

Integrated Fire Risk Management Framework: A Strategic Approach for Industrial Resilience

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Abstract

Industrial areas have become increasingly susceptible to fire hazards due to high population density, intricate infrastructure, and hazardous operational activities. Nevertheless, a significant number of organizations still lack an integrated and comprehensive framework for managing fire-related risks. This study seeks to formulate and empirically test the Integrated Fire Risk Management Framework (IFRM) as a strategic model to enhance industrial resilience against fire incidents. Employing a quantitative methodology with a descriptive-correlational design, the research involved 100 respondents comprising facility managers, safety officers, and industrial fire emergency response personnel. Data were gathered using a closed-ended questionnaire based on a Likert scale and analysed through regression and correlation techniques. The findings demonstrate that the IFRM has a statistically significant impact on industrial resilience, indicated by a regression coefficient of 0.362 and a significance level of 0.000 ($p < 0.001$). Moreover, the IFRM construct was validated as both reliable and internally consistent, with a Cronbach's Alpha value of 0.632. Each IFRM component risk identification, mitigation planning, emergency training, rapid response mechanisms, and post-fire recovery plays a critical role in enhancing the adaptive and operational capacities of industrial systems. These results highlight the essential role of a holistic IFRM-oriented strategy in maintaining operational continuity and promoting industrial sustainability amid escalating environmental and technological risks.

Keywords: Emergency Preparedness, Fire Risk Management, Regulatory Enforcement, Safety Training, Urban Resilience

INTRODUCTION

Industrial zones face increasing vulnerability to fire hazards due to high population density, complex infrastructure, and the concentration of hazardous industrial activities. Fires in these areas lead to severe consequences, including significant economic losses, public health crises, environmental damage, and enduring impacts on the climate system. Both the natural environment and built infrastructure suffer substantial harm, disrupting ecosystem services critical to various economic sectors (Oliveira et al., 2018). Empirical research confirms a strong relationship between urbanization and fire occurrences. Highly urbanized regions exhibit a higher frequency of fire incidents, largely driven by the intensity of human activities and the abundance of flammable materials (Beal-Neves et al., 2020).

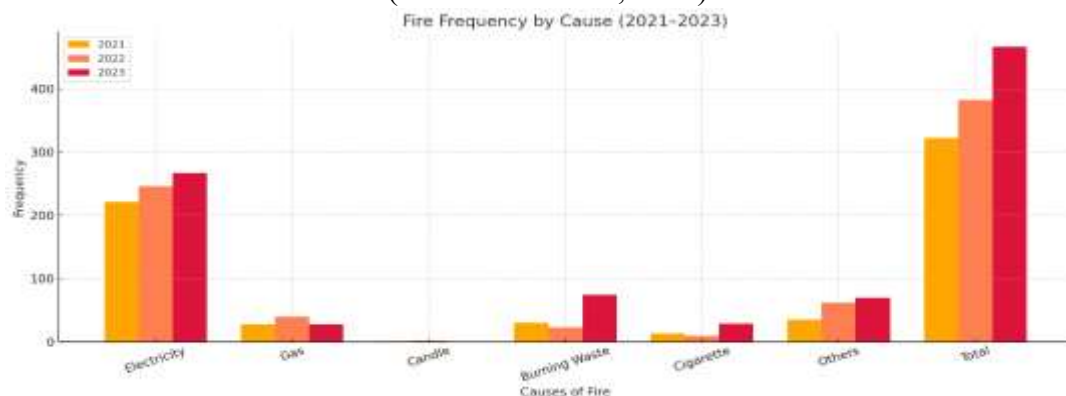


Figure 1. Fire Frequency Graph (2021-2023)

The analysis of fire frequency data from 2021 to 2023 reveals a consistent year-over-year increase in reported incidents. In 2021, authorities recorded 322 fire cases, which rose to 382 in 2022, and further escalated to 467 in 2023. This upward trend reflects a substantial growth in fire occurrences, with a 19 percent increase between 2021 and 2022, and a 22 percent rise from 2022 to 2023.

Electrical faults remained the leading cause of fires throughout the observed period. In 2021, electrical issues accounted for 221 incidents, representing approximately 69 percent of total cases. The number of such cases increased to 246 (64 percent) in 2022 and further to 267 (57 percent) in 2023. Although the proportion of total incidents attributed to electrical faults declined, the absolute number continued to rise.

This pattern underscores the persistent vulnerability of electrical systems and highlights the urgent need for enhanced technical oversight and preventive measures, particularly in residential and commercial settings. Unsafe acts or unsafe actions are factors that cause accidents (Prasetya et al., 2021).

Other causes also exhibited notable trends. Fires resulting from waste burning increased dramatically, from 23 incidents in 2022 to 74 in 2023, indicating a significant gap in public awareness regarding the hazards of open burning. Incidents linked to gas usage fluctuated, rising from 25 in 2021 to 40 in 2022 before declining to 27 in 2023. Additionally, cigarette-related fires showed a marked increase, rising from 9 cases in 2022 to 29 in 2023. These findings suggest the need for targeted public education and stricter regulatory enforcement to address emerging and persistent fire risks.

Despite the existence of fire safety regulations and protocols, numerous organizations lack a comprehensive and integrated framework that effectively unifies risk assessment, prevention, preparedness, mitigation, and emergency response strategies. Zhang *et al.* (2013) found that, although the government has established various policies such as the National Emergency Response Plan and the Environmental Emergency Response Plan these frameworks have not been implemented in a coordinated and integrated manner across different levels of government, nor have they sufficiently engaged community participation.

This study underscores that the current risk management system remains predominantly hierarchical, characterized by a top-down structure in which government authorities and technical professionals retain central control over decision-making and strategic implementation. Such a model marginalizes the role of communities in key processes, including risk identification, public communication, and participatory decision-making during emergencies. The limited involvement of the public indicates a fundamental gap in the integration of essential elements required for a robust and inclusive risk management framework.

Pu (2024) asserts that, although the government responded swiftly and on a large scale to the COVID-19 pandemic through regional lockdowns, community quarantines, the rapid construction of emergency medical facilities, and the deployment of advanced technologies such as artificial intelligence and QR codes this study emphasizes the continued absence of a comprehensive and integrated risk management framework. An effective framework should cohesively incorporate risk assessment, prevention, preparedness, mitigation, and emergency response. During the initial phase of the pandemic, the government exhibited delays in recognizing and responding to the scale of the emerging threat. Local authorities imposed restrictions on the dissemination of public information, thereby impeding efforts to raise public awareness and preparedness. Inadequate inter-agency coordination, underdeveloped early warning systems, and delayed communication of critical information further obstructed the timeliness and effectiveness of decision-making processes throughout the crisis.

The community's lack of preparedness was further aggravated by inadequate public health education prior to the crisis, resulting in insufficient awareness among residents regarding appropriate emergency response measures. The implementation of a uniform total quarantine

policy, without accounting for local socio-cultural and infrastructural contexts, produced significant social consequences including disruptions to healthcare services, increased social isolation, and heightened psychological distress. These outcomes indicate that the emergency response strategy lacked inclusivity and adaptability. Moreover, the uneven distribution of logistical resources, caused by shortages in personnel and transportation capacity, highlights deficiencies in the coordination between logistics planning and local crisis management systems.

A fragmented approach and inconsistent enforcement of policies have resulted in notable gaps in resilience, thereby heightening the risk of substantial human, environmental, and economic losses. Prior research on integrated fire risk management frameworks especially those employing a holistic perspective within industrial contexts remains limited. Existing literature predominantly concentrates on individual components, such as prevention or emergency response, without advancing a comprehensive model that systematically integrates risk assessment, mitigation, preparedness, and post-incident recovery (Barua & Cvekovic). This study seeks to bridge this critical gap in the scholarly discourse.

This study encompasses a geographically defined area comprising strategically selected industrial zones. The research is conducted within the operational scope of the BPBD office, which holds primary responsibility for fire management in the industrial sector. Temporally, the analysis is grounded in fire incident records and the implementation of fire risk management practices over the past five years.

The primary objective of this research is to develop an Integrated Fire Risk Management Framework designed to strengthen resilience in industrial areas through systematic risk assessment and the application of effective management strategies. Specifically, the study aims to identify the key risk factors that significantly contribute to the occurrence of fire incidents within the industrial sector. Furthermore, the research seeks to assess the effectiveness of the existing fire risk management systems currently employed.

Using a systematic approach, this study will develop and validate an integrated framework intended to enhance the effectiveness of mitigation, preparedness, and response to fire-related risks. Furthermore, it will examine the influence of fire safety training, regulatory enforcement, and resource allocation on efforts to reduce fire risks. The findings of this research are expected to generate strategic policy recommendations aimed at sustainably strengthening fire resilience capacities in both urban and industrial settings.

This study employs ISO 31000 as its foundational risk management framework, which offers a strategic and holistic approach by integrating risk processes into governance, strategy, and operations Mamujaja and Cahyono (2024), with the ISO 31000:2018 version emphasizing structured processes such as effective communication, contextual framing, systematic assessment, and continuous improvement contribute to organizational resilience (Widianti, Firdaus and Rakhmawati, 2024). The framework integrates High Reliability Organization (HRO) theory, which explains how entities operating in high-risk environments maintain safety and stability by continuously anticipating and learning from potential failures (Stock and McFadden, 2017). The Swiss Cheese Model (SCM) further conceptualizes how accidents emerge from the alignment of latent failures across multiple organizational layers, allowing systemic vulnerabilities to compound and manifest as incidents (Moura et al., 2015). Additionally, Protection Motivation Theory (PMT) provides a psychological lens to understand individual protective behaviors, emphasizing the cognitive appraisal of threat severity, perceived vulnerability, and the efficacy of available responses (Taheri-Kharamneh *et al.*, 2020; Eberhardt and Ling, 2023; Okati–Aliabad *et al.*, 2023).

The Integrated Fire Risk Management Framework (IFRM) strengthens industrial resilience by combining preventive and responsive strategies to mitigate fire hazards, ensuring operational sustainability in environments exposed to escalating risk. Strong organisational governance and the development of resilient infrastructure, particularly within high-technology

sectors, serve as critical determinants of fire resilience. Xu et al. (2024) identify three essential elements that support this capacity: enhanced fire protection systems, the development of sustainable and fire-resistant facilities, and organisational management structures that reinforce safety practices. This conceptual foundation informs the formulation of the first hypothesis:

H1 – An Integrated Fire Risk Management Framework has a significant effect on Industrial Resilience.

A systematic approach to fire risk identification is essential for enhancing industrial resilience and reducing the negative impacts of fire incidents, particularly in high-risk sectors such as energy production. This process involves comprehensive evaluations of hazards, vulnerabilities, and the capacity of facilities to respond effectively. Leal *et al.* (2022) emphasize the importance of identifying risk factors in critical civil infrastructure, as such assessments uncover hidden vulnerabilities that require mitigation. Based on this foundation, the study presents the second hypothesis:

H2 – Systematic fire risk identification has a significant effect on industrial resilience.

Effective fire mitigation and prevention planning is critical for ensuring operational stability and safety within industrial settings. An integrated risk assessment approach facilitates the identification of potential hazards and the development of tailored mitigation strategies. Ebrahemzadieh *et al.* (2015) emphasize the significance of regular inspections, maintenance of safety equipment, and comprehensive risk evaluations in preventing major incidents, especially in the petrochemical and manufacturing industries. Based on this rationale, the study proposes the third hypothesis:

H3 – Effective fire mitigation and prevention planning has a significant effect on industrial resilience.

Emergency training plays a crucial role in strengthening industrial resilience, particularly in high-risk sectors, by combining theoretical knowledge with practical simulation exercises to enhance personnel readiness during crisis situations. Kristensen *et al.* (2022) demonstrate that integrating classroom instruction with simulation-based drills significantly improves both conceptual understanding and practical response capabilities, as seen in fields such as aviation and aquaculture. Based on this evidence, the study formulates the fourth hypothesis:

H4 – Emergency training has a significant effect on industrial resilience.

The speed and effectiveness of fire emergency response are critical determinants of industrial resilience, especially in high-risk sectors such as oil and gas. Rapid response systems help minimize damage, prevent escalation, and expedite recovery, thereby sustaining operational continuity. Habibah and Cahyaningrum (2022) highlight that properly implemented emergency response mechanisms significantly enhance workplace safety and reduce risk. Based on this evidence, the study advances the fifth hypothesis:

H5 – Rapid fire response significantly affects industrial resilience.

Comprehensive post-fire recovery planning is essential for ensuring long-term industrial resilience, particularly in the face of increasing climate-induced fire events. Effective recovery strategies must integrate ecological restoration with the continuation of industrial operations. Research by Guz *et al.* (2022) and Davis *et al.* (2023) demonstrates that the severity of fire events significantly influences ecosystem regeneration, with high-intensity fires posing greater risks to resilience. Additionally, Gallagher *et al.* (2021) stress the importance of incorporating ecological insights into recovery plans to protect biodiversity and ecosystem services. Based on this rationale, the study presents the sixth hypothesis:

H6 – Comprehensive post-fire recovery plans have a significant effect on industrial

Characteristic	Total	Percentage (%)
Age		
20 - 25	24	24.0
26 - 31	11	11.0
32 - 37	16	16.0
38 - 43	21	21.0
44 - 49	10	10.0
50 - 55	18	18.0
Gender		
Male	54	54.0
Female	46	46.0
Graduate		
Senior Highschool	24	24.0
S1	36	36.0
S2	22	22.0
S3	18	18.0
TOTAL	100	100

resilience.

Figure 2. Conceptual Framework

RESEARCH METHODS

The study employed a quantitative methodology with a descriptive and correlational design, consistent with the approach outlined by De Pilli et al. (2024), which focuses on identifying patterns and examining relationships among the variables analysed. Data collection relied on a structured survey administered to 100 respondents, including safety officers, facility managers, employees, and members of fire emergency response teams associated with BPBD units operating in industrial environments over a two-month period. The analysis incorporated both primary data from the survey and secondary data obtained from fire incident reports, audit records, and regulatory compliance documentation. The study applied non-purposive sampling to recruit participants. Following Alhumaid & AAssali (2023), the research instrument consisted of a closed Likert-scale questionnaire designed to systematically capture respondents’ perceptions and experiences. The instrument underwent validity and reliability testing prior to deployment, including the use of Cronbach’s Alpha to confirm internal consistency. Data analysis proceeded in two stages. Descriptive statistics summarised respondent characteristics and data distributions. Inferential statistical techniques, including correlation and regression analysis, were then applied to evaluate the significance and strength of relationships among the core research variables.

RESULT AND DISCUSSION

Analysis of Respondent Characteristics

Table 1. Characteristics of Respondents

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.086 ^a	.007	-.003	3,143

a. Predictors: (Constant), Integrated Fire Risk Management Framework (X)

Referring to the data presented in Table 1, the majority of respondents fall within the productive age range of 20 to 55 years, with the highest representation in the 20–25 year (24%)

and 38–43 year (21%) age brackets. This distribution suggests that the participants are professionally active individuals, consistent with occupational roles such as safety officers, facility managers, or emergency response personnel. The gender composition appears relatively balanced, with a slight predominance of male respondents, indicating a degree of gender inclusivity within the domains of emergency response and industrial facility management, despite these fields traditionally being male-dominated. In terms of educational attainment, most respondents possess higher education qualifications, with bachelor's degree holders (S1) comprising 36% and master's degree holders (S2) representing 22% of the sample. This implies that the respondents have sufficient cognitive and professional capacity to comprehend and apply principles of fire risk management. Furthermore, the presence of doctoral degree holders (S3) at 18% signifies the inclusion of individuals with advanced academic credentials or senior organizational roles.

Hypothesis Testing

Table 2. Determination Coefficient Test

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.086 ^a	.007	-.003	3,143

a. Predictors: (Constant), Integrated Fire Risk Management Framework (X)

The correlation coefficient (R) of 0.086 indicates a very weak positive linear relationship between the Integrated Fire Risk Management Framework (X) and Industrial Resilience (Y), while the coefficient of determination (R Square) of 0.007 shows that only 0.7% of the variation in Industrial Resilience is explained by the independent variable. This suggests that 99.3% of the variance is attributed to other factors outside the model, highlighting the limited explanatory power of X in a univariate context. The adjusted R Square value of –0.003 further confirms that including the variable does not improve the model and may slightly reduce its predictive capability, which is typical for models with a single, non-significant predictor.

Additionally, the standard error of the estimate at 3.143 indicates a high average deviation of observed values from the regression line, underscoring the model's low predictive accuracy.

Multiple Linear Regression Test

Table 3. Multiple Linear Regression Test

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11,820	1,235		9,573	,000
	Integrated Fire Risk Management Framework (X)	,362	,087	,465	4,161	,000

a. Dependent Variable: Industrial Resilience (Y)

$$Y = a + b_1X_1 + b_2X_2 + \dots + b_nX_n$$

Description:

Y : Industrial Resilience

A : Constant (Fixed value)

b₁, b₂ : Regression coefficient (Estimated value)

X₁ : Integrated Fire Risk Management Framework (X)

$$Y = 11,820 + 0,362X_1$$

The constant coefficient of 11.820 signifies that when the Integrated Fire Risk Management Framework (X) equals zero, the predicted value of Industrial Resilience (Y) is 11.820. This value represents the baseline level of industrial resilience in the absence of fire risk management implementation. The regression coefficient of 0.362 indicates that each one-unit

increase in the fire risk management framework score leads to an increase of 0.362 units in industrial resilience. This positive relationship implies that the implementation of a more robust fire risk management framework contributes to enhancing industrial resilience. The t-value of 4.161, accompanied by a significance level of 0.000 ($p < 0.001$), demonstrates that the independent variable exerts a statistically significant effect on the dependent variable, confirming the validity of the framework's contribution to resilience outcomes. Furthermore, the standardised beta coefficient of 0.465 reflects a moderate to strong effect of the Integrated Fire Risk Management Framework on Industrial Resilience, positioning it as a substantial predictor within the regression model

F-test (Simultaneous)

Table 4. F-test (Simultaneous)

ANOVA ^a					
Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	860.540	1	860.540	15.735	.000 ^b
Residual	535.120	98	5.462		
Total	1,395.660	99			

a. Dependent Variable: Industrial Resilience (Y)

b. Predictors: (Constant), Integrated Fire Risk Management Framework (X)

The F value of 15.735 indicates a substantial disparity between the variation accounted for by the regression model and the unexplained residual variation. This suggests that the model contributes significantly to explaining the variability in Industrial Resilience. The significance value of 0.000, which is well below the conventional threshold of 0.05 (and even below 0.001), confirms that the F-test result is statistically significant. This finding demonstrates that the independent variable (X) exerts a simultaneous and meaningful influence on the dependent variable (Y), affirming the model's appropriateness for predictive and analytical purposes. Furthermore, the Mean Square value for the regression, recorded at 860.540, is markedly higher than the residual Mean Square of 5.462, thereby reinforcing the conclusion that the model captures a considerably larger proportion of variance compared to random error.

In relation to the research hypothesis, although the current model examines only a single independent variable namely the Integrated Fire Risk Management Framework (IFRM) the F-test results confirm that this variable exerts a statistically significant collective influence on industrial resilience. Therefore, the F-test provides empirical support for hypothesis H1, which posits that the Integrated Fire Risk Management Framework significantly affects industrial resilience. Should subsequent analyses in this study include multiple independent variables, as outlined in hypotheses H2 through H6 (encompassing Risk Identification, Mitigation, Emergency Training, Rapid Response, and Post-Fire Recovery), the F-test would remain an appropriate statistical tool for evaluating the overall significance of these variables' combined effects on industrial resilience.

T-test (partial)

Table 5. T-test (partial)

Coefficients ^a					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1(Constant)	11,820	1,235		9,573	,000
Integrated Fire Risk Management Framework (X)	,362	,087	,465	4,161	,000

a. Dependent Variable: Industrial Resilience (Y)

The regression coefficient (B) of 0.362 indicates that each one-unit increase in the Integrated Fire Risk Management Framework (X) score leads to a 0.362-unit increase in the Industrial Resilience (Y) score. This positive relationship suggests that the more robust the implementation of fire risk management, the greater the level of industrial resilience. The t-value

of 4.161 and the significance level of 0.000 ($p < 0.001$) confirm that the independent variable X has a statistically significant partial effect on the dependent variable Y. This implies that the influence of the Integrated Fire Risk Management Framework on Industrial Resilience is not merely conceptual but is supported by empirical evidence. The standardized beta coefficient of 0.465 reflects a moderate to strong influence of variable X on Y, indicating that the framework serves as a substantial predictor within the regression model. The constant coefficient (intercept) of 11.820 represents the baseline value of Industrial Resilience in the absence of any implementation of the fire risk management framework ($X = 0$).

Discussion

The Integrated Fire Risk Management Framework (IFRM) serves as a critical mechanism for strengthening industrial resilience by encompassing both preventive strategies and responsive measures to fire hazards. This dual approach ensures the continuity and sustainability of industrial operations in the face of escalating environmental threats. Enhancing resilience to fire-related disruptions necessitates the integration of effective organizational management and robust structural design, particularly within high-technology sectors. Strong leader-member relationships serve as a foundation for inclusive collaboration, organizational learning, and long-term adaptability, fostering a culture of trust and strategic alignment that is essential in managing high-risk environments (Krisprimandoyo et al., 2025). By implementing these principles, enterprises can improve their adaptive capacity to fire risks, thereby reinforcing their overall resilience within the broader industrial ecosystem.

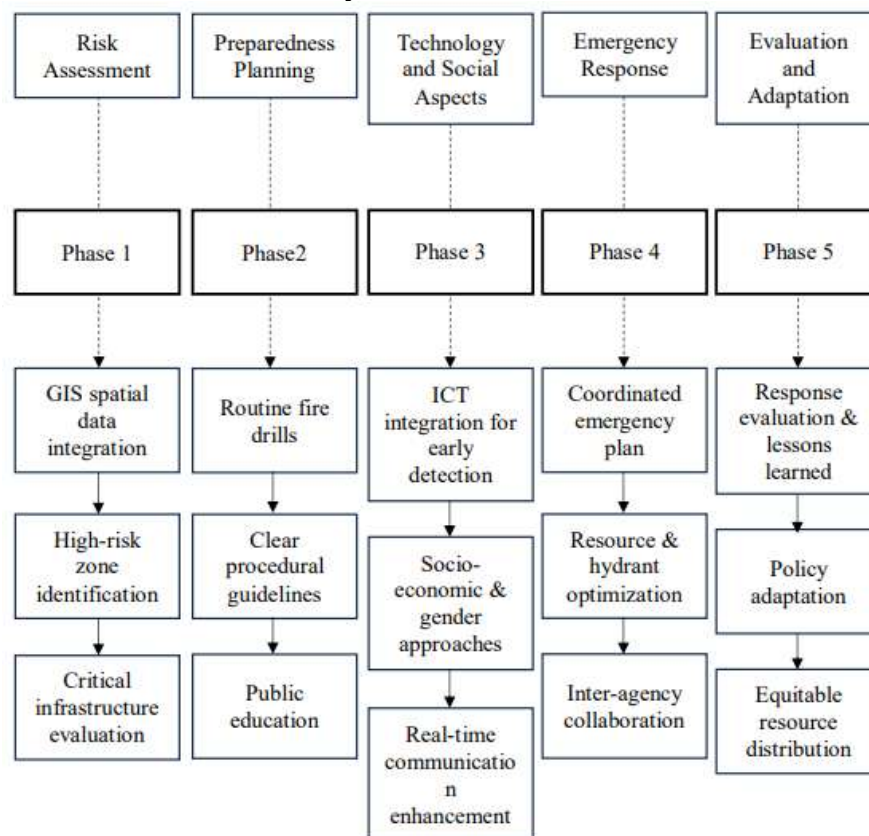


Figure 3. Integrated Fire Risk Management Framework

A critical component of this integrated framework involves conducting a rigorous risk assessment that incorporates both quantitative and qualitative methodologies. For instance, the application of geospatial analysis and Geographic Information Systems (GIS) has proven effective in identifying high-risk urban zones and fire hotspots (Thakare & Tajne, 2024). Leal *et al.* (2022) exemplify this through the integration of risk and resilience assessment methodologies for evaluating vital civil infrastructure.

Advances in technology have made human interaction easier (Susanto et al., 2024). By synthesizing spatial analysis, technological integration via Information and Communication Technology (ICT), and advanced risk science, the framework facilitates the measurement of hazard exposure, assessment of vulnerability, and mapping of interconnections between infrastructure and community elements (Dunn et al., 2020). This comprehensive assessment enables the establishment of a baseline risk profile, which is essential for preparedness planning and resource allocation (Oom et al., 2022).

Preparedness planning within this framework encompasses pre-incident mitigation strategies and capacity development across sectors. Empirical evidence from educational settings highlights the necessity of organized, cyclical training exercises, routine system maintenance, and well-defined procedural protocols (Raphela & Ndaba, 2024). These initiatives are designed to enhance emergency response knowledge while ensuring that fire preparedness permeates both public and private domains (Babatunde et al., 2020). Furthermore, the integration of socio-economic and demographic considerations into preparedness planning, as noted by Cvetković and Marković (2021), facilitates the customization of educational interventions and equitable resource distribution to address the specific needs of vulnerable populations. The deployment of ICT tools significantly enhances communication, early warning capabilities, and real-time decision-making during fire emergencies, thereby reducing response times and mitigating adverse impacts (McNeill et al., 2013). The response dimension of the framework holds equal significance. Effective emergency response relies on the implementation of coordinated action plans that correspond to assessed risk levels and preparedness strategies. Past fire incidents have underscored the necessity of sustaining operational readiness through systematic drills and inter-agency collaboration. Advanced spatial data analytics further contribute to response optimization by enabling strategic hydrant placement and efficient resource deployment. Sector-specific such as investigations into oil and gas facilities and public infrastructure systems demonstrates the importance of context-sensitive and targeted emergency response strategies in minimizing casualties and property losses.

Moreover, the framework underscores a multidimensional perspective by integrating biophysical hazards with social and economic dimensions. Embedding human rights and gender equity principles into disaster risk reduction ensures the inclusion of marginalized and at-risk populations in planning and response processes. Complementary research on wildfire risk management that adopts a community perception and adaptive governance approach reinforces the necessity of an interdisciplinary methodology that is both socially inclusive and technically robust. This integrative approach fosters the development of a resilient system capable of adaptively responding to evolving fire threats, while promoting equitable access to resources and comprehensive fire safety training for all stakeholders.

The Relationship between Integrated Fire Risk Management Framework and Industrial Resilience

The results derived from the simple linear regression analysis demonstrate that the Integrated Fire Risk Management Framework (X) exerts a statistically significant influence on Industrial Resilience (Y), as evidenced by a regression coefficient of 0.362, a t-value of 4.161, and a p-value of 0.000. This p-value is substantially below the conventional threshold of 0.05, thereby confirming a positive and statistically significant relationship between the two variables. Specifically, a one-unit increase in the implementation score of integrated fire risk management is projected to enhance industrial resilience by 0.362 points. These findings affirm that a comprehensive approach to fire risk management contributes meaningfully to reinforcing systemic resilience within industrial settings.

Correlation between systematic fire risk identification and industrial resilience

Risk identification is presumed to function as one of the key indicators within the Integrated Fire Risk Management (IFRM) framework. Given that the overall IFRM construct (X) has

demonstrated a statistically significant relationship with industrial resilience, it is reasonable to infer that subdimensions such as risk identification also contribute meaningfully within the construct. The validity of all IFRM indicators was confirmed, as each recorded an R count exceeding the critical value of 0.1966. Additionally, the construct exhibited adequate internal consistency, with a Cronbach's Alpha of 0.632, surpassing the accepted reliability threshold of 0.6. This indicates that the construct is both valid and reliable. These findings suggest that employing a systematic methodology for identifying potential fire hazards enhances the overall impact of IFRM on strengthening industrial resilience.

Correlation between effective fire mitigation and prevention planning and industrial resilience

Mitigation and prevention planning, similar to risk identification, constitutes an integral component of the Integrated Fire Risk Management (IFRM) framework (X). The regression analysis reveals a statistically significant and substantively meaningful relationship, suggesting that effective implementation of mitigation strategies within this framework can significantly influence industrial resilience. Although the R-Square value of 0.007 indicates that only 0.7% of the variance in industrial resilience is explained by the IFRM variable, the statistical significance of the relationship remains intact. This finding implies that, while the explanatory power is limited in magnitude, the IFRM framework holds meaningful relevance. Consequently, these results highlight the necessity for further development and refinement of the IFRM framework, particularly through the enhancement of subcomponents such as mitigation and prevention, to maximize its overall contribution to industrial resilience.

Correlation between emergency training and industrial resilience

Emergency training serves as one of the indicators within the Integrated Fire Risk Management (IFRM) framework; therefore, its influence is implicitly validated through the statistically significant effect of the IFRM construct (X) on industrial resilience (Y). This suggests that the incorporation of emergency training within the IFRM framework enhances organizational preparedness and facilitates swift response during fire incidents, thereby contributing to the overall strengthening of resilience against operational disruptions.

Correlation between rapid fire response and industrial resilience

Rapid response to fire incidents constitutes one of the key indicators within the Integrated Fire Risk Management (IFRM) framework. The validity testing of IFRM indicators has confirmed their appropriateness, and the overall construct has demonstrated a statistically significant effect on industrial resilience (Y). Accordingly, rapid response emerges as a critical determinant in the effectiveness of IFRM in enhancing industrial resilience. The presence of a positive correlation between rapid fire response and industrial resilience further underscores its strategic importance in mitigating the adverse impacts of fire-related disruptions.

A comprehensive post-fire recovery plan for industrial resilience

The Integrated Fire Risk Management (IFRM) framework demonstrates a statistically significant relationship with industrial resilience. Consequently, it can be inferred that each component within the framework including post-fire recovery plans plays a contributory role in enhancing industrial resilience. Key findings from the study reveal that the regression coefficient of 0.362 and a p-value of 0.000 indicate a strong and positive impact of higher IFRM implementation levels on industrial resilience. Furthermore, the construct's validity is supported by an R count exceeding 0.1966 and a Cronbach's Alpha of 0.632, confirming its reliability and internal consistency.

From a critical standpoint, a comprehensive post-fire recovery plan represents a vital closing phase in the fire risk management cycle. Its function extends beyond the restoration of operations; it also serves to mitigate the likelihood of similar future incidents. In contemporary industrial ecosystems where operations are intricately linked to environmental and operational sustainability such recovery plans embody the system's adaptive capacity and resilience.

In conclusion, the empirically supported significance of the IFRM framework underscores the pivotal role of comprehensive post-fire recovery planning in cultivating a fire-resilient industrial landscape, particularly in the context of climate-induced hazards and the increasing complexity of industrial operations.

CONCLUSION

This study confirms that the implementation of the Integrated Fire Risk Management Framework (IFRM) significantly enhances industrial resilience, with all its core components systematic risk identification, mitigation and prevention planning, emergency training, rapid response, and post-fire recovery contributing to improved adaptive and operational capabilities in fire-prone industrial environments. The analysis reveals a positive correlation between robust IFRM implementation and industrial resilience, supported by a regression coefficient of 0.362 ($p = 0.000$), and further validated through reliability and validity testing. These findings underscore the importance of adopting a holistic, integrated fire risk management strategy as a critical foundation for ensuring industrial sustainability and continuity in the face of increasing environmental and technological threats.

Based on the study's conclusions, several strategic recommendations are proposed to enhance industrial resilience through the Integrated Fire Risk Management Framework (IFRM). Industries should embed IFRM practices into the standard operating procedures and reinforce them through continuous training, structured simulation exercises, and coordinated collaboration with relevant stakeholders. Policymakers should refine fire safety regulations by implementing an integrated, multilevel governance model to improve coordination among governmental bodies, industrial stakeholders, and local communities in risk identification and emergency planning. Additionally, the adoption of advanced digital technologies such as AI-based early warning systems, IoT-enabled fire detection, and data-driven recovery analytics is recommended to strengthen all phases of the IFRM cycle. Further empirical research is also needed to evaluate each IFRM component (X1–X6) independently, enabling more precise analysis of their contributions to industrial resilience and informing the design of more targeted mitigation strategies.

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