A Community-Based AI Framework for Fire Disaster Risk Reduction in Urban Areas

Oky Iyan Pratama, Febrian Sukma Wardhana*, Daniel David Hartama Sitompul

PT Telkom Indonesia (Persero) Tbk, Indonesia
febrian.wardhana@telkom.co.id

Abstract. Residential fire incidents remain a persistent challenge in many urban areas of Indonesia, leading to significant social and economic losses. Conventional mitigation efforts are often constrained by limited public awareness, delayed emergency reporting, and the absence of effective early warning systems. This study presents the SI APIC (Siaga Api Cerdas) initiative as a community-based digital transformation model that integrates artificial intelligence (AI), digital reporting platforms, and community empowerment to strengthen local disaster resilience. A qualitative case study approach was employed to examine the implementation of the program in Padang Sambian, Denpasar, Bali. Data were collected through observation, documentation review, participant assessments, and stakeholder feedback, and analyzed using thematic analysis with methodological triangulation. The program involved 395 community members and demonstrated measurable improvements in community preparedness. More than 90% of participants achieved high comprehension scores in post-training assessments, and the majority reported increased confidence in responding to fire emergencies. The deployment of AI-enabled CCTV provided real-time early detection capabilities, while integration with digital reporting systems improved coordination with emergency services. This study contributes to the literature by proposing an integrated digital resilience framework that combines AI-based early warning systems, digital platforms, and structured community engagement. The findings highlight that aligning digital technologies with social innovation and stakeholder collaboration can produce sustainable and scalable disaster risk reduction outcomes in urban communities.

Keywords: Digital Transformation; Community Resilience; Disaster Risk Reduction; Artificial Intelligence; Social Innovation

1 Introduction

1.1 Background

Urban disasters continue to pose significant challenges to sustainable development, particularly in densely populated areas where rapid urbanization, limited infrastructure, and low preparedness increase vulnerability. Among these hazards, residential fires represent one of the most frequent and destructive incidents, causing loss of life, economic damage, and long-term social disruption.

A. Sobandi and E. Suryadi (eds.), *Proceedings of the International Conference on Digital Transformation in Business and Organisations (ICDTBO 2026)*, Advances in Economics, Business and Management Research 400,
https://doi.org/10.2991/978-94-6239-754-5_17

Disaster risk is increasingly recognized not only as an emergency management issue but also as a sustainability challenge that requires proactive mitigation and resilience-building efforts [1]. The Sendai Framework for Disaster Risk Reduction 2015–2030 emphasizes the importance of understanding risk, strengthening governance, and enhancing preparedness through inclusive and technology-based approaches [1]. Similarly, the Sustainable Development Goals (SDGs) highlight disaster resilience as a key component of sustainable urban development [2].

Recent advances in digital transformation have introduced new opportunities to address disaster-related challenges. Technologies such as artificial intelligence (AI), information and communication technologies (ICT), and digital platforms enable real-time monitoring, early detection, and improved coordination during emergencies [3,4]. However, technological solutions alone are insufficient to ensure sustainable outcomes. Effective disaster risk reduction also requires community participation and stakeholder collaboration to support implementation and long-term impact [5].

In Indonesia, residential fire incidents remain a major concern, particularly in urban settlements with high population density and limited safety infrastructure. Many communities still rely on manual reporting systems and lack access to early detection mechanisms, resulting in delayed response and increased losses. These conditions highlight the need for integrated approaches that combine technology with community-based solutions.

To address these challenges, the SI APIC (Siaga Api Cerdas) initiative was developed as a community-based digital transformation model. The program integrates AI-enabled fire detection, digital reporting systems, fire safety education, and community empowerment to strengthen local disaster resilience. By combining technological innovation with social participation and multi-stakeholder collaboration, SI APIC aims to create a scalable and sustainable approach for urban fire risk mitigation.

1.2 Problem Statement and Research Gap

Despite growing interest in digital technologies for disaster management, several challenges remain. Public awareness and preparedness for fire emergencies are still limited, early detection systems are rarely available at the community level, and emergency reporting often depends on manual processes that delay response. In addition, many digital initiatives focus primarily on technological deployment without ensuring community engagement and sustainability.

Existing studies have examined the role of AI in disaster detection and the importance of community-based disaster risk reduction [4,5]. However, these approaches are often addressed separately. Limited research has explored how AI-based systems, digital reporting platforms, and structured community empowerment can be integrated within a unified framework to produce measurable social impact, particularly in developing countries.

This study addresses this gap by examining the SI APIC initiative as an integrated digital transformation model that combines technology, community participation, and stakeholder collaboration to enhance disaster resilience in urban areas.

1.3 Research Objective

This study aims to examine the role of digital transformation in strengthening community-based fire disaster risk reduction through the implementation of the SI APIC initiative. Specifically, the objectives of this study are to:

1. Analyze the role of AI-based technologies in supporting early detection and fire risk mitigation;
2. Examine how digital reporting platforms enhance emergency response coordination;
3. Evaluate the contribution of stakeholder collaboration and community participation in strengthening disaster resilience;
4. Assess the social impact of integrating digital technologies with community-based approaches; and
5. Propose a replicable framework for integrating digital innovation and social empowerment in urban disaster risk reduction.

2 Literature Review

2.1 Disaster Risk Reduction and Community Resilience

Disaster Risk Reduction (DRR) aims to minimize vulnerabilities and enhance the capacity of communities to anticipate, respond to, and recover from disasters. The Sendai Framework emphasizes risk awareness, preparedness, and multi-stakeholder collaboration as key components of resilience building [1]. Similarly, sustainable development agendas highlight disaster resilience as essential for inclusive urban development [2].

Community resilience refers to the ability of communities to adapt to and recover from adverse events while maintaining essential functions [7]. Previous studies indicate that education, training, and community participation significantly improve disaster preparedness and response capacity, particularly in urban areas with limited resources [3,4]. However, while community-based approaches strengthen social capacity, they often lack integration with technological systems.

2.2 Digital Transformation and AI for Disaster Management

Digital transformation has introduced new capabilities for disaster management, particularly through artificial intelligence (AI), data analytics, and digital platforms. These technologies enable real-time monitoring, early warning, and improved coordination in emergency situations [5].

AI-based systems, especially those using computer vision, can detect fire and smoke patterns in real time, allowing for faster response compared to conventional methods [6,7]. In addition, digital reporting platforms enhance communication between communities and emergency services, improving response efficiency [8]. However, existing studies primarily focus on technical performance, with limited attention to user adoption and integration at the community level. This suggests that

technological solutions alone are insufficient without supporting social and institutional mechanisms.

2.3 Social Innovation and Stakeholder Collaboration

Social innovation emphasizes the development of solutions that address societal challenges through collaboration and community engagement [9]. In disaster risk reduction, effective collaboration among governments, private sector actors, and communities is essential for ensuring sustainability and scalability [10].

The Quintuple Helix model highlights the role of multi-stakeholder interaction in innovation processes, while the Society 5.0 concept emphasizes human-centered digital transformation that integrates technology with social needs [11,12]. These perspectives suggest that successful disaster risk reduction requires combining technological innovation with community empowerment and institutional collaboration.

2.4 Synthesis and Research Positioning

The literature indicates that digital technologies, community participation, and stakeholder collaboration each play important roles in disaster risk reduction. However, these elements are often studied separately, resulting in fragmented approaches. Limited research has examined how AI-based detection, digital platforms, and structured community empowerment can be integrated within a unified framework to produce measurable social impact. This study addresses this gap by examining an integrated approach to community-based disaster resilience.

3 Methodology

3.1 Research Design

This study adopts a qualitative case study approach to examine the implementation of the SI APIC (Siaga Api Cerdas) initiative as a community-based digital transformation model for fire disaster risk reduction. The case study method is suitable for exploring complex socio-technical systems within their real-world context, particularly where technological innovation, community participation, and institutional collaboration interact simultaneously [3].

The research focuses on the application of digital transformation in disaster risk reduction, emphasizing how artificial intelligence (AI), digital platforms, and social innovation mechanisms contribute to strengthening community resilience.

3.2 Research Setting

The study was conducted in Padang Sambian, Denpasar, Bali, an urban residential area characterized by relatively high population density and closely clustered housing structures. Such conditions increase vulnerability to residential fire incidents and may complicate emergency response efforts. Preliminary assessments identified several challenges within the community, including limited access to fire preparedness education, inadequate early warning mechanisms, dependence on manual emergency

reporting processes, and limited availability of fire suppression equipment at the household level. These conditions made the area suitable for implementing and evaluating a community-based disaster resilience initiative. The SI APIC program was implemented through collaboration among Telkom Indonesia, the Denpasar Fire and Rescue Department, local community leaders, and community members.

3.3 Conceptual Framework

This study is guided by an integrated conceptual framework derived from the synthesis of literature on digital transformation [3], disaster risk reduction [1], and social innovation [9]. The framework conceptualizes disaster resilience as the result of interaction among three key dimensions:

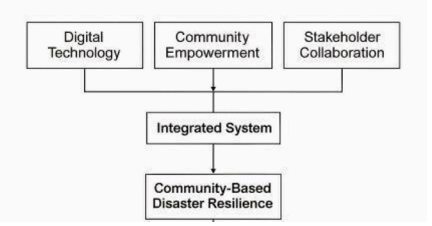

Fig. 1. SI APIC community resilience framework, showing the integration of digital technology, community empowerment and stakeholder collaboration in strengthening disaster resilience.

1. Digital Technology
   This dimension includes the deployment of AI-based early detection systems and digital reporting platforms. AI-enabled CCTV systems are used to detect fire and smoke in real time, while digital platforms support faster communication and emergency coordination [5,7].
2. Community Empowerment
   This dimension involves education, training, and capacity-building activities designed to improve community awareness and preparedness. It also includes the formation of local community ambassadors (AJEG) who contribute to knowledge dissemination and sustainable engagement.
3. Stakeholder Collaboration
   This dimension emphasizes coordination among key stakeholders, including government agencies, private sector organizations, and local communities. Effective collaboration enhances resource utilization and supports long-term sustainability of disaster risk reduction initiatives [10].

The framework assumes that the integration of these dimensions enhances early detection, accelerates response time, and strengthens community resilience. It therefore serves as the analytical lens for evaluating the implementation and impact of the SI APIC initiative.

3.4 Data Collection

Data were collected from multiple sources to ensure comprehensive analysis and methodological triangulation.

1. Observation
   Direct observations were conducted during program preparation, training sessions, simulation exercises, and technology deployment to understand implementation dynamics and community participation.
2. Documentation Review
   Project reports, training materials, implementation documentation, monitoring records, and visual documentation (photos and videos) were analyzed to capture program processes and outputs.
3. Participant Assessment
   Structured post-training assessments were conducted to evaluate participant knowledge and understanding of fire prevention and emergency response procedures. These assessments included quantitative scoring to measure learning outcomes.
4. Stakeholder Feedback
   Qualitative feedback was collected from community members, local leaders, and institutional partners to assess perceived effectiveness, benefits, and challenges of the program.

The use of multiple data sources enhances data reliability and supports triangulation, improving the credibility of research findings.

3.5 Data Analysis

Data were analyzed using a combination of thematic analysis and descriptive evaluation techniques. Qualitative data from observations, documentation, and stakeholder feedback were systematically coded and categorized into key themes, including community preparedness, technology adoption, stakeholder collaboration, social impact, and program sustainability.

The analysis followed an iterative coding process to identify patterns, relationships, and emerging insights related to the conceptual framework.

Quantitative data, including participation rates and assessment scores, were analyzed descriptively to evaluate program effectiveness and learning outcomes. The integration of qualitative and quantitative findings enables a more comprehensive understanding of the program's impact.

3.6 Validity and Reliability

To ensure the validity and reliability of the findings, this study employs methodological triangulation by integrating multiple data sources, including observation, documentation, participant assessments, and stakeholder feedback. Triangulation allows cross-verification of findings and reduces potential bias.

In addition, consistency in data collection and analysis procedures was maintained through systematic documentation and standardized assessment instruments. These measures enhance the credibility and trustworthiness of the research results.

3.7 Program Implementation

The implementation of the SI APIC initiative was conducted in three main phases:

1. Preparation Phase
   This phase involved stakeholder coordination with local authorities and the Fire and Rescue Department, site assessments, and identification of fire risk conditions.
2. Execution Phase
   The program activities included:
   a. Fire safety education and awareness campaigns
   b. Practical fire emergency simulations
   c. Demonstration of fire suppression techniques (APAR and fire blanket)
   d. Introduction and utilization of digital reporting platforms (SiSUPIT)
   e. Deployment of AI-enabled CCTV systems
   f. Distribution of fire preparedness equipment
   g. Formation of AJEG community ambassadors

   A total of 395 community members participated in these activities.
3. Monitoring and Evaluation Phase
   This phase focused on assessing participant understanding, technology adoption, stakeholder engagement, and overall program effectiveness through post-training assessments and feedback collection.

3.8 Evaluation Framework

To assess program effectiveness, this study adopts a Theory of Change perspective that links program inputs, outputs, outcomes, and long-term impacts.

1. Inputs
   SI APIC implementation team, Denpasar Fire and Rescue Department, Antares Eazy AI CCTV, SiSUPIT platform, Fire preparedness equipment, Community volunteers.
2. Outputs
   395 residents participated in education and simulation activities, AI-enabled CCTV deployed, Fire preparedness equipment distributed, AJEG community ambassadors established.
3. Outcomes
   Increased community awareness and preparedness, Improved emergency reporting and response coordination, Enhanced stakeholder collaboration, Strengthened local disaster resilience.

Table 1. Summary of SI APIC Program Outcomes.

Indicator	Description	Result
Participants	Residents involved in program	395 residents
Training Outcome	Post-training comprehension level	>90% high score
Technology Implementation	System deployed	AI-CCTV, SiSUPIT
Community Engagement	Local group formed	AJEG
Observed Impact	Behavioral and preparedness change	Increased preparedness

4. Long-Term Impacts
   Reduced fire risk and vulnerability, Sustainable community-based early warning ecosystem, Improved urban resilience, Potential replication in other communities and municipalities

4 Result and Discussion

This section presents the key findings from the SI APIC implementation, analyzed using the framework of digital transformation, community empowerment, and stakeholder collaboration.

4.1 Community Preparedness

The program involved 395 residents in fire safety training and simulation activities. Post-training assessments show that more than 90% of participants achieved high comprehension scores, indicating strong knowledge improvement.

Participants also reported increased confidence in responding to fire emergencies. Behavioral changes were observed, such as improved electrical safety awareness and better handling of cooking risks. These findings confirm that community-based training significantly enhances disaster preparedness, as highlighted in previous studies [3,4].

4.2 AI-Based Early Detection

The deployment of AI-enabled CCTV systems improved early identification of fire risks through real-time smoke and fire detection. This reduces reliance on manual observation and enables earlier intervention.

This result is consistent with prior research showing that AI can enhance early warning systems and reduce disaster impact [6,7]. However, some participants had limited understanding of how the technology works, indicating the need for better user education to support adoption.

4.3 Digital Reporting System

The integration of SiSUPIT as a digital reporting platform improved communication between residents and emergency services. Participants were able to report incidents more quickly compared to manual methods.

This supports previous findings that digital platforms enhance coordination and response efficiency in disaster management [8].

4.4 Community Empowerment

The formation of AJEG as a community ambassador group plays an important role in sustaining the program. AJEG members promote fire safety awareness and support continuous engagement within the community.

This aligns with social innovation theory, which emphasizes the role of community participation in ensuring long-term impact [9].

4.5 Stakeholder Collaboration

The collaboration between PT Telkom Indonesia, the Fire and Rescue Department, and the local community contributed significantly to program success. This partnership enabled effective use of resources and ensured alignment with existing emergency systems.

The result supports previous studies highlighting the importance of multi-stakeholder collaboration in disaster resilience initiatives [10].

4.6 Integrated Impact

Overall, the findings show that the integration of technology, community participation, and collaboration produces stronger disaster resilience outcomes.

1. Technology improves detection and response speed
2. Community empowerment enhances preparedness
3. Collaboration ensures sustainability

This integrated approach reflects the concept of human-centered digital transformation in Society 5.0 [12]. The SI APIC model demonstrates a scalable and practical framework for disaster risk reduction in urban communities.

These findings demonstrate measurable improvements in community preparedness based on both quantitative assessment results and qualitative feedback from participants.

5 Result and Discussion

This study demonstrates that the SI APIC (Siaga Api Cerdas) initiative offers an effective community-based digital transformation model for strengthening residential fire resilience, as evidenced by its implementation in Padang Sambian, Denpasar, Bali. By integrating artificial intelligence, digital reporting platforms, and community empowerment, the program addressed key limitations of conventional mitigation efforts, including low public awareness and delayed emergency reporting.

Among the 395 participating community members, over 90% achieved high comprehension scores in post-training assessments, alongside increased confidence in emergency response. The AI-enabled CCTV system provided real-time early detection, while integration with digital reporting platforms improved coordination with emergency services.

These findings contribute an integrated digital resilience framework combining

AI-based early warning, digital platforms, and structured community engagement, underscoring that aligning technology with social innovation and stakeholder collaboration yields sustainable, scalable disaster risk reduction outcomes. The SI APIC model thus offers a practical reference for community-based fire mitigation policy, with future research warranted to test its scalability across diverse contexts using quantitative or mixed-methods approaches.

References

1. United Nations Office for Disaster Risk Reduction (UNDRR): *Sendai Framework for Disaster Risk Reduction 2015–2030*. United Nations, Geneva (2015).
2. United Nations: *Transforming Our World: The 2030 Agenda for Sustainable Development*. United Nations, New York (2015).
3. Vial, G.: Understanding digital transformation: A review and a research agenda. *Journal of Strategic Information Systems* 28(2), 118–144 (2019).
4. Erokhin, V., Komendantova, N.: Digital transformation for disaster resilience: Emerging technologies and governance challenges. *International Journal of Disaster Risk Reduction* 107, 104460 (2024).
5. Patel, S.S., Rogers, M.B., Amlôt, R., Rubin, G.J.: What do we mean by "community resilience"? A systematic literature review of how it is defined in the literature. *PLoS Currents Disasters* 9 (2017).
6. Chun, S.A., Geller, J., Grinberg, M., Pendyala, V.S., Chun, S.Y.: Transforming disaster risk reduction with AI and big data: Opportunities and challenges. *WIREs Data Mining and Knowledge Discovery* 15(1), e1534 (2025).
7. Chakraborty, J., Collins, T.W., Grineski, S.E.: Artificial intelligence, geospatial analytics, and disaster risk management: Emerging opportunities and challenges. *International Journal of Disaster Risk Reduction* 95, 103870 (2024).
8. Samarakkody, A., et al.: Technological innovations for enhancing disaster resilience in smart cities: A systematic review. *Sustainability* **15**(15), 12036 (2023).
9. Kawane, T., Ozaki, Y., Suresh, D., Zhang, Y., Mazumder, S., Shaw, R.: Social innovation and disaster risk reduction in Japan: challenges and opportunities. *Disaster Prevention and Resilience* **3**, 8 (2024).
10. Imperiale, A.J., Vanclay, F.: Conceptualizing community resilience and the social dimensions of risk: A systematic literature review. *International Journal of Disaster Risk Reduction* 71, 102804 (2022).
11. Carayannis, E.G., Barth, T.D., Campbell, D.F.J.: The Quintuple Helix innovation model: Global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship* 1(2), 1–12 (2012).
12. Deguchi, A., Hirai, C., Matsuoka, H., Nakano, T., Oshima, K., Tai, M., Tani, S.: What Is Society 5.0? In: *Society 5.0: A People-Centric Super-Smart Society*, pp. 1–23. Springer, Singapore (2020).