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INTEGRATING DISASTER RISK REDUCTION INTO SCIENCE EDUCATION TO STRENGTHEN HIGHER EDUCATION RESILIENCE: EVIDENCE FROM A PHILIPPINE HEI

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ABSTRACT

Natural disasters continue to pose great global challenges, intensified by urbanization and increasing human vulnerability. These risks expose higher education institutions (HEIs) to greater disaster impacts, highlighting the need for effective disaster risk reduction (DRR) systems and educational approaches that cultivate resilience. This study assessed DRR compliance at a Philippine HEI while examining the extent to which science education supports disaster resilience and sustainable development initiatives. Using a convergent mixed-method design, quantitative survey data collected from 99 students and 87 faculty members (Total number of respondents is 186) and qualitative focus group discussions (8 group members per group with 8 teams of 64 participants,) were collected and analyzed across four DRR domains: Prevention and Mitigation, Preparedness, Response, and Rehabilitation and Recovery. Findings revealed a moderate level of overall DRR compliance (Overall Mean = 3.41, SD = 0.78 on a 5-point Likert scale), indicating that DRR measures were generally implemented but remained inconsistent across domains. Disaster Response emerged as the strongest domain. (Mean = 4.12, SD = 0.65), reflecting well-established emergency procedures and response mechanisms. In contrast, lower scores were recorded in Preparedness (Mean = 3.08, SD = 0.82), Prevention and Mitigation (Mean = 3.25, SD = 0.79), and Rehabilitation and Recovery (Mean = 3.19, SD = 0.85). Moreover, significant gaps were identified in preparedness planning, infrastructure adequacy, psychosocial support, and the systematic integration of DRR concepts into science and general education curricula. Qualitative findings further showed that science education initiatives on disaster awareness and resilience were often,neglected and poorly aligned with institutional DRR policies and practices. These results suggest that while operational response systems have developed in its own way, long-term institutional resilience requires stronger preparedness mechanisms and a more deliberate curricular integration of DRR competencies. By examining the alignment between institutional DRR compliance and science education practices in higher education, this study provides empirical evidence on how educational and organizational systems can be integrated to strengthen disaster resilience and support the achievement of the Sustainable Development Goals.

Keywords: disaster risk reduction; science education; institutional resilience; higher education

INTRODUCTION

Natural disasters continue to pose significant challenges to sustainable development worldwide, threatening progress towards the Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). The increasing frequency and intensity of extreme weather conditions—including typhoons, floods, heatwaves, and wildfires—have amplified disaster risks across regions, particularly in rapidly urbanizing and densely populated areas (Botzen et al., 2019; Cisternas et al., 2024). Climate change

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further exacerbates these risks by increasing environmental instability and human vulnerability (Ebi & Bowen, 2016; Sultana & Scheffran, 2025). Consequently, disaster risk reduction (DRR) has become a critical priority for governments, communities, and educational institutions seeking to strengthen resilience and adaptive capacity.

The Philippines is a particularly relevant nation for DRR research due to its high exposure to natural hazards. Experiencing approximately 18–20 tropical cyclones annually and facing recurring threats from flooding, storm surges, earthquakes, and sea-level rise, the country consistently ranks among the most disaster-prone nations globally (UNDRR, 2019; Purwar et al., 2020; Santos, 2021; Chen & Su, 2024). These conditions place considerable pressure on educational institutions, which are expected not only to ensure operational continuity during disasters but also to cultivate disaster-resilient citizens capable of informed decision-making. Despite national and institutional DRR initiatives, preparedness and resilience capacities remain uneven across educational settings (Torani et al., 2019; Shah et al., 2024; Tyas et al., 2025; Daminar & Cabonce, 2026), highlighting the need for evidence-based approaches that integrate disaster preparedness with educational goals.

International policy frameworks have increasingly recognized education as a central mechanism for building resilience. The Hyogo Framework for Action and the Sendai Framework for Disaster Risk Reduction emphasize the importance of understanding disaster risk, strengthening governance, investing in resilience, and enhancing preparedness and recovery capacities (Patel et al., 2021). Beyond emergency management, these frameworks-depict the role of education in developing the knowledge, skills, and dispositions necessary for risk-informed action. Within science education, this perspective aligns closely with the goals of scientific literacy, disaster literacy, risk literacy, and systems thinking. Scientific literacy enables individuals to interpret evidence, evaluate information, and make informed decisions regarding complex environmental and societal challenges. Disaster literacy and risk literacy extend these competencies by fostering the ability to understand hazards, assess risks, and respond appropriately to disaster-related situations. Similarly, systems thinking helps learners recognize the interconnected relationships among environmental, social, technological, and institutional factors that influence disaster vulnerability and resilience.

Recent studies have highlighted the growing importance of integrating DRR into educational systems and curricula. Research has shown that higher education institutions (HEIs) play a critical role in advancing disaster preparedness, community resilience, and sustainability initiatives (Kawasaki et al., 2020; Cvetković et al., 2024; Scolobig & Balsiger, 2024; Masocha et al., 2025). However, existing studies mainly focus on DRR awareness programs, policy implementation, disaster education initiatives, or institutional preparedness assessments. Although these studies demonstrate the value of DRR in educational contexts, they also reveal persistent challenges, including fragmented implementation, limited curriculum integration, and inconsistent institutional practices.

Moreover, previous research has generally examined institutional DRR compliance and educational initiatives separately. Limited empirical evidence exists regarding how institutional DRR compliance is reflected in educational practices, particularly in science education, where disaster preparedness can serve as a context for developing scientific literacy, risk interpretation, evidence-based reasoning, and systems thinking competencies (Nakano & Yamori, 2021; Alcántara-Ayala et al., 2025; Masocha et al., 2025). Existing studies have not sufficiently examined whether institutional DRR mechanisms are aligned with educational practices that support disaster literacy and resilience-building among learners. As a result, the relationship between organizational preparedness systems and science education remains inadequately understood, particularly within higher education institutions in disaster-prone developing countries.

This gap is particularly important because preliminary evidence suggests that while many institutions have established emergency response procedures, challenges remain in preparedness planning, infrastructure resilience, psychosocial support systems, and curriculum-based DRR integration (Astawa et al., 2022; Nielo, 2024; Mohammed et al., 2025; Haase et al., 2026). Furthermore, science education continues to be underutilized as a platform for promoting disaster literacy, sustainability-oriented competencies, and systems-based understanding of risk and resilience (Setiawan et al., 2017; Saregar et al., 2025; Tyas et al., 2025; Blodgett et al., 2026). Understanding how institutional DRR practices and science education initiatives are aligned is therefore essential for strengthening disaster resilience in higher education.

Against this backdrop, the present study assesses DRR compliance in a higher education institution across four key domains: prevention and mitigation, preparedness, response, and rehabilitation and recovery. It further examines the perceptions and experiences of administrators, faculty members, and students regarding DRR implementation and explores the extent to which science education supports disaster preparedness and resilience-building efforts. By investigating the intersection of institutional DRR compliance and science education practices, this study provides empirical evidence on how educational and organizational systems can be aligned to strengthen disaster resilience in higher education settings. By following this practice, it supports ongoing efforts to advance sustainable, disaster-resilient educational institutions that align with global sustainability and resilience goals. This study's novelty lies in its integrated approach, which bridges institutional compliance with pedagogical practice in ways that few prior studies have attempted. While existing research has examined DRR integration into school curricula or general resilience-building in higher education, this work uniquely connects compliance assessment with curriculum integration by developing a DRR-Science Education Matrix that maps institutional policies and operational practices against science-based teaching and learning opportunities. It integrates institutional resilience models with science education practices, employing a mixed-methods design to link quantitative operational compliance data (e.g., policy audits and checklist evaluations) with qualitative insights into educational embedding (e.g., stakeholder interviews and classroom observations).

In doing so, the study produces an evidence-based institutional resilience framework and a resilience competency framework tailored for higher education. These contributions offer practical tools for aligning organizational systems with curriculum development—such as embedding disaster risk concepts into science courses on climate change, environmental hazards, and risk modeling—to strengthen disaster resilience. By investigating this intersection, the research provides empirical evidence on how educational and organizational systems can be logically aligned, supporting ongoing global efforts (e.g., under the Sendai Framework and Sustainable Development Goals) to advance sustainable, disaster-resilient higher education institutions.

METHODS

This study employed a convergent mixed-methods design (Creswell, 2013) to obtain a comprehensive understanding of disaster risk reduction (DRR) compliance within a Philippine higher education institution (HEI). In this design, quantitative and qualitative data were collected and analyzed in parallel, followed by integration during interpretation to allow triangulation of findings. The quantitative strand measured DRR compliance across institutional domains, while the qualitative strand explored stakeholders' experiences, perceptions, and contextual interpretations of DRR implementation and the integration of science education. The design aligns with a pragmatic paradigm, which prioritizes the use of multiple forms of evidence to address complex educational and institutional problems.

The study was conducted in four systematic stages:

Stage 1: Instrument Development and Validation

The quantitative instrument, entitled School Emergency and Disaster Preparedness Level of Compliance Instrument, was adapted from the UNISDR (2015) framework. It was aligned with four DRR domains: Prevention and Mitigation, Preparedness, Response, and Rehabilitation and Recovery. The adaptation process involved aligning content with institutional HEI contexts and refining it based on expert review to ensure relevance and clarity.

Content validation was conducted through evaluation by subject-matter experts in disaster risk reduction and educational research, focusing on clarity, relevance, and alignment with DRR indicators. A pilot test was conducted to assess instrument clarity and internal consistency prior to full deployment. Reliability was determined using Cronbach's alpha to examine internal consistency across the overall scale and DRR domains. In addition, prototypicality assessment was conducted to ensure that items adequately represented institutional DRR compliance constructs. In a prototypicality assessment, the dimensions of identity that matter most vary are context-specific (Hudson et al., 2020). In this assessment, Researchers typically ask participants to: (1) rate items on a scale (e.g., 1–10) for how good an example they are of the category; (2) generate typical examples first, then rate or evaluate them; (3) use other measures like feature listing,

similarity judgments, reaction times (faster verification for prototypes), or priming effects.

Interview and focus group discussion (FGD) guides were developed in parallel with the survey instrument to ensure alignment. All qualitative prompts were mapped to the same four DRR domains to enable direct comparison between quantitative and qualitative findings.

Stage 2: Selection of Participants

Purposive sampling was employed to select 186 participants based on their direct or indirect involvement in DRR-related institutional functions. This sampling strategy was chosen because it intentionally selects individuals from diverse subgroups within the institution to capture a wide range of perspectives on DRR implementation and the integration of science education. Purposive sampling is particularly suitable for exploratory and mixed-methods studies in institutional settings, as it ensures representation across key stakeholder roles rather than aiming for statistical generalization.

Inclusion criteria required that participants: (1) held direct or indirect involvement in DRR-related institutional functions; (2) had institutional exposure to emergency protocols and safety procedures; or (3) demonstrated academic engagement in science education or DRR-related initiatives. Exclusion criteria included: (1) individuals with no current affiliation to the institution (e.g., alumni who had graduated more than one year prior or former staff); (2) persons who had been part of the institution for less than six months (to ensure sufficient exposure to policies and practices); (3) individuals unwilling or unable to provide informed consent.

The target sample size of 186 participants was determined through a combination of factors: (1) the need to achieve adequate representation across the five stakeholder groups for both quantitative (survey) and qualitative (interviews/FGDs) components; (2) power considerations for statistical analysis of the survey instrument (targeting a minimum of 30 participants per major subgroup for reliable subgroup comparisons and Cronbach's alpha estimation); and (3) practical constraints including institutional size, willingness to participate, and resource availability for data collection.

Participants included administrators, faculty members, non-teaching staff, students, and designated DRR personnel. Inclusion criteria required participants to have institutional exposure to emergency protocols and safety procedures, or academic engagement in science education or DRR-related initiatives. The sample composition was structured to capture multiple institutional perspectives on DRR implementation and on the integration of science education.

Stage 3: Data Collection

Quantitative data were collected through structured surveys that measured DRR compliance across the four identified domains. A four-point Likert scale (1–4) was used to assess compliance.

Qualitative data were gathered through semi-structured interviews and FGDs conducted in English and Filipino. All sessions were recorded with participants' consent, transcribed verbatim, and supplemented with field notes to capture contextual observations. Ethical protocols were strictly followed, including informed consent, confidentiality, voluntary participation, and the right to withdraw at any stage of the study.

Stage 4: Data Integration

Following Fetters, Curry, and Creswell's convergent mixed-methods integration approach, quantitative and qualitative data were merged during interpretation. Integration was conducted through comparison of findings to identify convergence, complementarity, and divergence between statistical results and thematic insights. Where discrepancies emerged, qualitative data were used to contextualize and explain quantitative patterns, ensuring a more comprehensive interpretation of institutional DRR compliance and science education-related practices.

Quantitative data were analyzed using descriptive statistics, including mean, frequency, and standard deviation, to determine the level of DRR compliance across the four domains. Results were interpreted using standard Likert-scale classification procedures to categorize compliance levels.

To strengthen analytical depth, comparative analysis across DRR domains was conducted to identify relative strengths and gaps in institutional compliance patterns. Where appropriate, results were also disaggregated by stakeholder group to examine variation in perceptions across administrators, faculty, staff, and students.

Qualitative data were analyzed using Braun and Clarke's (2006) six-phase thematic analysis framework: familiarization, coding, theme generation, theme review, theme definition, and reporting. This approach enabled systematic identification of recurring patterns related to DRR implementation, institutional challenges, and the role of science education in disaster preparedness and resilience-building.

The integration of quantitative and qualitative findings followed a triangulation strategy to examine convergence and divergence across datasets. This strengthened the validity of findings by allowing cross-validation of statistical trends with thematic evidence, consistent with established mixed-methods integration procedures.

RESULTS AND DISCUSSION

Safety Compliance in Disaster Risk Reduction

The assessment of disaster risk reduction (DRR) compliance across four institutional domains revealed an overall moderate level of implementation, indicating that DRR systems are present but unevenly institutionalized across organizational functions. While all domains fall within the moderate range, variation in mean scores suggests meaningful differences in the depth of implementation rather than uniform performance.

The assessment of disaster risk reduction (DRR) compliance across four institutional domains revealed an overall moderate level of implementation. Disaster Preparedness recorded the lowest mean (M = 2.91), highlighting critical gaps in anticipatory planning, role clarity, institutional readiness structures, and organizational learning.

This finding is particularly relevant to science education, as preparedness relies heavily on the development of scientific and disaster literacy among learners, educators, and institutional stakeholders. Science education equips individuals with the foundational knowledge of natural hazards (e.g., geological, meteorological, and environmental processes), risk assessment, systems thinking, and evidence-based decision-making—skills essential for shifting from reactive response to proactive preparedness. Strong science literacy directly supports DRR compliance by fostering hazard awareness, understanding of causal mechanisms, and the ability to interpret early warning–signals and mitigation strategies. Conversely, weak science education contributes to the observed preparedness deficits, as limited exposure to risk-based reasoning leaves communities and institutions less equipped for anticipatory actions.

Among the four domains, Disaster Response obtained the highest mean (M = 3.07), indicating relatively stronger institutional capacity for reactive measures such as evacuation procedures, emergency coordination, and immediate response protocols. Although the numerical difference between response (M = 3.07) and preparedness (M = 2.91) appears small, it is substantively meaningful in DRR practice, as it reflects a systemic tendency to prioritize operational response over anticipatory and preventive strategies. This pattern is consistent with prior findings that institutions often invest more heavily in response mechanisms than in preparedness and mitigation systems (Atmojo et al., 2018; Torani et al., 2019; Shah et al., 2024; Haase et al., 2026).

Disaster Preparedness recorded the lowest mean (M = 2.91), indicating gaps in anticipatory planning, role clarity, and institutional readiness structures. This finding suggests that preparedness remains underdeveloped not only in procedural terms but also in organizational learning and continuity planning. This is largely due to people's lack of disaster awareness, which in turn makes them in lack of Disaster Preparedness. Similar trends have been documented in higher education settings where DRR frameworks are implemented in policy but remain weakly institutionalized in practice (Patel et al., 2023; Cvetković et al., 2024; Nielo, 2024; Gacitua, 2025). From a science education perspective, weak preparedness reflects limited opportunities for learners and stakeholders to engage in systems thinking and risk-based reasoning, which are central to the development of scientific and disaster literacy.

Moderate scores in prevention and recovery further indicate fragmentation in the DRR system, where initiatives exist but are not fully integrated into institutional structures and academic programming. This aligns with the well-documented implementation gap between global DRR frameworks and localized institutional practice (Manyena, 2016; Raju & da Costa, 2018; Gaillard, 2019; Zhang et al., 2026). Rather than functioning as a coherent resilience system, DRR activities appear distributed across administrative functions, with limited curricular embedding.

The overall safety compliance mean (M = 3.00) confirms a moderate level of DRR institutionalization. However, this "moderate" classification should not be interpreted as uniform adequacy; instead, it reflects partial implementation characterized by strong procedural response capacity but weaker preventive, educational, and sustainability-oriented systems.

Institutional Gaps in Disaster Risk Reduction Implementation

The findings indicate that DRR implementation in the institution is primarily compliance-driven rather than learning-centered. While institutional policies and safety systems exist, their operationalization remains uneven across acade-

mic and administrative domains, suggesting a gap between formal compliance and lived resilience practices.

Key Institutional Gaps Identified

Analysis of quantitative and qualitative data reveals recurring structural and educational gaps:

1. Limited integration of DRR into the curriculum, particularly in science education
2. Outdated and non-adaptive emergency preparedness systems
3. Absence of alternative warning and continuity mechanisms
4. Weak hazard and vulnerability assessment practices
5. Inconsistent drills, simulations, and risk communication activities
6. Limited digitization and preservation of DRR knowledge resources

These gaps indicate that DRR functions largely as an administrative requirement rather than an embedded educational and cognitive framework. This supports earlier observations that DRR implementation often remains policy-oriented rather than practice- and learning-oriented (Ogra et al., 2021; Abderhalden et al., 2025; Daminar & Cabonce, 2026). From a science education standpoint, this also reflects missed opportunities to develop scientific literacy, particularly in evidence-based reasoning, environmental interpretation, and risk-informed decision-making.

Qualitative Themes and Analytical Interpretation

Table 1 presents qualitative findings organized into six major themes reflecting institutional DRR experiences. To enhance analytical rigor, thematic analysis followed Braun & Clarke's (2006) framework, and credibility was strengthened through systematic coding, iterative theme refinement, and cross-validation with quantitative findings to ensure triangulation and interpretive convergence.

The qualitative results not only describe institutional experiences but also explain the mechanisms underlying moderate DRR compliance, particularly the disconnection between policy structures and educational practice. The findings demonstrated the themes and the respective implications result due to the four domains introduced earlier: types of disasters; disaster readiness and institutional capacity; security and safety issues; and stakeholder compliance and coordination.. The research findings proved the need for disaster education to address the causes and effects, prevention and response, and management and recovery from disaster events. The educational process must include diverse and practical techniques that reinforce disaster knowledge and builds a culture of safety and resilience amongst citizens. (Apronti et al., 2015).

Table 1. Summary of Themes, Subthemes, and Supporting Quotes

Theme	Subtheme	Supporting Quotes	DRR Implication
Types of Disasters Encountered	Natural Hazards	"We must consider flooding and earthquakes." — S2 and A2	Need for science-based hazard mapping and risk modeling in HEIs
		"A landslide affected a nearby area." — A1	Strengthens the need for geohazard awareness in the curriculum
	Man-made Hazards	"We bury it in the ground." — S1 (formalin disposal)	Indicates gaps in environmental safety and chemical waste management
	Technological Hazards	"Power interruptions… cause problems in IT." — A1	Requires integration of resilient ICT and backup systems
	Psychosocial Hazards	"There is a student who jumped from SC 4th floor." — S1	Highlights need for mental health and crisis intervention systems
Disaster Readiness and Institutional Capacity	DRR Training	"An orientation was conducted for all employees during the pandemic." — S4	Training is event-based rather than sustained capacity building
	Emergency Protocols	"We immediately implemented a policy for quarantine." — A1	Shows reactive rather than proactive DRR systems

	Risk Communication	"We use social media and Facebook for announcements." — A1	Need for structured and science-based risk communication systems
	LGU Coordination	"We invite technical personnel for seminars." — A1	Indicates partial but informal inter-agency collaboration
	Curriculum Integration	"We do not receive DRR training as faculty." — F1	Reveals a gap in the institutionalization of DRR in education
Security and Safety Issues	Campus Security	"Every vehicle is given an ID for security." — S1	Physical security measures are present but limited in scope
	Digital and Social Safety	"We had crises related to social media issues." — A3	Highlights emerging cyber-psychosocial risks in HEIs
	Document Security	"We digitized our important documents." — A3	Positive shift toward digital resilience and continuity
Stakeholder Compliance and Coordination	Regulatory Compliance	"We coordinate with local and national agencies." — A1	Compliance exists but is resource-dependent
Institutional Resource Adequacy	Emergency Supplies	"We acquired alcohol, sanitizers, and masks." — A1	Basic preparedness is present but limited in scope
	Infrastructure Systems	"We lack a proper PA system." — A3	Indicates infrastructural gaps in emergency communication
	Technical Expertise	"We have resident engineers." — S2	Shows the availability of internal technical capacity
	Financial Constraints	"We don't have a budget for the required safety upgrades." — S2	Major barrier to DRR implementation sustainability
	Innovation	"We installed solar chargers on lamp posts." — A1	Demonstrates emerging sustainability-oriented DRR innovation
Recovery Mechanisms	Academic Continuity	"Modules are sent online during quarantine." — S4	Reflects digital resilience and continuity strategies
	Physical Recovery	"We moved offices within two to three days." — S1	Shows reactive but efficient structural recovery
	Psychological Recovery	"We issued a gag order, and things calmed down." — A3	Indicates informal psychological recovery practices

Theme 1: Types of Disasters Encountered

Participants reported exposure to multi-hazard environments, including natural, technological, ecological, and social risks, reinforcing the Sendai Framework's emphasis on a multidimensional understanding of disaster risk (United Nations Office for Disaster Risk Reduction, 2021).

Reports of flooding, earthquakes, and pandemics align with global evidence on increasing climate and geophysical risks in educational contexts (Cadag et al., 2017; Botzen et al., 2019; Rouhanizadeh & Kermanshachi, 2019; Mărgărint et al., 2023). Importantly, these experiences highlight the need for science education that develops learners' ability to interpret environmental risk systems rather than treating disasters as isolated events.

Subtheme: Man-made Hazards

Statements such as *"we bury it in the ground"* regarding chemical disposal reveal gaps in environmental risk awareness and scientific reasoning. This reflects not only procedural weakness but also limited environmental literacy and risk-informed judgment. Such findings highlight the need for integrating environmental science and sustainability principles into DRR education (UN Environment, 2017; Gunarathne et al., 2024), particularly through inquiry-based science learning that builds conceptual understanding of ecological consequences.

Theme 2: Disaster Readiness and Institutional Capacity

Although DRR training and protocols exist, they are largely episodic rather than sustained. As reflected in participant accounts such as *"An orientation was conducted during the pandemic,"* preparedness activities are often reactive and event-driven rather than systematically embedded.

This pattern aligns with findings that DRR capacity-building in HEIs is frequently limited to compliance training rather than continuous learning processes (Khorram-Manesh et al., 2018; Gotangco et al., 2021; Vu et al., 2025). From a science education perspective, this indicates limited development of disaster literacy, particularly in applying scientific reasoning to real-world hazard scenarios.

The absence of structured curriculum integration further constrains the development of systems thinking, which is essential for understanding interconnected environmental and societal risks (Wahyono et al., 2022; Masocha et al., 2025; Sari et al., 2025).

Theme 3: Security and Safety Issues

Findings extend the concept of safety beyond physical hazards to include digital and psychosocial risks, consistent with emerging literature on expanded institutional safety frameworks (Liu et al., 2017; Abbes, 2025).

This broadened risk landscape highlights the need for interdisciplinary science education that integrates ICT literacy, psychology, and environmental science to foster holistic risk awareness and decision-making skills.

Theme 4: Stakeholder Compliance and Coordination

While compliance with external regulatory bodies such as CHED and BFP is evident, implementation is constrained by financial and operational limitations. This reflects a common pattern in DRR systems, where compliance is achieved at the policy level but is constrained by resource asymmetries and institutional capacity gaps (Manyena et al., 2013; Alshehri et al., 2016; Puri et al., 2024).

Theme 5: Institutional Resource Adequacy

Resource limitations remain a central barrier to DRR implementation, particularly in infrastructure and training. However, emerging innovations such as solar energy adoption reflect early movement towards sustainability-oriented resilience strategies, aligning with science-based DRR approaches (Hassan et al., 2023; Kencono et al., 2026; ur Rehman et al., 2026). These developments suggest potential entry points for strengthening science education through applied sustainability practices.

Theme 6: Recovery Mechanisms

Recovery practices include academic continuity systems, infrastructure repair, and limited psychosocial support. Continuity of online learning reflects global trends in digital resilience (Al-Labadi et al., 2025; Carbo Vélez et al., 2026). However, the limited attention to psychological recovery indicates an incomplete resilience framework, despite evidence that mental health support is critical in post-disaster educational recovery (Khorram-Manesh et al., 2018; Fukuchi et al., 2026).

Synthesis and Theoretical Interpretation

The findings suggest that HEIs operate within a compliance-oriented DRR model rather than a learning-oriented resilience model. While institutional response systems are relatively well developed, the preventive, educational, and curricular dimensions remain weak.

A key theoretical implication is that DRR in higher education should not be perceived solely as institutional preparedness, but rather as a science literacy and systems-thinking development process. When viewed through a science education lens, DRR gaps reflect not only operational deficiencies but also limited opportunities for developing scientific literacy, disaster literacy, and risk-informed decision-making competencies.

Unlike studies that focus primarily on infrastructure or policy compliance (Prashar et al., 2023; Cvetković et al., 2024), this study provides empirical evidence that institutional DRR compliance is structurally disconnected from science education practices, thereby limiting its potential to build long-term resilience.

Overall Interpretation

Overall, HEIs remain predominantly response-oriented rather than resilience-oriented, consistent with the global DRR implementation patterns (Aitsi-Selmi et al., 2016; Islam et al., 2020; Ogra et al., 2021; United Nations Office for Disaster Risk Reduction, 2021). The findings reinforce the argument that science education plays a critical role in transforming DRR from procedural compliance into cognitive and behavioral resilience.

Strengthening DRR in higher education requires not only institutional policy enhancement but also curriculum transformation that integrates scientific literacy, disaster literacy, systems thinking, and sustainability competencies, aligned with SDG 4 (Quality Education) and SDG 13 (Climate Action).

CONCLUSION

This study examined DRR compliance in a higher education institution across prevention and mitigation, preparedness, response, and rehabilitation and recovery. Findings indicate an overall moderate level of compliance, reflecting partial institutionalization of DRR systems. Disaster response emerged as the strongest domain, while preparedness was the weakest, revealing persistent gaps in anticipatory planning, training, infrastructure resilience, and curricular integration. Qualitative results reinforce these findings by showing that DRR implementation is constrained by resource limitations, fragmented coordination, and limited integration of psychosocial and mental health support. Overall, the institution demonstrates a predominantly reactive rather than proactive DRR orientation. A key contribution of this study is the identification of a disconnection between operational DRR compliance and its integration into science education and broader academic practices. This highlights the need to reposition DRR not only as an institutional requirement but also as a learning-oriented framework that supports scientific literacy, disaster literacy, and systems thinking among stakeholders. Strengthening DRR in higher education requires embedding disaster risk concepts into interdisciplinary curricula, improving preparedness systems, and enhancing institutional collaboration. Future research may further explore comparative analyses across institutions and examine the effectiveness of specific science education interventions in developing disaster resilience competencies.

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