and documentary evidence. Dependability was supported by maintaining detailed documentation of coding procedures, thematic matrices, and analytic memos. Confirmability was enhanced through reflexive memoing, which allowed critical examination of interpretive decisions throughout the analysis. Rather than seeking statistical generalization, the study aims for analytic generalization, contributing to the theoretical understanding of institutionalized preparedness and educational resilience governance within socio-ecological contexts.

3.6 Limitation

As a single-case study within a specific socio-environmental context, the findings are not intended to be statistically generalized. However, the detailed insight provided offers transferable knowledge applicable to similar disaster-affected educational settings. Additionally, while the research captures institutional and professional perspectives, it does not include direct input from students, parents, or broader community members. This recognized limitation should be more fully addressed in future studies to capture the ecosystem of school-based resilience.

4. RESULTS

4.1 Examining school safety toward earthquakes in the Chiang Rai context

This study explores how schools implement safety in disaster risk reduction (DRR) practices in Chiang Rai. The findings are organized into three interrelated domains: (1) institutional capacity, (2) physical infrastructure, and (3) external relationships.

4.1.1 Institutional capacity challenges in Chiang Rai

The 2014 earthquake in Chiang Rai revealed weaknesses in how schools understood and implemented disaster preparedness. Despite being located in a region with known seismic risk, institutional readiness across schools was characterized by fragmentation, inconsistency, and a primarily reactive approach. This was largely the result of weak planning frameworks, minimal policy enforcement, and a gap between schools and district governance mechanisms.

In the absence of standardized disaster risk reduction (DRR) directives from local education authorities, most schools developed informal, leader-dependent practices rather than systematic strategies. As a result, the implementation of DRR differed significantly. Some schools held occasional evacuation drills, while others only displayed safety signage without corresponding protocols. In several cases, no preparedness activities existed at all. Disaster education, when present, was often peripheral, treated as an optional viewed an optional extracurricular activity rather than embedded in school curricula or strategic development plans.

> "We knew earthquakes could happen, but there was no checklist, no training, no funding plan. Each principal did what they could manage." (School principal, personal communication, December 23, 2024).

This reflects a broader pattern of decentralization, resulting in isolated efforts rather than an integrated readiness system. Without oversight or technical support from the district level, schools were left to rely on limited knowledge and resources. Teachers reported having to improvise drills using outdated materials or personal judgment, practices that, while well-intentioned, created significant disparities in student safety and institutional readiness.

Moreover, disaster response efforts were often reactive rather than embedded. Increased activity was often observed immediately after an incident, like conducting emergency drills or updating plans, but this momentum was rarely sustained. Without follow-through or structural reinforcement, DRR initiatives lost momentum over time. Institutional memory was rarely documented or formally transferred, leaving schools vulnerable to cycles of amnesia and repetition with each change of leadership or staff.

> "We had a big meeting after the quake, and made lots of plans. But two years later, many new teachers didn't even know we had an evacuation route." (School teacher 1, personal communication, December 24, 2024).

This highlights a deeper systemic vulnerability: the lack of mechanisms to promote institutional learning, intergenerational continuity, and accountability. Data systems to track preparedness activities were largely absent, and most annual school plans did not allocate specific funding for DRR. With school budgets heavily weighted toward fixed costs like salaries and maintenance, investment in preparedness was frequently deprioritized.

The gap between national policy commitments and local implementation further worsened the situation. Although the Thai government has endorsed frameworks such as the Sendai Framework and emphasized DRR in education policy, these commitments have not been fully implemented at the school level. Implementation guidelines, resource distribution mechanisms, and professional development opportunities have not kept pace with policy ambitions. This disconnect has left frontline educators with unclear direction and limited capacity, resulting in a policy–practice gap that continues to undermine meaningful preparedness.

In the absence of sustained technical support or institutional mandates to integrate DRR into the operational fabric of school management, many schools remain in what might be called a state of preparedness limbo, not entirely unaware of risk, yet far from structurally equipped to manage it. This ambiguity fosters dependence on individual initiative rather than on coherent, system-level processes.

> "We expected schools to be ready. But the truth is, without consistent guidance and support, we can't expect them to be resilient on their own." (Sub-district Administrative Officer, personal communication, December 22, 2024).

This case highlights the pressing need for institutional scaffolding that goes beyond ad hoc preparedness. Clear mandates, designated budgets, monitoring systems, and strategic partnerships, particularly with local universities, are essential to transforming fragmented practices into a unified governance approach. Without these structural supports, school-based resilience will remain uneven, unsustainable, and vulnerable to being reactivated only in the aftermath of the next disaster.

4.1.2 Physical infrastructure and the everyday geography of risk in Chiang Rai schools

The 2014 earthquake in Chiang Rai revealed weaknesses in the physical infrastructure of schools across the province, revealing how deeply material fragility intersects with broader institutional preparedness gaps. Although the event did not cause widespread casualties in educational settings, it highlighted the compromised structural integrity of many school buildings, particularly those in rural and mountainous areas, where decades-old construction had failed to meet seismic safety standards. Numerous classrooms suffered cracked walls, fallen ceilings, or dislodged tiles, prompting emergency closures in affected schools.

> "After the quake, we had to close one wing of the school. The cracks were too dangerous. But we didn't have funds for engineers or repairs—we just blocked the area and hoped nothing worse would happen." (School principal, personal communication, December 23, 2024).

This response reflects a broader trend: lacking access to formal engineering assessments or retrofitting support, schools were forced to depend on improvised containment measures rather than systemic interventions. The disparities in infrastructure maintenance mirrored broader inequalities. While better-funded urban schools had benefited from renovation programs, many rural schools continued to operate in aging buildings with minimal structural updates. Few have undergone seismic retrofitting, and most lacked building-specific evacuation plans tailored to local terrain.

> "We teach students about earthquakes in class, but the truth is, our building wouldn't survive a strong one." (School teacher 2, personal communication, December 24, 2024)

This disjunction between disaster awareness and physical preparedness highlights a critical gap between educational intent and infrastructural reality. Beyond the structures themselves, many schools faced

significant challenges in designing and executing safe evacuation protocols. Narrow corridors, obstructed exits, and the absence of dedicated open spaces posed logistical hazards during both drills and real emergencies. While some schools displayed evacuation maps, these were often generic and failed to account for local environmental risks such as unstable slopes or landslide-prone areas.

> "The map looked good on paper, but it wasn't grounded in the real risks we face." (Deputy principal, personal communication, December 23, 2024).

This points to an overreliance on standardized materials that lacked contextual accuracy, providing symbolic reassurance rather than actionable safety. Similarly, emergency supplies such as food, water, and first-aid kits were often inadequate, outdated, or stored in locations inaccessible during crises. In many cases, "safe zones" were poorly designed, lacking shade, seating, or proximity to vulnerable student groups, which limits their effectiveness.

> "We keep emergency bags, but they're mostly symbolic… It's more for demonstration than real use." (School teacher 3, personal communication, December 24, 2024).

This admission reflects a broader institutional culture in which disaster preparedness was driven more by formal compliance than by functional utility. Without regular inventory checks, adequate funding, or sustained training, emergency resources functioned more as visual tokens of readiness than as usable assets during emergencies. Together, these findings underscore the urgent need to reframe school infrastructure not merely as static assets but as active components of resilience planning, requiring continuous investment, local adaptation, and integration with broader disaster governance systems.

4.1.3 External relationship and the governance gap in school-based disaster preparedness

The 2014 earthquake in Chiang Rai not only exposed internal weaknesses in school preparedness but also highlighted the fragmented, underdeveloped nature of external relationships between schools, local authorities, communities, and support networks. Effective disaster risk reduction (DRR) extends beyond institutional boundaries and depends critically on a school's capacity to coordinate with external actors. However, field findings show that these relationships were broadly weak, irregular, and insufficiently institutionalized. Following the earthquake, many school administrators reported receiving minimal technical or strategic assistance from education offices or disaster management agencies. Communication was often limited to reporting damage, without subsequent guidance or coordinated planning.

> "We were told to report damages, but no one told us what to do next. There was no visit, no checklist, no help with planning. It felt like we were left on our own." (School principal, personal communication, December 23, 2024).

This sentiment reflects a broader institutional disconnect, where support from governing bodies was reactive and procedural rather than strategic or sustained. Relationships with community actors, including parents, local leaders, and civil society groups, were similarly informal and ad hoc. While communities provided spontaneous assistance during emergencies, these efforts relied on personal relationships rather than formal structures.

> "The community helped when we asked, especially the parents. But there's no system. It depends on who's available and who knows who." (School teacher 4, personal communication, December 24, 2024).

This reliance on informal networks led to uneven disaster responses, particularly in under-resourced rural areas. Furthermore, school preparedness activities, such as drills, often exclude key stakeholders, including local officials and emergency responders, thereby weakening opportunities for shared learning and coordination.

> "We didn't involve the community in drills because we saw it as an internal school matter. But now we realize that when disaster strikes, the whole village is involved." (Sub-district Administrative Officer, personal communication, December 22, 2024).

This insight, although important, emerged after the crisis, highlighting a reactive learning culture rather than an embedded governance approach. Compounding these gaps were structural barriers to resource

mobilization. Few schools had access to sustained support from NGOs or local agencies, nor did they possess the administrative capacity to apply for external funding.

> "We heard some schools got help from NGOs, but we didn't know who to contact or how to ask," (School teacher 5, personal communication, December 24, 2024).

Overall, these findings reveal that while schools are often at the frontline of disaster response, they remain peripheral to formal disaster governance, lacking the partnerships, recognition, and support systems necessary to build long-term resilience. The findings are summarized in Table 1.

Table 1: School safety reflection from the Chiang Rai earthquake

Domain	Key findings
Institutional capacity	Schools exhibited fragmented and reactive disaster preparedness due to a lack of standardized DRR policies, institutional memory, and sustainable funding. Disaster education was ad hoc and dependent on individual leadership, leading to inconsistent implementation and vulnerability to staff turnover.
Physical infrastructure	Many school buildings, especially in rural areas, lacked seismic safety, retrofitting, and context-specific evacuation planning. Emergency resources were symbolic rather than functional, and facilities such as safe zones were inadequately equipped, highlighting a gap between awareness and physical preparedness.
External relationship	Schools had weak and informal connections with local authorities and communities. Support from the government and NGOs was minimal, uncoordinated, and largely reactive. Drills excluded key stakeholders, and schools were unable to access external funding or formalize community partnerships.

4.2 The nexus of school safety, Community of Practice, Socio-Ecological System, and Education for Sustainable Development in the case of the Chiang Rai earthquake

4.2.1 University-school collaboration as a catalyst for disaster education innovation

Across the selected case schools in Chiang Rai Province, the collaboration between the university and local educators acted as a transformative mechanism for developing disaster education tailored to young children. Teachers frequently noted that before the partnership, DRR content was either absent or superficially implemented, limited to occasional fire drills or poster displays. Through sustained engagement with the university faculty, schools began to reimagine DRR as a pedagogical opportunity rather than a procedural obligation.

The university facilitated a series of co-design workshops, in which teachers, curriculum developers, and education students worked together to develop age-appropriate educational materials, including picture books, storytelling guides, classroom games, and interactive songs about earthquake safety. These activities fostered a shared sense of purpose and professional identity, resonating with Wenger (1998)'s model of mutual engagement and shared repertoire within a Community of Practice.

> "We used to think disaster topics were too scary for small children. However, with the university's help, we've now created stories and games that engagingly teach safety. It's learning through care, not fear." (School teacher 6, personal communication, December 24, 2024).

This approach shifted the narrative from fear-based messaging to developmentally appropriate resilience education, incorporating emotional literacy, spatial awareness, and basic safety protocols into everyday classroom routines.

4.2.2 Co-creation of culturally and linguistically relevant learning tools

A key finding was the importance of cultural contextualization in disaster education for early learners. Working in ethnically diverse communities, the university-school teams intentionally developed materials that reflected local language, imagery, and narratives, thereby enhancing engagement and accessibility. For example, earthquake safety songs were written in both Thai and local dialects. Simultaneously, storybooks featured familiar settings, rice fields, wooden houses, and local animal characters, to make abstract risk concepts more relatable for children.

These co-created materials did not adhere to a one-size-fits-all model; instead, they were iteratively tested, refined, and adapted through classroom use and feedback loops. Teachers emphasized that such localization was essential for meaningful learning and retention among young children, especially in communities with limited access to formal DRR campaigns.

> "We didn't just deliver materials. We learned from university professors and researchers, as well as from the students who assisted in collecting our ideas. That's why the tools are used, not because they came from experts, but because they came from everyone together." (School teacher 7, personal communication, December 24, 2024).

This participatory model reflects core principles of Education for Sustainable Development (ESD), especially co-learning, contextual relevance, and shared responsibility. Within the resilience framework, ESD contributed in three interrelated ways. First, it enhanced risk literacy and adaptive competencies. By integrating disaster concepts into mathematics, arts, and physical education, preparedness became embedded in everyday learning rather than confined to occasional drills. Students adopted evacuation logic, spatial awareness, and safety protocols through repetition and embodiment. Second, ESD practices supported the institutional embedding of disaster knowledge. Cross-curricular integration reduced reliance on single-event preparedness and positioned DRR as part of routine pedagogical design. This shift enhanced continuity and reduced vulnerability to staff turnover, strengthening institutional capacity. Third, the approach facilitated intergenerational knowledge transfer. Teachers reported that students communicated safety practices to family members, extending preparedness beyond school boundaries.

> "During the last drill, one of my Grade 2 students reminded me to check the headcount. That's when I realized—they're not just absorbing information; they're becoming responsible actors." (School teacher 3, personal communication, December 24, 2024).

These outcomes indicate that ESD functions build the relational and cognitive dimensions of community resilience. By fostering participatory learning, contextual adaptation, and shared agency, ESD practices contribute to socio-ecological resilience not only at the classroom level but within broader school-community networks. In this sense, disaster education shifts from compliance-oriented safety instruction toward embedded resilience governance.

4.2.3 Strengthening institutional trust and professional development through the network

The collaboration also reinforced professional development and institutional learning among teachers and school administrators. Participants described the university not just as a provider of knowledge, but as a trusted partner who helped navigate curricular, logistical, and psychological barriers to DRR integration. Through mentoring, observation, and iterative design cycles, teachers improved their pedagogical confidence and reflexivity.

Moreover, the network fostered horizontal learning among schools. Joint exhibitions, teacher showcases, and peer-to-peer classroom visits became spaces for disseminating innovations in DRR education and building collective accountability. These social processes reflect the networked resilience found in strong CoPs, where learning extends beyond individual practice to shape institutional norms and identity.

> "We don't see ourselves as waiting for orders from the Ministry anymore. We act because we are part of a learning network that values local initiative." (School principal, personal communication, December 22, 2024).

This empowerment is not merely anecdotal; it is structurally significant. It indicates a shift from dependency to distributed leadership in disaster governance, where teachers become co-producers of safety alongside formal authorities. As a result, the research findings are summarized in Table 2 below.

Table 2: Implementation of grounded Community of Practice (CoP), Socio-Ecological Systems (SES), and education for sustainable development

Domain	Theme	Key findings
Institutional capacity	University-school collaboration	Co-design of DRR Material through workshops, mentorship, and networked professional support.
Physical infrastructure	Culturally and linguistically diverse pedagogy	Materials localized in language, culture and geography to foster relevance and retention and DRR concepts embedded in play-based and cross-curricular pedagogy for kindergarten and primary.
External relationship	Institutional trust and professional development through practice-based networks	Teachers gained agency and capacity through participatory learning cycles and peer collaboration.

Table 2 summarizes how collaborative practices translated theoretical frameworks into operational domains. Across institutional, spatial, and relational levels, preparedness shifted from reactive intervention to embedded governance practice. This integration demonstrates that resilience-building in this context was not limited to infrastructural reinforcement but emerged through the co-production of knowledge, contextual adaptation, and sustained relational engagement.

5. DISCUSSION

This study enhances theoretical and empirical understanding of how university–school networks can function as place-based systems of disaster risk governance and platforms for building community resilience and sustainable development. Drawing on integrated frameworks of Community of Practice (CoP), Socio-Ecological Resilience (SES), and Education for Sustainable Development (ESD), the findings offer a distinctive account of how educational institutions, when operating collaboratively and reflexively, become key sites of adaptive learning and localized capacity-building in post-disaster contexts. This research contributes original insights to three intersecting academic fields: disaster education, participatory governance, and localized SDG implementation.

Rather than reinforcing conventional models of disaster education as top-down knowledge transmission, the study shows that schools function as adaptive governance units. Through collaborative curriculum development, participatory drills, and cross-institutional dialogue, disaster knowledge is co-produced among teachers, university actors, students, and local officials. This repositioning shifts disaster education from compliance-based safety instruction toward an embedded governance practice grounded in shared responsibility.

The concept of Community of Practice (Wenger, 1998) is critically extended here by illustrating how disaster education is practiced not only within schools but across institutional boundaries—through joint curriculum development, peer-to-peer teacher exchanges, and shared post-drill reflections. These interactions constitute a multi-scalar CoP that includes educators, local officials, researchers, and students as co-participants in shaping disaster meaning, response, and readiness. This challenges the bounded nature of traditional CoP theory and contributes to the emerging literature examining how learning communities operate across formal—informal and actor—institution divides (Akkerman & Bakker, 2011).

From a socio-ecological perspective, resilience is enacted through socio-spatial practices woven into daily school life. GIS mapping exercises, localized evacuation planning, safety signage, and culturally adapted teaching tools illustrate how preparedness becomes materialized within the physical and symbolic spaces of education. These practices go beyond infrastructural retrofitting and anchor resilience in routines, artifacts, and institutional memory. In doing so, the study responds to critiques that SES frameworks may overlook grounded human agency by demonstrating how adaptive capacity is cultivated through everyday pedagogical practices (Servant-Miklos, 2022).

Importantly, when assessed against the three operational preparedness dimensions, namely planning and policy integration, operational procedures and training systems, and financial allocation and resource commitment, the university–school network demonstrates a moderate-to-strong level of community resilience. Planning mechanisms were formalized and integrated into curricular structures; operational procedures, such as drills and participatory simulations, were routinized; and relational coordination extended beyond the school to parents and local stakeholders. However, long-term financial allocation and structural independence from external partnership support remain partially evolving. This indicates a transitional resilience condition in which institutional embedding is substantially established but not yet fully autonomous.

Resilience is shown to emerge not only from technical preparedness. It is equally important to specify how community resilience manifests within resilience, which does not refer solely to infrastructural robustness or policy compliance; rather, it reflects the strengthening of relational capacities among teachers, students, parents, and local stakeholders. In addition, these findings, such as from the co-production of environmental knowledge, are embodied in school routines and artifacts such as safety maps, signage, and localized drills. In fact, SES theory situates resilience within the material culture of learning environments and offers a methodological contribution by demonstrating how everyday educational spaces become sites for the mobilization of disaster knowledge. This spatialized understanding contributes to existing work on environmental governance and provides an empirical response to critiques that SES frameworks often overlook grounded human agency (Servant-Miklos, 2022; Modica & Zoboli, 2016).

Notably, community resilience in this context extends beyond institutional capacity. It is relationally constituted across parents, teachers, students, and local stakeholders. Parent-teacher engagement in preparedness discussions fostered shared accountability. Students acted as conduits of intergenerational knowledge transfer, extending risk awareness within households. Participatory drills involving village leaders

and local responders strengthened horizontal coordination. These dynamics illustrate that resilience is distributed across a network of trust, communication, and shared practice rather than confined to school infrastructure alone.

This study advances debates in the field of university-community engagement by documenting how higher education institutions can serve as epistemic and organizational intermediaries within localized DRR networks. The university-school network in Chiang Rai illustrates a transition from project-based outreach to a sustained, co-constructed partnership model, wherein universities act not as technical advisors but as co-learners and co-designers of risk education systems.

This shift reflects the evolving role of universities in sustainability science (Stephens et al., 2008; Trencher et al., 2014) and contributes to the literature on knowledge democracy by demonstrating how universities can redistribute authority, facilitate horizontal learning, and amplify the voices of marginalized institutional actors, such as rural teachers and school administrators. Repositioning universities as localized facilitators of participatory governance enhances our theoretical understanding of how educational actors can bridge the implementation gap between national DRR policies and frontline community realities.

A key academic contribution of this research is to illustrate how global development frameworks, particularly SDG 4 (Quality Education), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action), are translated into practice through school-based disaster education. Furthermore, the findings indicate that capacity building has catalyzed a shift in institutional identity. Schools no longer view disaster preparedness as an externally imposed obligation but as an integral part of their mission. Some schools even reported incorporating disaster education into parent-teacher meetings, student leadership programs, and school development plans, signaling a growing institutional commitment to resilience building.

These shifts also produced tangible spillover effects at the community level. In some cases, students shared emergency knowledge with their families, while school-based simulations invited participation from village leaders and local responders. This expansion of impact demonstrates the transformative potential of education as a conduit for social learning beyond the classroom, reinforcing the principles of socio-ecological resilience and participatory governance.

Crucially, this integrated approach to education, resilience, and development directly supports the advancement of several Sustainable Development Goals (SDGs): SDG 4 (Quality Education) by embedding disaster risk reduction into the teaching and learning process and empowering teachers to lead resilience education; SDG 11 (Sustainable Cities and Communities) through school-community collaborations that strengthen inclusive and locally grounded disaster governance; and SDG 13 (Climate Action) by enhancing risk literacy, adaptive capacity, and proactive planning in the face of environmental uncertainty.

Through participatory drills, teacher-led curriculum adaptation, and intergenerational community engagement, schools transformed global goals into local governance practices. This contributes to the literature on SDG localization by demonstrating that, when empowered through partnerships and capacity-building, schools become institutional agents of sustainability, rather than passive implementers. The study also responds to critiques that the SDG framework often lacks community ownership or cultural relevance by providing a grounded example of how education can serve as the connective tissue between policy discourse and lived development practice.

The cross-cutting insights from this study point to an emerging theory of educational resilience governance, which integrates learning, infrastructure, community engagement, and environmental adaptation. This perspective diverges from traditional binaries of “education versus emergency” or “curriculum versus infrastructure” by demonstrating that school resilience arises from a hybrid assemblage of social trust, knowledge practices, spatial design, and institutional coordination.

Such a framework opens new directions for interdisciplinary theorization, bridging critical education studies, disaster governance, and political ecology. It invites scholars to view schools not merely as sites of intervention but as resilience nodes embedded within territorial, institutional, and epistemic landscapes of adaptation. Theoretically, it contributes to an underexplored nexus between pedagogical co-production and adaptive systems thinking, with practical implications for the design of future disaster risk reduction (DRR) policies and sustainable development goal (SDG) monitoring strategies, as shown in Figure 2.

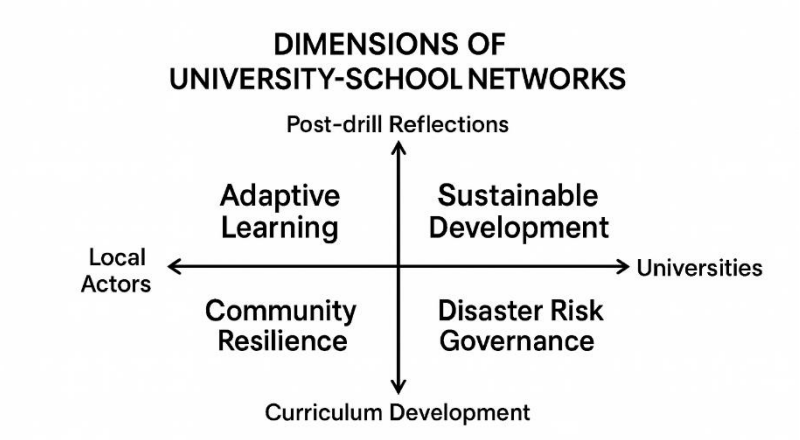

Figure 2: University-school network for disaster risk reduction

6. CONCLUSION

This study explores the potential of university–school networks in Chiang Rai, Northern Thailand, to function not only as educational alliances but also as transformative platforms for building resilience in communities vulnerable to disaster. What emerged from this inquiry is a clearer picture of how educational institutions, when engaged in meaningful collaboration, can become deeply rooted agents of change in the broader landscape of disaster risk governance and sustainable development.

Drawing on an integrated framework that combines Community of Practice (CoP), Socio-Ecological Systems (SES), and Education for Sustainable Development (ESD), the research demonstrates that resilience in schools is not delivered externally or secured through infrastructure alone. Rather, it is institutionalized through three interrelated preparedness dimensions: planning and policy integration, operational procedures and training systems, and financial allocation and resource commitment. Across these domains, the university-school network in Chiang Rai reflects a moderate-to-strong level of community resilience. Preparedness has been formally integrated into the curriculum and governance structures; drills and participatory simulations have become routinized; and relational coordination extends beyond school boundaries to parents and local stakeholders. At the same time, long-term financial autonomy and full structural independence remain under development, indicating a transitional resilience condition as the system moves toward stronger institutional embedding.

These findings illustrate that resilience grows through relationships, trust, and shared learning. Teachers and school leaders, working in partnership with university actors, have reinterpreted disaster preparedness not as compliance with external mandates but as a contextualized and evolving governance practice. Through co-designed teaching materials, localized storybooks, student-led safety drills, and parent–teacher engagement, preparedness has become a regular part of everyday school life.

Importantly, these collaborative practices translated the abstract aspirations of SDG 4, SDG 11, and SDG 13 into institutional routines and community engagement. Schools shifted from peripheral implementers of policy to central actors in cultivating a culture of preparedness and sustainability. Community resilience in this context is therefore relational as well as institutional, distributed across teachers, students, families, and local stakeholders who collectively sustain adaptive capacity.

Ultimately, this study enhances our understanding of educational resilience governance, in which adaptive capacity emerges from the interplay of institutional embedding, socio-spatial practice, and participatory collaboration. The Chiang Rai case demonstrates that strengthening disaster resilience in educational systems requires more than technical safety measures; it depends on durable planning systems, routinized operational practices, sustained resource commitments, and relational networks that extend beyond school walls. In this sense, resilience is neither episodic nor imposed; it is cultivated through everyday institutional practices.

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DECLARATION

1. Conflict of interest
The authors declare no conflict of interest

2. Generative AI and AI-assisted technologies in the writing process
The manuscript was written by the authors. Generative AI tools (e.g., ChatGPT-4 and Grammarly) were subsequently used only to assist with language and the visual layout of conceptual figures. All analytical content, interpretation, and conclusions were developed by authors who take full responsibility for the manuscript.

3. Data availability statement
The data supporting the findings of the study are available within the article.

4. Ethics statement
This study was approved by the Ethics Committee of Mae Fah Luang University (Code: EC24087-23). The approval was granted on May 15, 2024. Informed consent was obtained from all participants involved in the study.

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6. Contributor Role Taxonomy (CRediT)
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