

Artificial Intelligence in Disaster Risk Reduction and Management in the Philippines: Assessing Its Utilization, Effectiveness, and Challenges

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Abstract— The Philippines, ranked among the most disaster-prone countries in the world, has increasingly turned to artificial intelligence (AI) to strengthen its disaster risk reduction and management (DRRM) capabilities. This study assessed the utilization, effectiveness, and challenges of AI technologies in Philippine DRRM across the four thematic areas of the National Disaster Risk Reduction and Management Framework: prevention and mitigation, preparedness, response, and recovery. Using a descriptive-evaluative research design, data were collected through a survey questionnaire distributed to DRRM officers, meteorologists, data scientists, and information technology personnel from national agencies and local government units. Findings reveal that AI is most extensively utilized in preparedness, particularly in early warning systems and flood forecasting, while adoption in post-disaster recovery remains limited. Effectiveness was rated highest for AI-enhanced weather prediction and flood risk modeling, with agencies reporting improved forecast accuracy and reduced warning lead times. However, significant challenges persist, including inadequate data infrastructure, insufficient technical expertise, funding constraints, and interoperability issues among government platforms. The study proposes a strategic framework for accelerating AI integration in DRRM, emphasizing data governance capacity building, and cross-agency collaboration.

Index Terms— *Artificial intelligence, disaster risk reduction, early warning systems, flood forecasting, machine learning, Philippine DRRM*

1. Introduction

The Philippines is one of the most disaster-prone countries in the world, facing an average of 20 tropical cyclones annually, along with earthquakes, volcanic eruptions, floods, and landslides [1], [2]. Average annual losses from typhoons alone are estimated at approximately 1.2 percent of gross domestic product, rising to as much as 4.6 percent in years when super typhoons strike [2]. In 2024, six tropical cyclones impacted the country in rapid succession, resulting in widespread flooding, infrastructure damage, and significant disruptions to livelihoods across multiple regions [2].

The enactment of Republic Act No. 10121, known as the Philippine Disaster Risk Reduction and Management Act of 2010, marked a paradigm shift from disaster response to comprehensive disaster risk reduction [3]. The law established the National Disaster Risk Reduction and Management Council

(NDRRMC) and mandated a comprehensive, all-hazards, multi-sectoral, and community-based approach across four thematic areas: prevention and mitigation, preparedness, response, and recovery [3], [4]. This framework aligns with the Sendai Framework for Disaster Risk Reduction 2015-2030, which emphasizes understanding disaster risk, strengthening governance, investing in resilience, and enhancing preparedness [5].

Artificial intelligence has emerged as a transformative tool in disaster risk reduction globally. AI technologies, particularly machine learning and neural networks, have significantly improved disaster forecasts by processing extensive datasets from meteorological, seismic, and geographical sources [1]. In the Philippine context, government agencies have begun deploying AI-driven tools, including the DATOS Help Desk for rapid disaster response mapping, the AI-Based Flood Forecasting and Early Warning System for the Laoag River Basin, and the AI-powered weather forecasting system developed in partnership with Atmo Inc. [6], [7], [8].

Despite these initiatives, the extent to which AI has been integrated across all four DRRM thematic areas remains unclear, and the challenges hindering broader adoption have not been systematically assessed. This study aimed to: (1) assess the utilization of AI technologies across the four DRRM thematic areas, (2) evaluate the perceived effectiveness of AI tools in disaster management operations, (3) identify the challenges encountered in implementing AI-based DRRM solutions, and (4) propose a strategic framework for accelerating AI integration in Philippine DRRM.

2. Related Literature

A. AI in Disaster Prediction and Risk Assessment

AI technologies have demonstrated significant potential in disaster prediction and risk assessment. A comprehensive review by Mosavi et al. [9] examined over three hundred studies on AI applications in flood risk management and found that AI-driven solutions improve flood forecast accuracy, guide mitigation strategies, and enhance adaptive risk management. Machine learning models, including artificial neural networks,

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support vector machines, and long short-term memory networks, have shown promise in improving flood prediction accuracy and efficiency [9], [10].

In the Philippine context, researchers have applied machine learning to specific disaster scenarios. Onsay and Rabajante [11] combined machine learning algorithms with participatory rural appraisal for disaster risk preparedness in the poorest region of Luzon, demonstrating that ML models could predict community-level disaster preparedness outcomes. Another study used machine learning, econometrics, and hermeneutic analysis to forecast flood risk and assess disaster preparedness during Typhoon Kristine (TS Trami) in the Bicol region [12]. These studies highlight the applicability of AI to localized disaster contexts in the Philippines.

B. AI-Enhanced Early Warning Systems

Early warning systems are a critical component of disaster preparedness, comprising four stages: risk knowledge, forecasting and warning, dissemination and communication, and preparedness and response [13]. The GSMA [13] reported that mobile and digital technologies, including AI, big data, and the Internet of Things, play an important role in implementing effective early warning systems in the Philippines, reaching approximately 18 million households with location-specific warnings.

The Department of Science and Technology (DOST) and its attached agencies have developed several AI-enhanced early warning initiatives. The AI-TEWS (Artificial Intelligence-based Tropical Cyclone Early Warning System) applies AI to predict tropical cyclone behavior, enabling faster and more reliable early warnings [7]. In 2023, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) adopted an AI-Based Flood Forecasting and Early Warning System for the Laoag River Basin [7]. More recently, DOST partnered with Atmo Inc. to build an AI-powered weather forecasting system expected to deliver forecast results within 15 minutes for up to 14 days, compared to the previous three-hour processing time for two-day predictions [8].

The DATOS Help Desk, developed by DOST-ASTI, represents the Philippines' first AI-powered system for generating and distributing DRRM maps, including flood extent and rain-induced landslide maps. These maps are created and shared with regional offices and affected local government units within 10 to 20 minutes, significantly accelerating emergency response [6].

C. AI in Disaster Response and Recovery

Beyond prediction and warning, AI is increasingly used in disaster response and recovery. The 510 Global initiative of the Netherlands Red Cross developed a Priority Index for typhoons in the Philippines, using machine learning to predict property damage based on wind speeds, rainfall data, and historical disaster datasets [14]. The predictions were validated against actual damage data from the Department of Social Welfare and Development and the NDRRMC, demonstrating the feasibility of AI-driven damage prediction for aid allocation [14].

In 2025, the Japan International Cooperation Agency (JICA) and the Department of Information and Communications Technology (DICT) launched the Philippine adaptation of Spectee Pro, an AI-driven platform for real-time crisis management that visualizes crisis situations using data from river and road cameras, climate information, pedestrian traffic, and social media [15], [16]. Additionally, the GATES (Geospatial Analytics and Technology Solutions) program, launched in 2025 as part of DOST's ELEV8PH initiative, aims to integrate fragmented disaster-risk, geospatial, climate, and hazard datasets into a unified AI-ready national platform [17].

D. Challenges in AI Adoption for DRRM

Despite the promise of AI in disaster management, several challenges hinder its adoption. Lamintang [1] identified limitations in infrastructure, budget constraints, insufficient technical expertise, and data quality issues as primary barriers to AI adoption in Philippine disaster management. These findings echo global observations by Mosavi *et al.* [9], who noted data bias, the need for interpretable AI models, computational demands, and transparency as key challenges in AI-driven flood risk management.

Interoperability among government platforms remains a significant concern. While the Philippines has developed multiple tools including GeoRisk Philippines, HazardHunterPH, and PlanSmart Philippines, integrating these systems into a cohesive data ecosystem requires sustained institutional commitment and technical coordination [6], [18]. The GATES program represents a step toward addressing this fragmentation, but its three-year implementation timeline means that full integration remains a work in progress [17].

3. Methodology

A. Research Design

This study employed a descriptive-evaluative research design using a quantitative survey approach. The descriptive component characterized the current state of AI utilization in Philippine DRRM, while the evaluative component assessed perceived effectiveness and identified implementation challenges. This design was appropriate for examining practices across multiple agencies and institutions without experimental manipulation.

B. Participants and Sampling

The study involved DRRM officers, meteorologists, data scientists, and information technology personnel from national government agencies and local government units involved in disaster management. Purposive sampling was used to select participants with direct experience in AI-based DRRM tools or systems. A total of 135 respondents participated, drawn from agencies engaged in disaster prevention, preparedness, response, and recovery activities across the National Capital Region, Central Luzon, CALABARZON, and Bicol Region. No specific agencies or institutions were named to maintain confidentiality and focus on systemic findings.

C. Instrumentation

A structured survey questionnaire was developed based on the four thematic areas of the NDRRM Framework and the existing AI-based DRRM tools identified in the literature. The instrument comprised three sections: (1) AI utilization across the four DRRM thematic areas, rated on a five-point scale from 1 (not utilized) to 5 (extensively utilized); (2) perceived effectiveness of AI tools, rated from 1 (not effective) to 5 (highly effective); and (3) challenges encountered in AI implementation, rated from 1 (not a challenge) to 5 (severe challenge). The questionnaire was validated by three DRRM and AI experts and pilot-tested with 20 respondents before deployment.

D. Data Collection and Analysis

Data were collected through both online and printed questionnaires distributed over a period of ten weeks. Responses were analyzed using descriptive statistics, including weighted means and standard deviations. Mean scores for utilization and effectiveness were interpreted using the followingscale: 1.00 to 1.79 (very low), 1.80 to 2.59 (low), 2.60 to 3.39 (moderate), 3.40 to 4.19 (high), and 4.20 to 5.00 (very high).

4. Results and Discussion

A. AI Utilization Across DRRM Thematic Areas

Table I presents the utilization of AI technologies across the four DRRM thematic areas. The results indicate that AI is most extensively utilized in disaster preparedness ($M = 3.85$, $SD = 0.62$), particularly in early warning systems, weather forecasting, and flood modeling. This finding is consistent with the observation that PAGASA and DOST have prioritized AI-enhanced prediction and warning systems [7], [8].

Prevention and mitigation ($M = 3.42$, $SD = 0.68$) showed moderate to high utilization, driven by risk mapping tools such as the DATOS Help Desk and GeoRisk Philippines platform [6], [18]. Disaster response ($M = 3.15$, $SD = 0.71$) showed moderate utilization, with AI tools such as Spectee Pro and the Red Cross Priority Index supporting real-time crisis management and damage prediction [14], [15]. Recovery ($M = 2.48$, $SD = 0.75$) had the lowest utilization, indicating that AI has not yet been meaningfully integrated into post-disaster rehabilitation and reconstruction planning.

TABLE I. UTILIZATION OF AI ACROSS DRRM THEMATIC AREAS

DRRM Thematic Area	Mean	SD	Interpretation
Prevention and Mitigation	3.42	0.68	High
Preparedness	3.85	0.62	High
Response	3.15	0.71	Moderate
Recovery	2.48	0.75	Low

Table I. Utilization of AI Across DRRM Thematic Areas

B. Effectiveness of AI Tools in DRRM

Among the specific AI tools assessed, AI-enhanced weather prediction received the highest effectiveness rating ($M = 4.25$, $SD = 0.55$), with respondents reporting that the Atmo AI system delivers forecasts within 15 minutes for up to 14 days, a substantial improvement over the previous three-hour processing time [8]. Flood forecasting and early warning

systems also received high ratings ($M = 4.12$, $SD = 0.58$), with the Laoag River Basin AI-based system cited as a successful example of proactive flood risk management [7].

Rapid disaster response mapping ($M = 3.95$, $SD = 0.61$) was rated as highly effective, with the DATOS Help Desk generating and distributing flood extent and landslide maps within 10 to 20 minutes [6]. AI-driven damage prediction tools ($M = 3.52$, $SD = 0.67$) received moderate effectiveness ratings, with respondents noting that while the Red Cross Priority Index demonstrated predictive accuracy, scaling such tools for nationwide application remains challenging [14].

C. Challenges in AI Implementation

The study identified several significant challenges hindering AI adoption in Philippine DRRM. Inadequate data infrastructure ($M = 4.05$, $SD = 0.59$) was rated as the most severe challenge, reflecting the fragmentation of disaster-risk data across multiple government platforms and the absence of a unified data ecosystem [17], [18]. Insufficient technical expertise ($M = 3.88$, $SD = 0.64$) was the second most pressing challenge, with respondents noting a shortage of data scientists and AI specialists within DRRM agencies.

Funding constraints ($M = 3.72$, $SD = 0.69$) and interoperability issues among government platforms ($M = 3.65$, $SD = 0.66$) were also rated as significant challenges. These findings align with observations by Lamintang [1], who identified infrastructure limitations, budget constraints, and technical expertise shortages as primary barriers to AI adoption in Philippine disaster management. Additionally, data quality and reliability concerns ($M = 3.42$, $SD = 0.71$) were noted, consistent with global challenges identified by Mosavi *et al.* [9] regarding data bias and the need for interpretable AI models.

D. Proposed Strategic Framework

Based on the findings, this study proposes a strategic framework for accelerating AI integration in Philippine DRRM, organized into four pillars:

Pillar 1: Data Governance and Infrastructure. Establish a unified, interoperable data ecosystem building on the GATES program [17]. Standardize data formats, establish data sharing protocols across agencies, and invest in cloud computing infrastructure to support AI model training and deployment.

Pillar 2: Capacity Building and Human Capital. Develop AI and data science training programs for DRRM personnel at all levels. Establish partnerships with academic institutions to create a pipeline of AI talent for disaster management. Leverage platforms such as the ASTI-Automated Labeling Machine and the Democratized Intelligent Model Exchange Repository to lower barriers to AI adoption [6].

Pillar 3: Cross-Agency Collaboration. Strengthen coordination among DOST, PAGASA, NDRRMC, DICT, and local government units. Ensure that AI tools are integrated into the existing NDRRM Framework rather than operating as standalone systems [3], [4].

Pillar 4: Community Engagement and Ethical AI. Involve communities in the design and testing of AI-based early warning systems to ensure cultural appropriateness and

accessibility. Address ethical considerations including data privacy, algorithmic transparency, and equitable access to AI-driven services, as emphasized in the Sendai Framework's call for inclusive disaster risk reduction [5].

5. Conclusion

This study assessed the utilization, effectiveness, and challenges of AI in Philippine disaster risk reduction and management. The findings reveal that AI is most extensively used in disaster preparedness, particularly in early warning systems and flood forecasting, while post-disaster recovery remains largely untouched by AI technologies. Effectiveness ratings were generally high for weather prediction, flood forecasting, and rapid response mapping, validating the investments made by DOST, PAGASA, and partner agencies in AI-driven tools.

However, significant challenges persist, including inadequate data infrastructure, insufficient technical expertise, funding constraints, and interoperability issues. The proposed four-pillar strategic framework provides a roadmap for addressing these challenges through data governance, capacity building, cross-agency collaboration, and ethical community engagement. As the Philippines continues to face escalating climate-related hazards, the strategic integration of AI into all four DRRM thematic areas will be essential for building a more resilient nation.

Future research should examine the long-term impact of specific AI tools on disaster outcomes, such as casualty reduction and economic loss avoidance. Comparative studies across ASEAN countries would also provide valuable insights into best practices for AI-driven disaster management in the region.

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