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ESTABLISHING TECHNOLOGY ATTRIBUTES IN HYBRID HUMANITARIAN ASSISTANCE AND DISASTER RECOVERY FRAMEWORK

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Abstract:

Humanitarian Assistance and Disaster Relief (HADR) become important part of Military Operations Other Than War (MOOTW) that has been emphasized in Malaysian's Defence White Paper. HADR causes severe life losses, severely impact on economy, health, well-being, and environment. The main critical issue in deployment of HADR operation is the absence of technology attributes where it unable to achieve HADR resilience. Natural disasters are uncertain and unpredictable where they have been understood as part of a non-traditional security agenda. Recently, ASEAN countries have paid greater attention to HADR as a non-traditional security issue due to the tenacious devastation. Most HADR executions in ASEAN are lacking communications, situational awareness and emerging technologies in the context of Industrial Revolution (IR) 4.0. A qualitative research method on focus groups in ASEAN's HADR is used to generate discussion using framework analysis inclusive with thematic analysis to draw insights on technology demands. This paper proposes a Hybrid HADR Framework that emphasizes the technology attributes in Sendai Framework for Disaster Risk Reduction (DRR) (2015 -2030) to enhance the effectiveness of HADR operation. Technology attributes are able to close the critical gaps in enhancing the effectiveness and efficiency of HADR operations. This framework will integrate various elements in the technology domain of both military and civilian capabilities in responding to HADR operations. This framework acknowledges that both military and civilian entities possess unique resources, expertise and logistical capabilities that can complement each other in addressing complex humanitarian crises and natural disasters by establishing technologies attributes. The key technology attributes is established based on the drawbacks of technology in ASEAN's HADR. The technology attributes in hybrid framework uses communication, Geospatial Information Systems (GIS), remote sensing, autonomous system,

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early warning system and data analytics of artificial intelligence (AI) models. This hybrid HADR framework improves effectiveness in ASEAN's HADR operations in Sendai Framework in technology domain.

Keywords:

Disaster Risk Reduction, HADR, IR 4.0, Technology, Sendai Framework

Introduction

Natural disasters can be categorized as the most dangerous hazards to humans and occurred frequently across the world. It causes a great loss of lives and infrastructure in developing countries that lack comprehensive and effective disaster management systems. In Association of Southeast Asian Nations (ASEAN), natural disasters such as flood, landslides, earthquake and tsunami has been affected severely for the past 20 years. Several stakeholders must take part in the operations of the HADR to deal with these catastrophes (Cook & Chen, 2022).

The response to natural disasters, conflicts and the COVID-19 pandemic has showcased the extensive network of emergency and disaster responders within ASEAN. Militaries are essential in HADR due to their specialized resources and expertise. Nonetheless, there is limited research on how these military forces connect and collaborate with each other and with other ASEAN nations. So, lacking technology attributes and data coordination is one of the critical issues in HADR operation in ASEAN (Trias & Cook, 2021). There is the limitations in the use of technology and standardized procedures in disaster preparedness and response during the HADR operation (Spandler, 2022).

Technological advancements play a critical role in improving the efficiency, coordination and effectiveness of disaster response efforts. Technology facilitates the development and operation of early warning systems that provide timely alerts for HADR operation. The technology in HADR operation demand sensors, satellite imagery, meteorological data and communication technologies to monitor and detect potential disasters for early evacuation and preparedness (Zhang et al., 2020). Many ASEAN countries are facing infrastructure limitations on technology deployments such as inadequate telecommunications and limited access to electricity. These challenges can hinder the deployment and operation of advanced technologies during HADR missions.

In recent decades, DRR has transformed from a narrowly defined technical field into a comprehensive global initiative focused on mitigating the risks associated with natural hazards. DRR seeks to minimise the impact of vulnerabilities and disasters through proactive and preventative planning (W. Wei, Mojtahedi, Yazdani, & Kabirifar, 2021). Figure 1 highlights the evolution of powerful DRR frameworks over the last 30 years.

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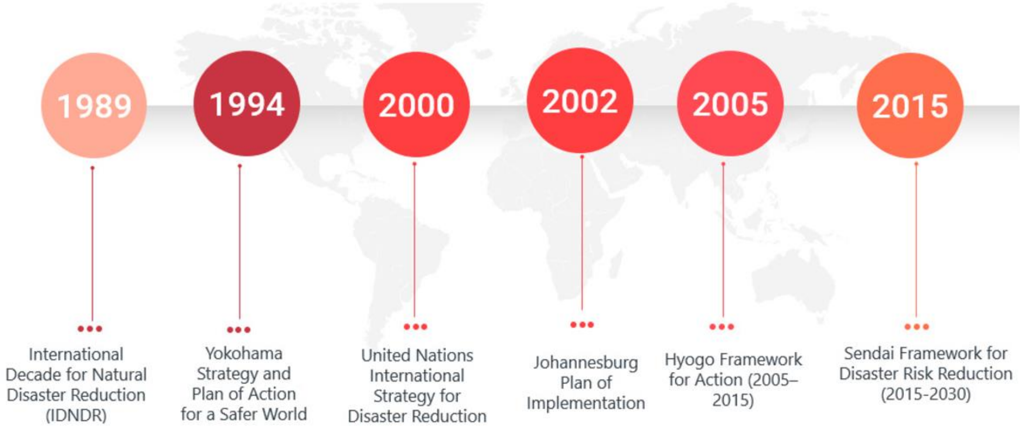

Figure 1: Disaster Risk Reduction Frameworks (W. Wei et al., 2021)

A drawback of DRR compared to Sendai framework has discovered the need of technology attributes in situational awareness, autonomous system, satellite, cyber security and artificial intelligence. The quality and updated of situational awareness will determine the success of the HADR operations (Kedia et al., 2022). This allows rapidly sharing of updated information from the disaster field and first responders to all the HADR agencies. Therefore, HADR operation on ASEAN countries demand an interoperability across various platforms to enable information sharing in real time and efficiently (Pradhan, Fuchs, & Noll, 2020).

A hybrid framework in the context of HADR typically refers to a comprehensive approach that combines various methodologies, technologies and organizational strategies to enhance the effectiveness of disaster response and recovery operations (Holstein, Aleven, & Rummel, 2020). This framework integrates traditional practices with modern innovations from Sendai framework. It optimises the strengths of Sendai in its 4 priorities to address complex challenges in disaster scenarios.

Literature Review

ASEAN countries is highly susceptible to natural disasters such as typhoons, earthquakes, tsunamis, floods and volcanic eruptions. Since 2000, ASEAN countries have faced numerous major disasters. The 2004 Indian Ocean Tsunami affecting Indonesia, Thailand, Malaysia, and Myanmar with up to 280,000 deaths and $15 billion in losses, the 2008 Cyclone Nargis in Myanmar caused over 138,000 deaths and $10 billion in damages. Indonesia's 2010 Mount Merapi eruption resulted in 353 deaths and $781 million in losses, while Thailand's 2011 floods caused 815 deaths and $46.5 billion in damages. The Philippines and Vietnam were hit by Typhoon Haiyan in 2013, resulting in 6,300 deaths and $5.8 billion in losses. The 2015 Southeast Asian Haze affected multiple countries, causing an estimated 100,000 premature deaths and $16.1 billion in losses. Indonesia's 2018 Sulawesi Earthquake and Tsunami led to over 4,300 deaths and $1.3 billion in damages. The Philippines faced Typhoon Goni in 2020, with 31 deaths and $415 million in losses, and Typhoon Rai in 2021, resulting in 410 deaths and $785 million in losses. Lastly, the 2022 Southeast Asian Floods caused several hundred deaths and billions in cumulative damages across Malaysia, Indonesia, Thailand, and Vietnam (Trias & Cook, 2021). This causes significant loss of life, property damage, and disruption to livelihoods. According to the United Nations Office for DRR, Southeast Asia is one of the most disaster-prone regions in the world (Islam & Khan, 2020).

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Importance of HADR in ASEAN

HADR operations are essential for ensuring a timely and coordinated response to disasters. Efficient HADR mechanisms enable member states to provide immediate relief, minimize casualties and address the urgent needs of affected populations (Jones & Hameiri, 2020). Coordinated efforts also ensure the efficient use of resources and prevent duplication of efforts. The ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management (AHA Centre) plays a critical role in coordinating these efforts (Spandler, 2022).

Sendai Framework

The Sendai Framework outlines four priority areas for action in disasters (Ikeda & Palakhamarn, 2024) as shown in Figure 2. Firstly, is **Understanding Disaster Risk** by enhancing understanding of disaster risk through better risk assessment, monitoring and early warning systems. Secondly, is **Strengthening Disaster Risk Governance to Manage Disaster Risk** by ensuring that DRR is a national and local priority with a strong institutional basis for implementation. Thirdly, is **Investing in DRR For Resilience** and resilience-building measures. This will enhance the resilience of communities and countries to disasters. Fourthly is **Enhancing Disaster Preparedness for Effective Response and Recovery by Ensuring Effective Response, Early Recovery, Rehabilitation and Reconstructio**n for strengthening resilience.

Figure 2: Sendai Framework's Priorities (W. Wei et al., 2021)

Methodology

The framework analysis is used as the method to develop the Hybrid HADR framework. The five steps in framework analysis are data familiarization, framework identification, indexing, charting and mapping and interpretation (Goldsmith, 2021) as shown in Figure 3.

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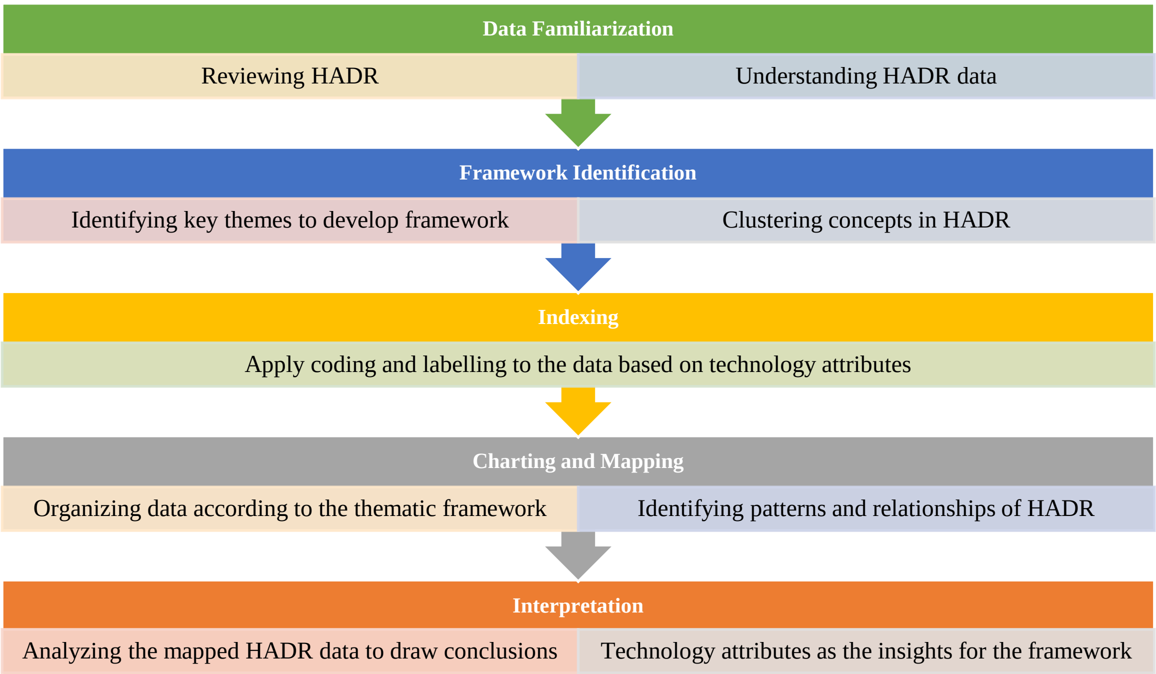

Figure 3: Five Steps of Framework Analysis as adapted from (Goldsmith, 2021)

Key Features for Hybrid HADR Frameworks

Integration of technologies combines advanced technologies such as artificial intelligence (AI), machine learning, robotics, remote sensing and geographic information systems (GIS) with traditional disaster management practices. It uses drones, Unmanned Aerial Vehicle (UAV), Unmanned Ground Vehicle (UGV), Unmanned Underwater Vehicle (UUV) for aerial surveys on disaster relief efforts. Coordination involves collaboration between various governmental agencies, non-governmental organizations (NGOs), military, private sector and international bodies to optimise the rapid response (Kumar & Singh, 2022). A seamless communication provides coordination between the National Disaster Management Authority (NDMA), National Disaster Response Force (NDRF) and local NGOs efficiently.

Decision making employs big data analytics and real-time information to inform strategic decisions, optimize resource allocation, and predict potential risks. Predictive analytics will forecast flood zones and prepare evacuation plans accordingly (Aretoulaki, Ponis, & Plakas, 2023). Adaptability is crucial to be dynamic and flexible to analyse and respond to various types of disasters. A framework that can be adjusted for small-scale local emergencies or large-scale international disasters. This paper summarises the key features of a Hybrid Framework in HADR is shown in Figure 4.

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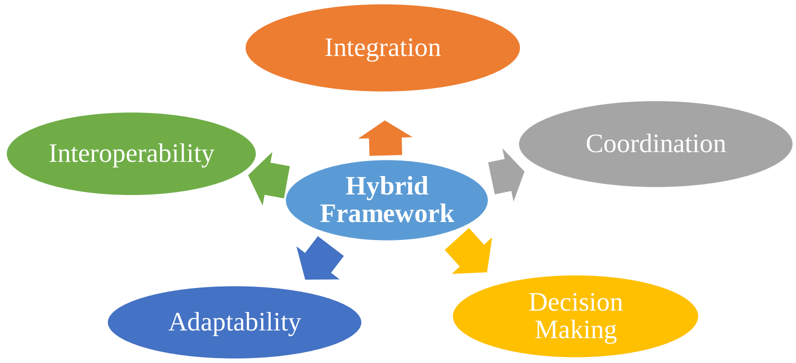

Figure 4: Key Features for Hybrid HADR Frameworks

Results and Discussion

This research discovered the technology gaps in ASEAN's HADR and proposed strategies to mitigate the issues as shown in Table 1.

Table 1: Insights on Technology Attributes' Importance for HADR in ASEAN

Technology Attributes	Gap Analysis	Action Plan
Seamless communication (Gray & Colling, 2021)	Uses legacy communication system analogue and digital where they are facing interoperability issues.	Integration under single platform and overcome interoperability issues.
Real time data improves situational awareness (J. Wei et al., 2024)	Lack of sensors to collect data from the HADR areas in real time.	Integrate and install necessary sensors and optimise the use of IOT.
Interoperability (Mani, Sultan, Plummer, & Goniewicz, 2023)	Variations and generations of technology gadgets facing interoperability issues.	Integrate, test and evaluate its performance to collect and analysis data in prior using a standard platform and mediating channels.
Geospatial mapping (Jitt-Aer, Wall, Jones, & Teeuw, 2022)	Lack of devices for remote sensing and perform the mapping on the HADR areas.	Integrate with autonomous system and existing platforms.
Real-time data visualization (Vaishya, Javaid, Khan, & Haleem, 2020)	Delay of data transfer. Even near to real time have latency about 10 seconds, or even few minutes.	Enhance the data transfer and connectivity with satellite communication and instant data processing.
Rapid response (Kedia et al., 2022)	Delay on deployment due to lack of planning and information on the disaster areas.	Enhance situational awareness in real time.
Autonomous System (Allen & Mazumder, 2020)	Lack of latest autonomous system such as UAV, UGV and UUV.	Autonomous is crucial to conduct operation 24/7 and access to high-risk areas.
Data sharing and data quality (Kedia et al., 2022)	Variety of platforms and format to collect and store data.	Use of big data to collect continuously on all sensors.
Data coordination for HADR (Jaffar et al., 2023)	Lack of command, control, communication from top to down in HADR theatre.	Situational awareness for decision making.

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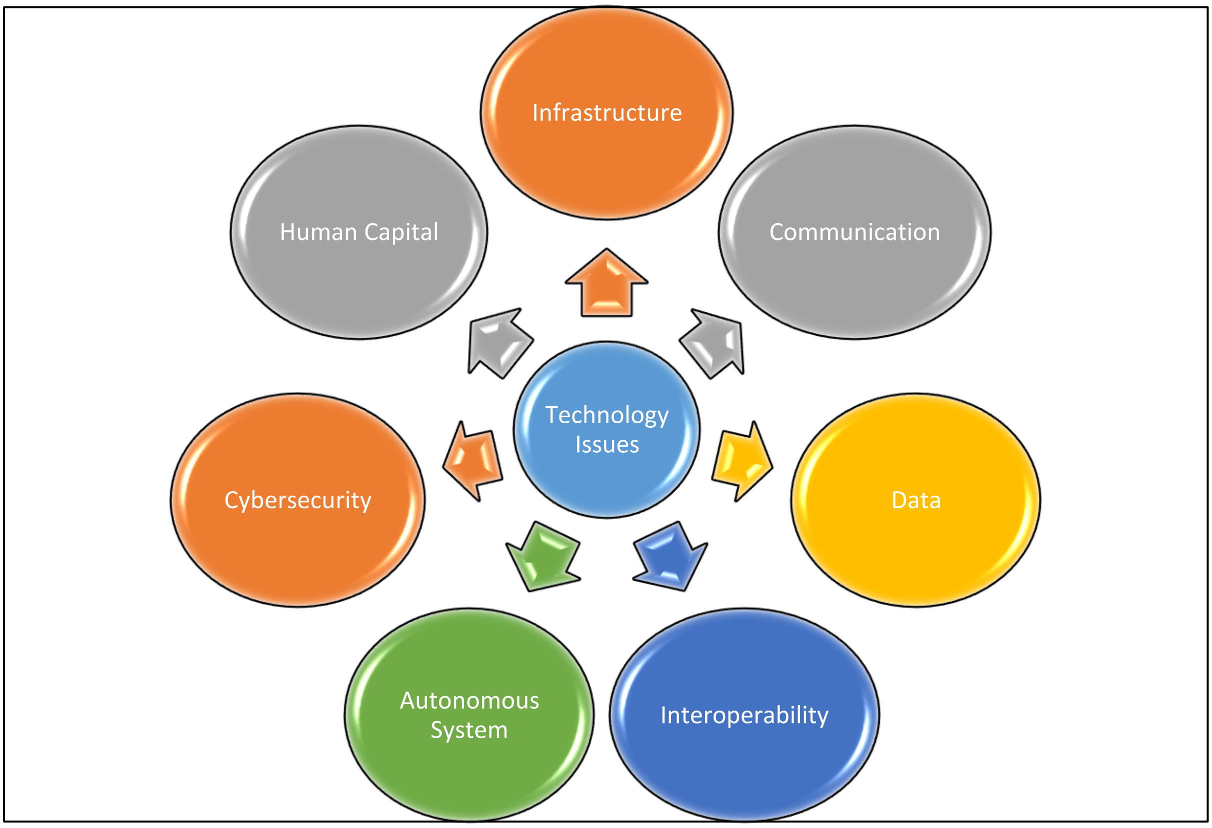

Figure 5: Technology Issues in HADR Frameworks

This paper suggests the main technology issues in HADR framework as shown in Figure 5. Disasters often disrupt communication networks and deny the HADR operation personnel to coordinate and control the scenario of disaster. So, a resilient communication system is crucial to withstand disasters in maintaining connectivity and coordination of HADR operations (Jayasekara et al., 2023). Data management in HADR is very complex with information scattered across various agencies and organizations in ASEAN include of the public. So, an effective HADR operations rely on accurate and timely data for decision-making (Shakibaei, Farhadi-Ramin, Alipour-Vaezi, Aghsami, & Rabbani, 2024). However, integrating data from the HADR field and ensuring interoperability between systems are essential for improving situational awareness.

Interoperability between different platforms and equipment in HADR operation is another critical issue. This can lead to coordination challenges and inefficiencies during response efforts, highlighting the need for standardized communication protocols and compatible technologies (Mani et al., 2023). Some disaster-affected areas in ASEAN countries are remote and difficult to access. Autonomous system would save the time and able to conduct high risk task. This allows access to any extent of distance and high-risk tasks in disaster areas efficiently. Apart of that, it able to send precise and accurate data in real time to assist decision making and update the situational awareness. Potential autonomous system are drones, satellite imagery or UAVs can help overcome these challenges by providing real-time data and surveillance capabilities (Aretoulaki et al., 2023).

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As technology becomes more integral to HADR operations, cybersecurity threats also become more prevalent. Malicious actors may target critical infrastructure or exploit vulnerabilities in digital systems, potentially disrupting response efforts and compromising sensitive data (Fekete & Rhyner, 2020). Many ASEAN countries may lack the technical expertise and capacity to effectively utilize advanced technologies for HADR. So, training and capacity-building programs for responders and officials is essential for maximizing the benefits of technology in disaster response and recovery (Lan Huong, Van Anh, Dat, Truong, & Tam, 2022).

Hybrid HADR Framework in ASEAN

The integration of technology into HADR operations has the potential to transform the disaster management in ASEAN which are prone to a variety of natural disasters (Aretoulaki et al., 2023). A comprehensive conceptual framework is essential to systematically understand and elaborate on the impact of AI in HADR. This framework can be divided into several key components of AI streamline such as information gatherings, data processing and results as shown in Figure 6.

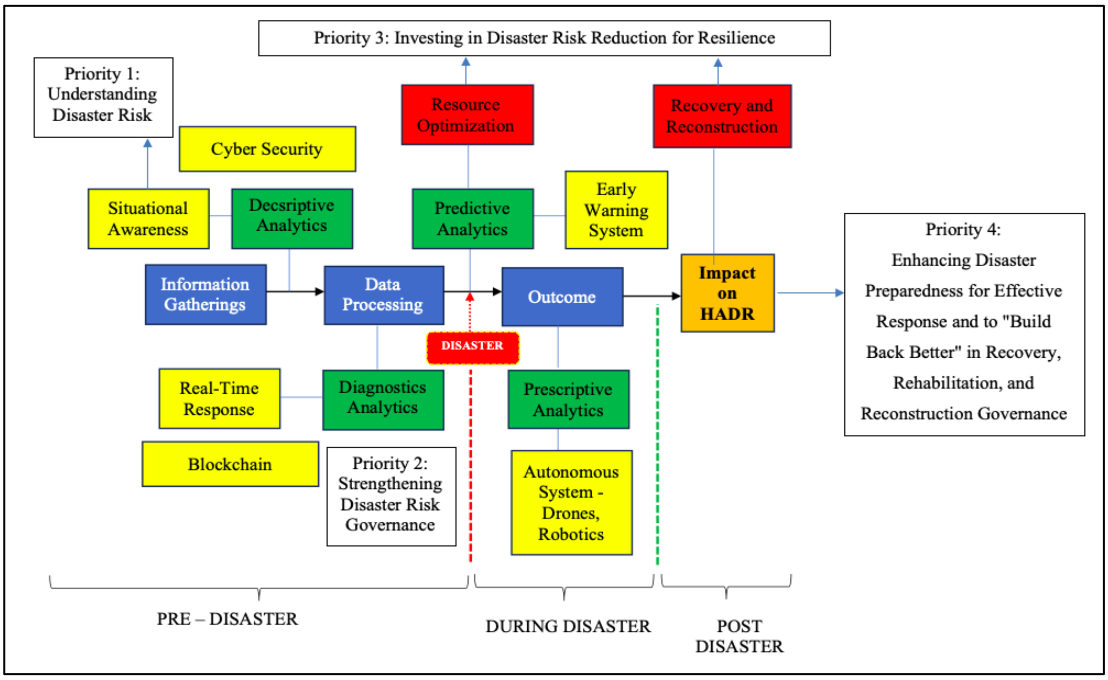

Figure 6: Hybrid HADR Framework as adapted from (Krishnan, Magalingam, & Ibrahim, 2021)

This paper suggests a framework consists of 4 main data analytics that derived from AI model (Krishnan et al., 2021) and comply with Sendai Framework's requirement (Ikeda & Palakhamarn, 2024). It contributes on the impact of HADR in each stage of disasters. Pre-disaster focuses on data gathering using descriptive analytics that provide the situational awareness based on the collected data from sensors, drones and responders from the field. The collected information is processed and be part of diagnostics analytics to provide for the real-time response. Just before a disaster occurs, it will trigger the predictive analytics to predict the intensity of disaster based on the behaviour pattern and history from the collected information. Subsequently, it will generate an early warning to alert public on the disasters. Immediately, the prescriptive analytics will propose a few feasible and suitable action plan with the minimum risks on the disaster areas. This framework has improvised the Sendai framework by establishing technology attributes.

Conclusion
A framework analysis on previous disasters, HADR operations and technology gaps in ASEAN reveals key patterns and technology needs. The analysis highlights crucial technology attributes for an effective HADR framework by identifying recurring disaster types and corresponding humanitarian activities. This approach ensures targeted technological improvements to enhance disaster response and relief efforts in the region. This Hybrid HADR Framework has improvised the Sendai Framework by establishing technology attributes. This hybrid framework addresses the 4 priorities and able to enhance Sendai Framework with a specific approach on mean of technologies. This hybrid HADR framework will be a direction for ASEAN countries to develop their preparation for HADR. Future work can be done to implement this Hybrid HADR Framework in ASEAN countries to evaluate its effectiveness and feasibility.

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