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Theoretical Construct: Investigating the Critical Factors of Informality (CFOI) Impacting Fire Risk Management Processes (FRMP) in Informal Settlements (INSE)

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Abstract
This paper aims to identify the impacts and correlations of critical factors of informality (CFOI) with fire risk management processes (FRMP) in informal settlements. The intent of the research is establishing the theoretical constructs to find solutions that contribute to the reduction of fire hazards, its impact, occurrences and risks in informal settlements and to consequentially base the mitigation strategies for fire risk reduction (FRR). To accomplish the intent of the research, pre-established forty-two (42) critical factors of informality (CFOI) have been identified and rationalized to develop the attribution models and to establish the impacts and correlations with fire risk management processes (FRMP) at different levels e.g. Mitigation level (M), Preparedness level(P), response level (R) and Recovery level (r). Understanding the impacts and correlations between CFOI and FRMP has the possibility to form a robust and heuristic fire risk management plan and effective fire safety policies, strategies, frameworks and guidelines, tailored to the existing multi-thematic complexities (MTC) and thematic risk factors (TRF) in informal settlements (INSE). Also, the research has the potential to determine targeted interventions for multiple stakeholders to address the unique challenges in implementing disaster management cycles (Mitigation, preparedness, Response and Recovery) for fire hazards and fire safety and to improve the technical knowledge to form flexible fire safety models with enhanced resilience and effective potential to reduce the fire risks in informal settlements.

KeyWords: **Informal Settlements (INSE), Fire Risk Management Processes (FRMP), Critical Factors of Informality (CFOI), Fire Risk Reduction (FRR), Fire safety**

1. INTRODUCTION

Fire risks and hazards are among the emerging issues in mushrooming urban informal settlements and must be addressed under the sustainable development goal (SDG) 11. NFPA 921 describes the causes of fire hazards as “the circumstances, conditions, or agencies that together accumulate the fuel, ignition source, and oxidizer (such as air or oxygen) responsible for fire hazards or combustion explosion”. Multiple fire causes have been officially included in the Fire & Rescue Service Incident Report (FRSIR), supported by the data compiled by Fire Protection Association of Southern Africa (FPASA).

Multiple studies have been established in the last two decades to understand the whole picture of fire in informal settlements. With the development of performance-based design, some studies have been conducted on fire risk analysis, quantitative risk analysis, probabilistic methods in buildings from different perspectives and levels(Yung and Benichou, 2002) (Kristiansson, G.H., 1996).

Multifaceted qualitative , semi quantitative and quantitative researches have been conducted to assess, evaluate and examine the fire risks in Informal settlements e.g. the causes of fire (Quiroz, Walls and Cicione, 2021), fire dynamics, spread and behavior (Cicione et al., 2021)(Cicione et al., 2022)(Beshir et al., 2021) ,Fire investigations(Quiroz et al., 2020), human behavior and perception during a fire hazard (Guevara Arce et al., 2021) (Ngau and Boit, 2020) and fire detection (Gibson, L. et al.,2018) etc. However, there has been odds and ends suggesting scarce in systematic theoretical methods for analyzing fire risks in informal settlements and the challenging concerning fire risk management.

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A growing concern is how to take appropriate fire risk management measures, to prevent and control potential fire accidents and to reduce the casualties and losses of accidents to ensure building fire safety (Xin and Huang, 2013).This research serves as bridge element to establish the relationship between the critical factors, not just facilitating fire risks but also impacting the fire risk management process at different levels or implementation of fire risk management processes in informal settlements making it susceptible to high damage and vulnerabilities.

The whole fire occurrence, fire dynamics and behavior depend upon the complicated circumstances existing in informal settlements, can be defined as multi-thematic complexities (MTC) (Alam and Paul, 2024). Mult thematic complexities further bifurcate or begets to form thematic risk factors (TRF), causing multiple hazards in informal settlements (Alam and Paul, 2024). In an established study (Alam and Paul, 2024), these thematic risk factors (TRF) have been clustered into forty-two critical factors of informality (CFOI) impacting fire risk and vulnerabilities (FRV) in informal settlements (Figure 1-1).

The idea of the current research is to add value to the existing body of knowledge pertaining to fire safety challenges in informal settlements by establishing the impacts and correlations of those forty-two (42) critical factors of informality (CFOI) with fire risk management processes (FRMP), aiming to unravel how each critical factor contributes to augmenting the fire risks and complicate the fire risk management processes at different levels or can be referred to as disaster management cycle(Arup Fire, 2018) e.g. mitigation, preparedness, response, and recovery, resulting in magnified damages and vulnerabilities in informal settlements.

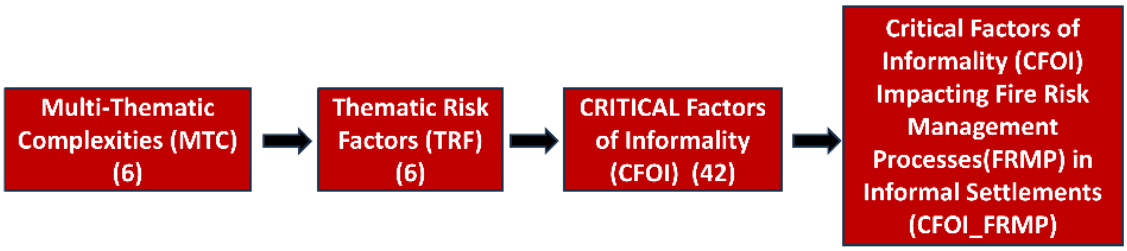

Figure 1-2 Correlations of MTC, TRF, CFOI & FRV (Source: Alam and Paul, 2024)

2. LITERATURE REVIEW

2.1 Determining Multi-thematic complexities (MTC), Thematic Risk Factors (TRF) & Critical Factors of Informality (CFOI)

Multi-thematic complexities (MTC) have been identified as complex networks or intricate interconnections and interactions between various themes in informal settlements, these complex systems give rise to the thematic risk factors (TRF) either responsible for multiple hazards or for facilitating it. The research identified six pre-established Multi-thematic complexities (MTCs) e.g. Socio-economic complexities (S), Behavioral complexities (B), Physical complexities (P), Administrative complexities (A), Environmental complexities (E) and Complexities of fire safety infrastructure (F) as shown the attribution model (Figure 2-1).

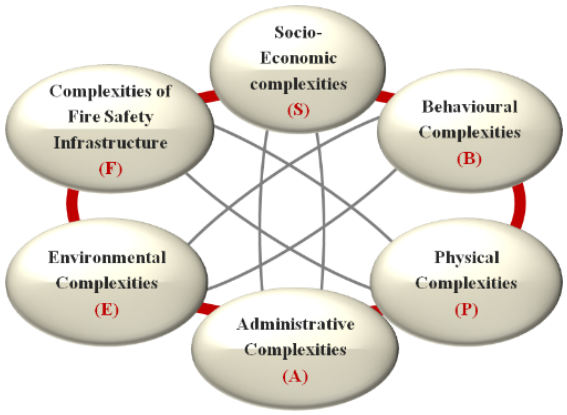

Figure 2-1 Multi-Thematic Complexities (MTC) in Informal Settlements (Source: Alam and Paul, 2024)

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The research considered Six preestablished thematic risk factors (TRF) e.g. Socio-economic Risk Factors (RS), Behavioral Risk Factors (RB), Physical Risk Factors (RP), Administrative Risk Factors (RA), Environmental Risk Factors (RE) and Risk Factors of Fire Safety Infrastructure (RF) (Figure 2-2), further bifurcating into forty-two critical factors of informality(CFOI) (Figure 2-2), impacting fire risks and vulnerabilities (FRV) (Alam and Paul, 2024).

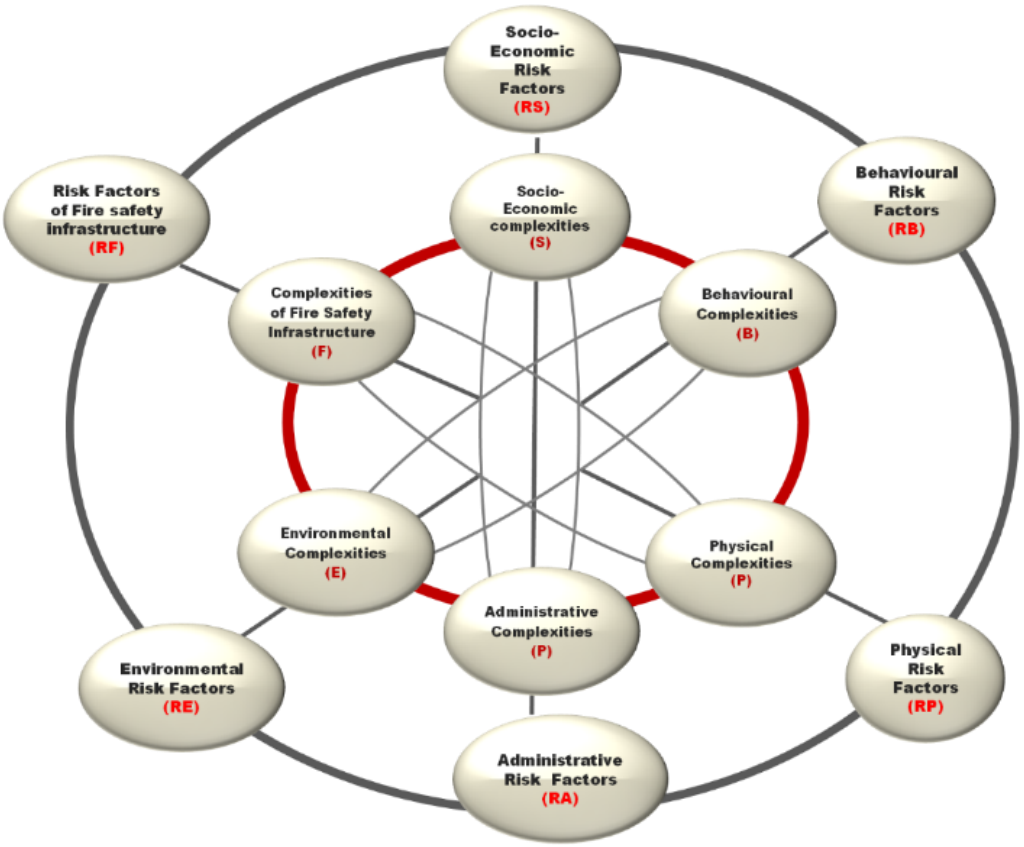

Figure 2-2 Attribution model showing correlations between multi-thematic complexity (MTC) and Thematic Risk Factors (TRF) in Informal Settlements (Source: Alam and Paul, 2024)

2.2 Determining Critical Factors of Informality (CFOI), Impacting Fire Risk Management Processes (FRMP)

Critical factors of informality (CFOI) have been identified as the complex existing circumstances impacting fire risks at different stages (Ignition, growth, development, evacuation and spread) and facilitating fire hazards (Alam and Paul, 2024).

The total of forty-two (42) pre-established critical factor of informality (CFOI) were considered to establish the impacts and correlations with fire risk management processes (FRMP) (Figure 2 3) . Seven (7) CFOI were identified under the socio-economic risk factors (RS). Four (4) major CFOI were identified under behavioral risk factors (RB). Twelve (12) CFOI were identified under physical risk factors (RP). Two (2) CFOI were identified under administrative risk factors (RA). Seven (7) CFOI were identified under environmental risk factors (RE). Lastly, ten (10) CFOI were identified under the risk factors pertaining to fire safety Infrastructure (RF). The impact and correlation of each CFOI with fire risk management processes (FRMP) has been provided (Table xxx)

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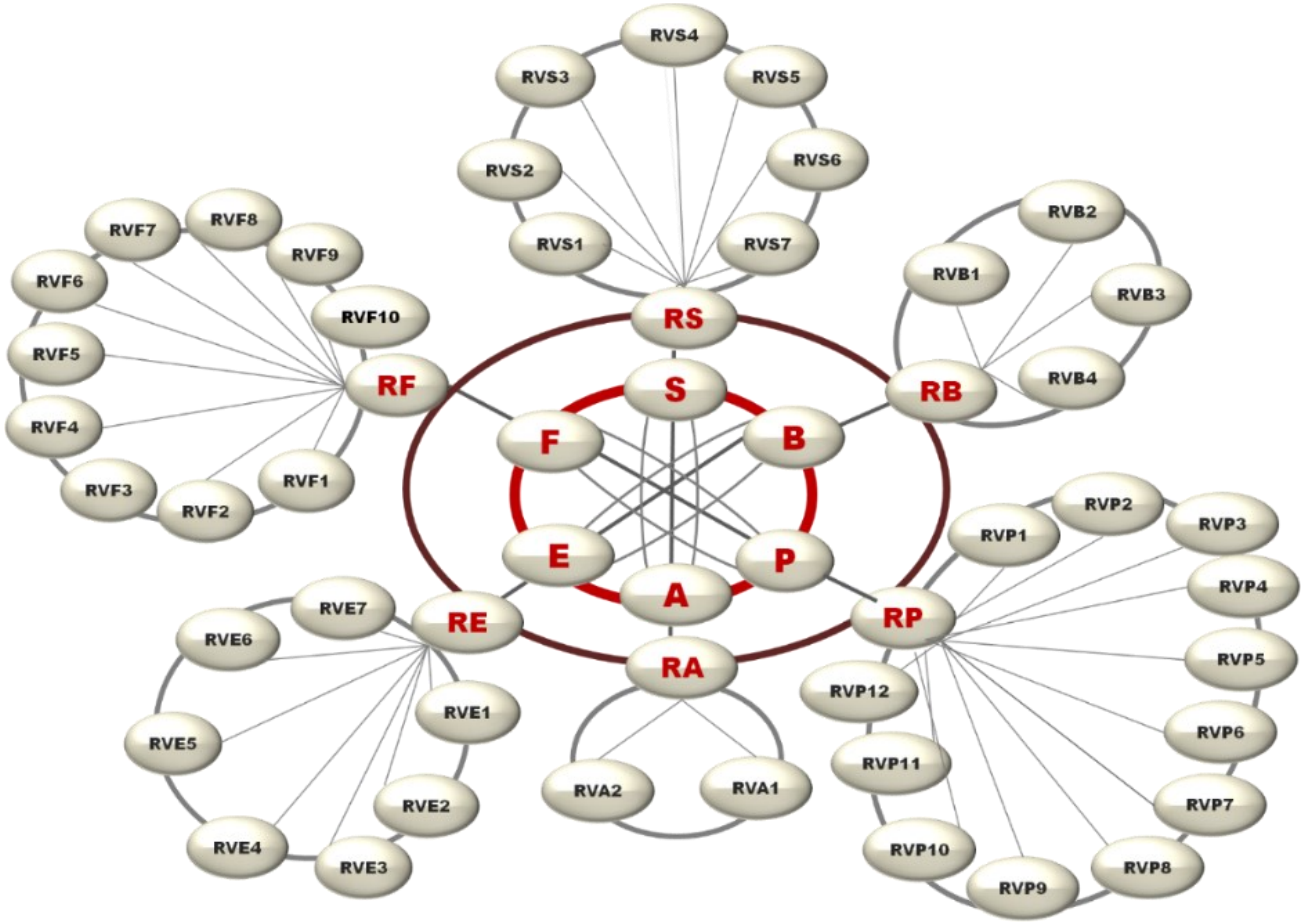

Figure 2-3 Critical Factors of Informality (CFOI) Anomaly of Thematic Risk Factors (TRF) associated with Multi-Thematic Complexities (MTC) (Source: Alam and Paul, 2024)

To conduct the research and establish the impacts and correlations of CFOI and FRMP, the forty-two CFOI has been re-encoded (Figure 2-4). The research findings have been extracted from extensive systematic literature overview, case studies, focused group discussion (FGDs) and hierarchy of Delphi surveys and expert's input.
This research does not intend to evaluate or quantify impact and correlations but rather serves as a primary keystone to step on towards the quantification of methods to assess the challenges of fire risks and safety in informal settlements and target effective and efficient investments in fire risk reduction by developing relevant mitigation strategies, guidelines and framework to reduce fire hazards in informal settlements.

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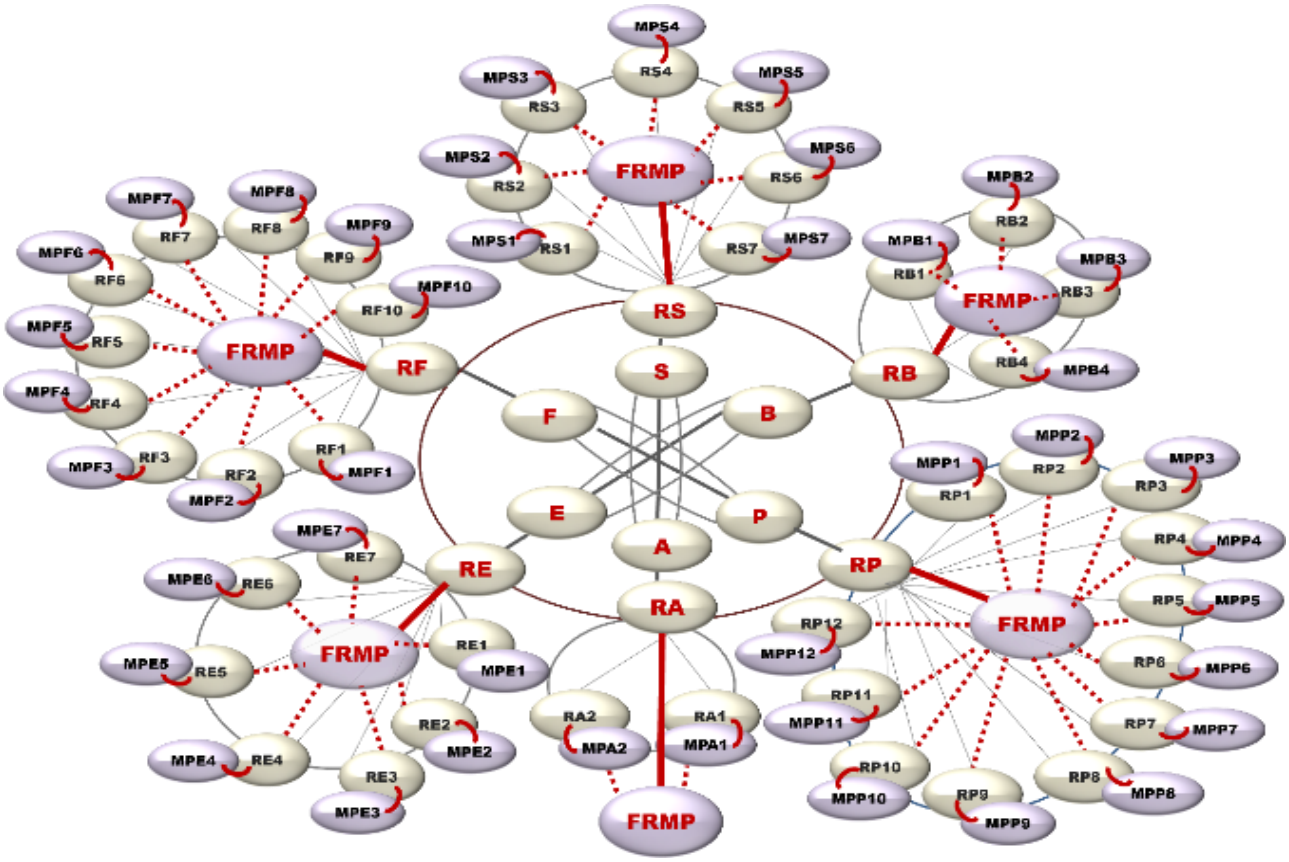

Figure 2-4 Re-encoding of Critical Factors of Informality (CFOI) Impacting Fire Risk Management Processes (FRMP) in Informal Settlements (CFOI_FRMP) (Source: Author)

2.3 Determining the levels of fire risk management Processes (FRMP)

Creating ripples in the sea, Arup has identified a framework for fire safety in informal settlements (Arup Fire, 2018). The framework intends to provide a structured way of approaching the challenge and supports the consideration of fire risk reduction in informal settlements. The framework is organized around the four stages of the disaster management cycle "MPRr" e.g. Mitigation (M), Preparedness (P), Response (R) and Recovery (r) (Figure 2-5).

Figure 2-5 Disaster management cycles considered in informal settlements (Source: Arup Fire,2018)

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Mitigation (M) refers to the management strategies or preventive measures to reduce the possibilities, severities, and subsequent damages by fire risks and hazards (Arup Fire, 2018). The fire safety in informal settlements should serve as the basis for mitigation strategies. Effective mitigation strategies can alleviate the probability, intensity, and effects of fire hazards. Mitigation investments are an affordable way to lower the danger of fire.

Preparedness (P) refers to the disaster management process comprising informed decisions, actions, planning, procedures, activities, resources and training undertaken to anticipate, respond, and recover from potential emergencies or disasters or fire hazards. Preparedness (P) ensures the readiness of an individual or a community to tackle pre-hazard, hazard and post hazard situations. Preparedness is directly correlated to the response and recovery. Preparedness comprises of strategies, processes, materials, and training that impact and educate stakeholders' fire response and recovery are all part of preparedness. Strategies for preparedness should make use of organizational structures, resources, and the abilities of pertinent stakeholders and communities. Organization & Planning, Awareness & Training, and Fire Safety Resources are the primary factors to consider when preparing in informal settlements.

Response (R) refers to the management processes comprising informed actions and decision making during a hazard to protect the critical infrastructure, lives, and property and to prevent subsequent damage. Large scale areas can be impacted by a fire that spreads quickly in informal settlements. Fire response may be greatly enhanced by coordination among emergency services, the community, and other stakeholders. Communication, evacuation, and existing firefighting infrastructure are the most important aspect of preparedness. A successful preparedness can lessen the number of fatalities, destruction of property, disruption of livelihoods, time, effort, and financial outlay needed to get the impacted informal community back to its regular way of life.

Recovery (r) is a post-hazard management process comprising of both long-term and short-term measures, strategies or actions. The short-term actions are taken immediately to assist healthcare and welfare, and longer-term to improvise planning and designing, implement fire safety practices, and allowing communities to navigate to normalcy. Recovery is a dynamic process where long-term strategic goals must be balanced with survivors' current needs.

The research intends to establish the significant impact and correlation of each CFOI with the four level of fire risk management processes (or can be referred to as four stages of the disaster management cycle (MPRr)) e.g. Mitigation(M), Preparedness(P), Response (R) and Recovery (r) to understand how critical factors of informality complicate fire risk management processes and forms the challenges for fire safety and what are the possible interventions and effective spots to formulate a comprehensive fire risk management plan, ensuring fire safety by improvising the fire risk management processes (FRMP) and reducing the impacts of CFOI in informal settlements.

2.4 Critical Factors of Informality (attributed to thematic risk factors (TRF), Impacting fire risk management processes (FRMP) in informal settlements

For the current research, the pre-established forty-two (42) critical factors of informality (CFOI) were identified to establish its impacts and correlations with fire risk management processes (FRMP) (Alam and Paul, 2024). The fire risk management processes (e.g. mitigation, preparedness, response, and recovery) were pre-established and referred to as disaster management cycles by the Structure of the framework developed by Arup (Arup Fire, 2018).

The attribution of each critical factors of informality (CFOI) with the fire risk and vulnerabilities (FRV) have already been established (Alam and Paul, 2024). However, the current qualitative research aims to establish the impacts and correlations of CFOI with FRM. The impact is based on three parameters, direct impact, indirect impact and No impact. Whereas the correlation too has been based on three parameters, positive correlation, Negative correlation and Non-correlated. The impacts and correlations have been established by the extensive systematic literature overview, case studies, focused group discussion (FGDs) and hierarchy of Delphi surveys and expert's input (Table 1,2,3,4,5 & 6)

2.4.1 Critical factor of informality (CFOI) attributed to Socio-Economic Risk factors (RS), Impacting fire risk management processes (FRMP)

Socioeconomic factors affect the way individuals interpret dangerous events or hazards (Rana *et al.*, 2020), as well as their potential adaptive capacities and preparedness for disasters (Cvetković *et al.*, 2022). The experts suggests that socio-economic factors significantly impact the fire risk management processes or disaster management cycle and can have both positive and negative correlations.

The current research suggests that all the identified CFOI attributed to Socio-Economic Risk factors (RS) indicates impact and correlations with FRMP. However, three (3) CFOI e.g. Lack of education & fire safety knowledge (MPS1),

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High density & overcrowding (MPS2) and Lack of monitoring & surveillance (MPS7) shows the significant and direct impact and strong negative correlations.
The Critical factors of Informality (CFOI) not just complicate the fire risk management processes at different level (e.g. mitigation, preparedness, response and recovery) but also perplexes the development and implementation of fire safety measures and framework. Therefore, the inclusive fire safety plan and strategies must indicate the alignments towards these aspects.

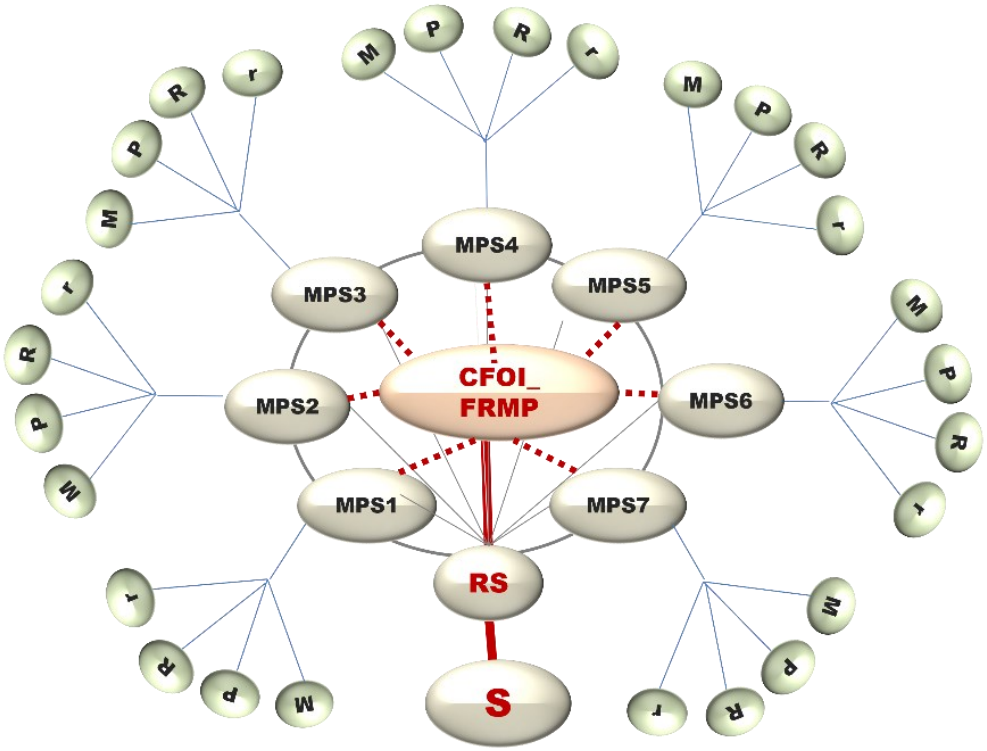

Figure 2-6 Theoretical Attribution model: CFOI Assigned to Socio-Economic Risk Factors (RS), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements (M=Mitigation, P=Preparedness, Response=R & Recovery=r)

Table 1 - CFOI attributed to Socio-Economic Risk Factors (RS), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements

Critical Factors Of Informality (CFOI)	Attributes Of Critical Factors Of Informality (CFOI) Impacting Fire Risk Management Processes (FRMP) ~ CFOI_FRMP	Nature of Correlation with Process 1 **'Mitigation (M)'**	Nature of Correlation with Process 2 **'Preparedness (P)'**	Nature of Correlation with Process 3 **'Response (R)'**	Nature of Correlation with Process 4 **'Recovery (r)'**
Lack of education & fire safety knowledge **(MPS1)**	The critical factor, **'Lack of education & fire safety knowledge (MPS1)'** directly impact the fire risk management processes (FRMP) significantly at every level (e.g. Mitigation, preparedness, response, and recovery). The informal dwellers show limited or no awareness about fire safety and fire hazards, resulting in poor implementation of fire safety practices, negatively impacting the mitigation strategies and complicating the implementation of preparedness measures in	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**

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	informal settlements. Also, due to low level of education, insufficient knowledge, and lack of fire safety training, informal dwellers demonstrates inadequate or no preparedness, residents might lack basic preparedness measures, such as availability of fire extinguishers, usage of fire retardant paint , escape plans, and mindful use of material application in construction to exacerbate the impact of a fire, on the other hand informal dwellers suffuse the dwelling units with high fuel load and combustible material. The Lack of education & fire safety knowledge of informal dwellers also impacts the potential of effective decision-making during the fire hazards, resulting in delayed responses, and very often the people become the obstruction in fire rescue operations, adversely affecting the community resilience and response during a fire hazard. After a fire hazards, communities without fire safety training may struggle to recover as the lack of knowledge about available resources or support systems can hinder effective rebuilding efforts, resulting in prolonged recovery.				
High density & overcrowding **(MPS2)**	The critical factor, '**High density & overcrowding (MPS2)** directly impacts fire risk management processes (FRMP) at every level (e.g. Mitigation, preparedness, response, and recovery). High density and overcrowding composed in informal communities without having fire safety knowledge become a peril and not only impact the possibilities and occurrences of fire hazard but also impact Mitigation measures and strategies (Higher density, higher the possibility of occurrences of fire hazards). High density and overcrowding in informal settlements negatively impact the adequacy of infrastructure and resources, affecting the preparedness for fire hazards. High density and overcrowding directly impacts the response operations as well e.g. limited/narrow or insufficient access and egress (catering to a larger population/high density) impacts the fire rescue, evacuation and control operations. High density and overcrowding also causes delays in decision making and very often results in conflicts among the informal dwellers at times of fire hazards causing Response and operation delays and subsequent damage. High density and overcrowding is also strongly and negatively correlated to Recovery e.g. the factor is attributed to higher vulnerabilities (social, economic an environmental) and possibility of high damage, resulting in long-term or prolonged **recovery,** post fire hazards in informal settlements.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Poor or Low level of maintenance **(MPS3)**	The critical factor **'Low level of maintenance (MPS3)'** directly impacts fire risk management processes (FRMP) at every level (e.g. Mitigation, preparedness, response, and recovery). Poor or low maintenance of informal dwellings and settlements, adversely affects the mitigation measures or implementation of mitigation measures in informal settlements for fire hazards due to the	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**

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	patchwork and poor application of highly flammable & combustible materials, surging the combustible fuel load of informal dwellings. Low maintenance creates unsafe conditions, increasing the risk of fires and adversely affecting the mitigation measures. Poor or low maintenance creates vulnerable situations impacting fire risks and fire safety affecting the preparedness in informal settlements. The critical factor impacts the response systems indirectly e.g. low or poor maintenance results in fragility of the structures complicating the response measures. Poor or low maintenance very often causes high damage and prolong recovery.				
No. of children present (0-6 years) **(MPS4)**	The critical factor, **'No. of children present (0-6 year) (MPS4)'** significantly and directly impact the fire risk management processes (FRMP) at two level (e.g. Mitigation and response,). Presence of children (below 6 years) in informal settlements with the possibility of them playing with fire ignition sources (e.g. matchsticks, firecrackers and candles, etc.) is negatively correlated to the mitigation measures (if existing in informal settlements) (Hirst and Underhill, 2023) by facilitating the possibility of occurrences of ire hazards. No. of children present (or presence of children below six years) in informal settlements often become challenging during the response time and fire rescue operations. However, the factor does not impact the preparedness and recovery directly and is non-correlated. However, the children are more susceptible to fatalities, burns and injuries, negatively correlating to the recovery measures.	**Direct Impact & Negative Correlation**	**Indirect Impact & Uncorrelated**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
No. of women present **(MPS5)**	**The critical factor, 'No. of women present (MPS5)'** impacts the fire risk management processes (FRMP) impacts at all levels of management process (e.g. Mitigation, preparedness, response and response) directly and indirectly. The presence of women is attributed to the practice of cooking, heating and burning, these activities increase the possibilities of accidental fire hazards impacting the mitigation measures in informal settlements, therefore the presence of women is negatively correlated to the Mitigation levels or measures. Bryan et al. reported that in case of fire, men were more focused on firefighting activities, whereas the immediate reaction of women was to evacuate and call the fire service (Bryan, J.L., 2002), they also assist in evacuation, fetching water and directing men (Hirst, 2023), these aspects signifies that woman very often tends to have a positive correlation with the response measures. Women are more vulnerable to burn injuries. However, in some cases, experts have noticed that the first reaction of men was to find the source of fire, whereas women were focused on the evacuation of family members (Fernandez et al., 2018),	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Both Positive and Negative Correlation**	**Direct Impact & Positive Correlation**

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	facilitating the responses and rescue operations. However, various experts and research suggests that presence of women during a fire hazard is negatively correlated to response measures as Women tends to guard the possessions diversely communicate through cell phones and keeps going back to the burning areas to collect valuable goods/belongings, completely obstructing fire rescue operations, communications and evacuation processes. Females are more concerned about the threat of fire to life (Cvetković et al., 2022). In terms of recovery Women shows a significant impact and positive correlations e.g. Women significantly organizes community, maintains strong social networks, manage household resources, keeps the track of needs and requirements of the family, and facilitate the mobilization to enhance collective action during recovery efforts and effectiveness of aid distribution and resource allocation. Women also possess valuable understanding concerning risks and resources which can inform recovery strategies. Experts suggests that Inclusive measures are more responsive and inclusive with the involvement of women in decision-making processes ensuring needs of the entire community.				
Presence of elderly (65 years or above), disabled and sick family member **(MPS6)**	The critical factor of **'Presence of elderly (65 years or above), disabled, and sick family members (MPS6)'** significantly impact the fire risk management processes (FRMP) at response level e.g. the elderly are most at risk due to poor mobility, rapid fatigue, confusion, and impaired vision or hearing. In addition, older people often refuse to evacuate (Cvetković et al., 2022) (Jenkins, Laska and Williamson, 2007), delaying and challenging the response operations during fire hazards.	**No Impact & Uncorrelated**	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Lack of monitoring & surveillance **(MPS7)**	The critical factor '**Lack of monitoring & surveillance (MPS7)**' impact the fire risk management processes (FRMP) at all levels of management process (e.g. Mitigation, preparedness, response and response,) and is highly and negatively correlated. Lack of monitoring and surveillance results in casual approach of informal dwellers in every aspect e.g. left open flame sources, unattended risk factors, unsupervised children left with fire ignition resources, conducting social & Religious activities or practices that provoke fire hazards (e.g. Pooja, Barbeque and open angethis etc. All the factors not just impact the mitigation strategies in informal settlements but also impacts preparedness, response and recovery.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**

2.4.2 Critical factor of informality (CFOI) attributed to Behavioral Risk Factors (RB), Impacting fire risk management processes (FRMP)

Residential building fire (Considering the informal settlements as residential dwelling) disasters are typically caused by human activity or specific behavior. Out of the three criteria impacting the level of fire response performance in the event of a structure fire (e.g. building traits, human qualities, and fire), Human qualities possessing behavioral

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constructs indicates a strong risk factor (Cvetković *et al.,* 2022). The current research suggests that all the identified CFOI attributed to Behavioral Risk Factors (RB), indicates impact and correlations with FRMP.
Most of the CFOI attributed to the behavioral risk are responsible for the ignition of fires and possibilities of occurrences of fire hazards in informal settlements. However, two CFOI e.g. Potential arsonists (MPB2) and Operation with sparks and open flames (MPB3) shows the significant and direct impact and strong negative correlations. These CFOI not just complicates the fire risk management processes but also makes it challenging to develop and implement the fire safety plan. Therefore, the inclusive fire safety plan and strategies must indicate the alignments towards these aspects.

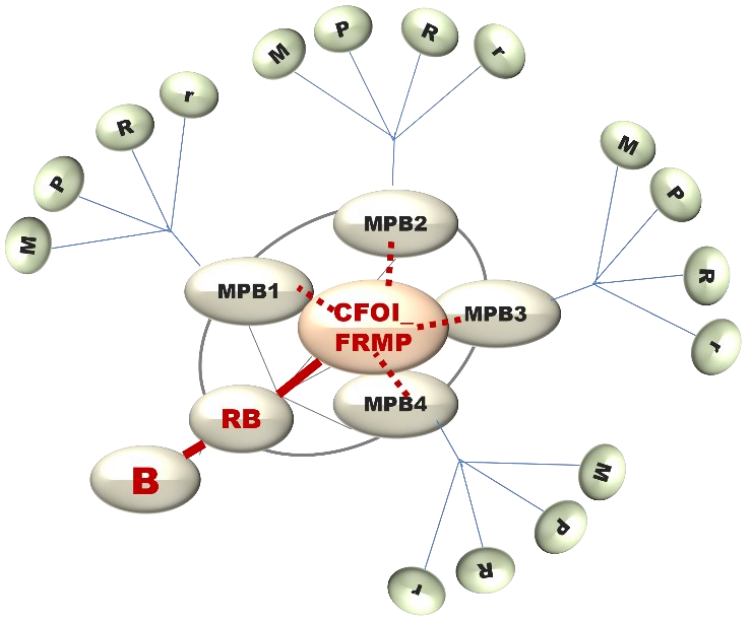

Figure 2-7 Theoretical Attribution model: CFOI attributed to behavioral Risk Factors (RB), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements (M=Mitigation, P=Preparedness, Response=R & Recovery=r)

Table 2 - CFOI attributed to behavioral Risk Factors (RB), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements

Critical Factors Of Informality (CFOI)	**Attributes Of Critical Factors Of Informality (FOI) Impacting Fire Risk Management Processes (FRMP) ~ CFOI_FRMP**	Nature of Correlation with Process 1 **'Mitigation (M)'**	Nature of Correlation with Process 2 **'Preparedness (P)'**	Nature of Correlation with Process 3 **'Response (R)'**	Nature of Correlation with Process 4 **'Recovery (r)'**
Smoking cigarette / disposed half-lit cigarette butts/drug Consumption/ alcohol consumption **(MPB1)**	The critical factor '**Smoking cigarette / disposed half-lit cigarette butts/drug Consumption/alcohol consumption (MPB1)'** directly impacts the fire risk management processes (FRMP) significantly at Mitigation level as the factor is attributed majorly to the ignition of fire resulting in the possibilities of occurrences of fire hazards. However, the factor is not directly attributed to the other management process e.g. preparedness, response and recovery(r)	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**	**No Impact & Uncorrelated**	**No Impact & Uncorrelated**

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Potential arsonists **(MPB2)**	The critical factor **'Potential arsonists (MPB2)'** directly impact the fire risk management processes (FRMP) at all levels (e.g. Mitigation, preparedness, response and response). The factor is attributed to the observed substance misuse problems e.g. mental stress or mental health issues Community Violence, Domestic violence, vandalization, Riots, Conflicts, and Crimes resulting in the possibility of fire hazards in informal settlements impacting the mitigation and preparedness of informal settlements. The factor is also attributed to the possibilities of delayed or obstructed emergency responses at times of fire hazards as the informal dwellers do not cooperate with the teams where additional or external support mechanisms are required for the rescue operation team to act., resulting in challenges for fire control and high damage, negatively impacting the recovery aspects as well.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Operation with sparks and open flames **(MPB3)**	The critical factor **'Operation with sparks and open flames (MPB3)'** directly impact the fire risk management processes (FRMP) at all levels due to its potential of facilitating fire risks and hazards. The factor is negatively correlated to all the aspects of mitigation, preparedness, response and recovery.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Repairing of informal dwelling **(MPB4)**	The critical factor **'Repairing of informal dwelling (MPB4)'** indirectly impacts the fire risk management processes (FRMP) at Mitigation and preparedness levels and indirectly impacts the response and response measures. The factor is attributed to the observed repairing behavior and techniques adopted by informal dwellers (e.g. use of papers, sandbags, or plastics to seal the openings in ceilings or walls), which forms the leaky details resulting in occurrences of fire hazards and fire spread impacting Mitigation and preparedness. However, the leaky details and patchy repairs forms challenges during the response time, complicating the fire rescue operations, resulting in delay and subsequent high damage leading to prolonged recovery time.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**

2.4.3 Critical factor of informality (CFOI) attributed to Physical Risk Factors (RP), Impacting fire risk management processes (FRMP)

The current research suggests that all the identified CFOI attributed to Physical Risk Factors (RP), indicates impact and strong correlations with fire risk management processes. Out of all the Thematic risk factors, physical risk consists of the highest critical factors of informality (CFOI). Structural Composition & combustibility (MPP1), Structural age & fragility (MPP2), Non-structural composition & combustibility (Internal fire load density or fuel load density) (MPP3), Critical Separation distance (average minimum distance to nearest neighbor) (NN) (MPP6), Lack of water resources, water supply and water drainage systems (MPP7), Critical patch size /patch density (CPS) (MPP11) and Edge density & Landscape density (PLAND)(MPP12) are the CFOI which directly impacts the FRMP and indicates a strong negative correlation with each CFOI equally . Consider that in informal settlements a 'critical patch' can constitute the vast majority or entirety of a settlement (Stevens, 2019), and the empirical approaches developed so far do not appear to meet the scope of the informal settlement problem. (Stevens, 2023). These CFOI make it difficult to create and carry out a fire safety strategy in addition to complicating the fire risk management procedures. Therefore, the alignments with these areas must be indicated in the comprehensive fire safety strategy and tactics.

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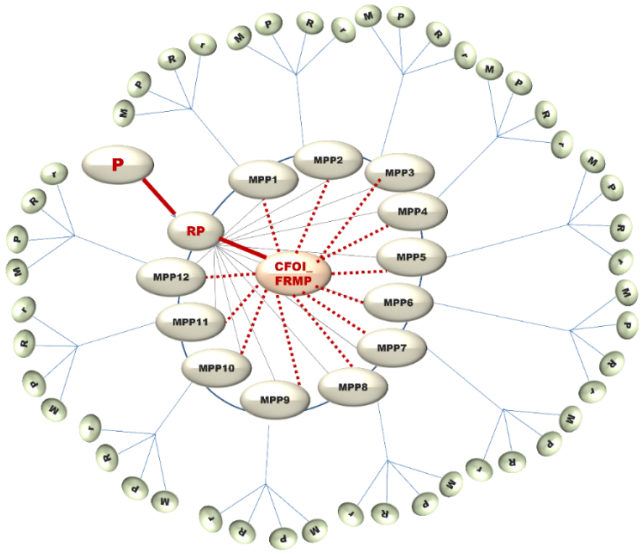

Figure 2-8 Theoretical Attribution model: CFOI attributed to Physical Risk Factors (RP), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements (M=Mitigation, P=Preparedness, Response=R & Recovery=r)

Table 3. CFOI attributed to Physical Risk Factors (RP), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements

Critical Factors Of Informality (CFOI)	**Attributes Of Critical Factors Of Informality (FOI) Impacting Fire Risk Management Processes (FRMP) ~ CFOI_FRMP**	Nature of Correlation with Process 1 **'Mitigation (M)'**	Nature of Correlation with Process 2 **'Preparedness (P)'**	Nature of Correlation with Process 3 **'Response (R)'**	Nature of Correlation with Process 4 **'Recovery (r)'**
Structural Composition & combustibility **(MPP1)**	The critical factor **'Structural Composition & combustibility (MPP1)'** directly and significantly impact the fire risk management processes (FRMP) at all levels or disaster management cycles (e.g. Mitigation, preparedness, response and response). The factor is attributed to the application of sub-standard and low-cost material, informal dwelling composition, and structural elements (e.g. Wall, columns, foundation, roof, and flooring) with poor & leaky details consisting of low fire resistance, high combustibility (Alam and Paul, 2024). The factor negatively impacts the mitigation and preparedness as it contributes to the facilitation and occurrences of fire hazards due to the physical complexities and high combustibility. The factor also impacts the response and recovery as the factor contributes to high rate of fire spread, development of secondary fires, delay in response time and high scale of damage leading to prolonged recovery phases.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Structural age & fragility **(MPP2)**	The critical factor **'Structural age & fragility (MPP2)'** negatively impacts the fire risk management processes (FRMP) at all levels of management process (e.g. Mitigation, preparedness, response and response). The structural age facilitates the possibilities and occurrences of fire hazards (old structure exhibits old services, old electricity and water connections, low maintenance, high repair patches and high risks of fire hazards) however the structural fragility impacts the preparedness as it becomes impossible to establish fire safety measures/infrastructure and equipment. The factor also complicates the fire rescue operations elongating the response time. The factor consequentially leads to high damages and prolonged recovery.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**

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Non-structural composition & combustibility (Internal fire load density or fuel load density) **(MPP3)**	The critical factor **'Non-structural composition & combustibility (Internal fire load density or fuel load density) (MPP3)'** directly impacts the fire risk management processes (FRMP) at all levels (e.g. Mitigation, preparedness, response and response). The factor is attributed to the presence and distribution of fuel load inside the informal dwelling unit. The fuel load facilitates the occurrence and spread of fire hazard, negatively correlating to Mitigation measures. The presence of high fuel load inside the dwelling unit signifies the low preparedness in terms of fire hazards. High fuel load facilitates the spread and possibilities of large scale of fires, complicating the response measures for both the informal dwellers and the fire rescue operations teams. High fuel load also symbolizes high damage, impacting the recovery.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Ventilation Profile of informal dwellings / informal settlement **(MPP4)**	The critical factor **'Ventilation Profile of informal dwellings / informal settlement (MPP4)' directly** impacts the fire risk management processes at Mitigation, preparedness, response level and indirectly impacts the recovery. The factor is attributed to the Presence of openings inside the dwelling units (e.g. doors, windows, shafts, Ventilators & chimneys, etc.). Openings and opening size influence the size of the flames omitted, the spread of fire, and the oxygen concentration in the atmosphere. The door and windows remain a weaker point for ignition resistance. hence the factor negatively correlated to the Mitigation, preparedness and response during the fire hazards in informal settlements. However, the factor is also positively correlated to the response measures, as the openings often acts as a punctures for the rescue operations. The factor is not directly corelated to the Recovery measures.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Both Negative and Positive Correlation**	**Indirect Impact & Non-Correlated**
Proximity & distance **(MPP5)**	The critical factor **'Proximity & distance (MPP5)'** directly impacts the fire risk management processes (FRMP) at Mitigation and preparedness and indirectly impacts at response and recovery levels. The factor is attributed to the distance proximities to any hazardous/ignition source e.g. electric pole, transmission line, Electric Substation, HT & LT Lines, forest/crop/bushes and industrial areas etc. that might facilitate the possibility of fire risk and occurrences of fire hazard, establishing negative correlations with mitigation and preparedness. Due to its complexities, the factor also has the negative correlations with response and recovery facilitate the fire spread, complicating fire rescue operations and causing high damages leading to consequentially prolonged recovery..	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Critical Separation distance (average minimum distance to nearest neighbor) (NN) **(MPP6)**	The factor **'Critical Separation distance (average minimum distance to nearest neighbor) (NN) (MPP6)'** directly impacts the fire risk management processes (FRMP) at all levels of management process (e.g. Mitigation, preparedness, response and response). The factor is attributed to the distance between neighboring dwellings or closely spaced buildings / Co dwelling / clusters / Attached adjacent walls etc., signifying the possibility of high fire spread involving multiple dwellings and exacerbating the Risk of Secondary Fires (Wang et al., 2021). The factor indicates negative correlations with each disaster management cycle (e.g. mitigation, preparedness, response and recovery)	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Lack of water resources, water supply and water drainage systems **(MPP7)**	The critical factor **'Lack of water resources, water supply and water drainage systems (MPP7)'** directly impacts the fire risk management processes (FRMP) at all the levels (e.g. Mitigation, preparedness, response and recovery). the factor is attributed to unreliable Sourcing, tattered and unkempt water drainage systems and insufficient water supply. The inadequacy of water to quell fire and inefficient Water Drainage Systems (Pucca/Covered /Underground) impacts mitigation measures and preparedness of informal settlements to tackle fire hazards and muddle the fire rescue operations, delays the response causing subsequent damage, causing prolonged recovery(Hu et al., 2022),	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**

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	therefore the factor is negatively correlated to each level of disaster management cycle.				
External fuel load **(MPP8)**	The critical factor **'External fuel load (MPP8)'** impacts the fire risk management processes (FRMP) directly at Mitigation, preparedness and response level and indirectly at recovery level. The factor is Attributed to the external surrounding fuel load arrangement or combustible material present outside the informal dwellings (e.g. woods, tires, rubbers, scrap, plastic, etc.). The factor is also attributed to the presence of trees, Shrubs, and Dry leaves outside the dwelling units. The vegetation or greenery often acts as fuel and bridge to fire spread from one dwelling to another dilating the possible scale of damage. The factor is also attributed to the Practice of informal dwellers to store waste/scrap, open waste disposal System outside the dwellings. The factor negatively correlates to the mitigation and preparedness at settlement levels and further complicates the response operations. Due to the possibility of high damage, the recovery also becomes acutely prolonged.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Lack of accessibility & egress **(MPP9)**	The critical factor, **'Lack of accessibility & egress (MPP9)'** directly impacts the fire risk management processes (FRMP) at preparedness level and Response level and indirectly impacts the mitigation measures and recovery. The factor is attributed to the narrow lanes/streets, limited means of access, and limited escape routes in informal settlements impacting **Mitigation and challenging or complicating the preparedness**. With high density or overcrowding the factor results in low evacuation capacity, obstructions and hindrance of entrance and exit routes complicating rescue operations, impacting **Response** and resulting in delays. The delay indicates high damage and prolonged **Recovery** due to the damages done by fire hazards.	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Presence of any unique characteristic (e.g. makeshift stairs /paths etc.) **(MPP10)**	The critical factor, **'Presence of any unique characteristic (e.g. makeshift stairs /paths etc.) (MPP10)'** directly impacts the fire risk management processes (FRMP) at preparedness level and response level and indirectly impacts the mitigation measures and recovery. The factor is attributed to the presence of unique and fragile structures e.g. Makeshift staircases, extended platforms, random and dead-end pathways(kutcha) and non-supported structural systems etc. These structure not just complicates the mitigation measures and preparedness but also impact the egress and forestalls the fire rescue operations and evacuation measures, impacting Response and recovery. Therefore, the factor is negatively correlated to each level of FRMP.	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Critical patch size /patch density **(CPS) (MPP11)**	The factor, **'Critical patch size /patch density (CPS) (MPP11)'** directly impacts the fire risk management processes (FRMP) at multiple levels (e.g. Mitigation, preparedness, response and response). The critical factor refers to the congestion within group of dwellings that all lie within a given critical distance (CD) where the possibility of fire spread within the settlement/cluster is very high if initiated from an ignition source. Critical patch size signifies the congestion in informal settlements. The congestion not just negatively correlates to the mitigation and preparedness measures but is very often responsible for obstructed rescue and challenging emergency operations, negatively correlating to the response measures. The factor is attributed to high rate of fire spread leading to higher possibilities of damage and prolonged delays, showing significant negative correlations to recovery. From the case studies it is very evident that due to large critical patch sizes in informal settlements, multiple informal dwellings burn within minutes due to high congestion and fire spread rate.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**

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Edge density & Landscape density (PLAND) **(MPP12)**	The critical factor, **'Edge density & Landscape density (PLAND) (MPP12)'** directly impacts the fire risk management processes (FRMP) at multiple levels (e.g. Mitigation, preparedness, response and response). The factor refers to the equals the sum of the lengths (m) of all edge segments in the landscape/settlements, divided by the total landscape area (m2), multiplied by 10,000 (to convert to hectares). The factor is attributed to the compactness in informal settlements, indicating high edge density or landscape density. The compactness not just negatively correlates to the mitigation and preparedness measures but also correlates to the response measures and recovery, due to the obstructed rescue and emergency operations and high rate of fire spread resulting in higher possibilities of subsequent damage.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**

2.4.4 Critical factor of informality (CFOI) attributed to Administrative Risk Factors (RA), Impacting fire risk management processes (FRMP)

Administrative factors are foundational to effective fire risk management processes. However, the research finding suggests strong impacts and negative correlations of the two CFOI e.g. Non-compliance of standards and byelaws (MPA1) and Lack of control & funding (MPA2), pertaining to Administrative Risk Factors (RA) with the fire risk management processes (FRMP) e.g. Mitigation, preparedness, response and recovery. The inclusive Fire safety Strategies should involve the clear obliteration of administrative risk factors in informal settlements and must delegate to strong policies, adequate resources, effective training, regulatory compliance, and community engagement comprehensively, preventing and responding to fire risks and hazards with resilience.

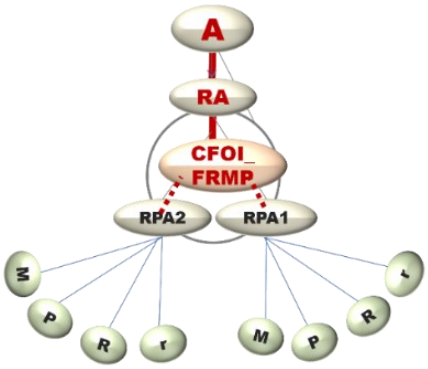

Figure 2-9 Theoretical Attribution model: CFOI attributed to Administrative Risk Factors (RA), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements (M=Mitigation, P=Preparedness, Response=R & Recovery=r)

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Table 4 - CFOI attributed to Administrative Risk Factors (RA), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements

Critical Factors Of Informality (CFOI)	Attributes Of Critical Factors Of Informality (FOI) Impacting Fire Risk Management Processes (FRMP) ~ CFOI_FRMP	Nature of Correlation with Process 1 **'Mitigation (M)'**	Nature of Correlation with Process 2 **'Preparedness (P)'**	Nature of Correlation with Process 3 **'Response (R)'**	Nature of Correlation with Process 4 **'Recovery (r)'**
Non-compliance of standards and byelaws **(MPA1)**	The critical factor, **'Non-compliance of standards and byelaws (MPA1)'** impacts the fire risk management processes (FRMP) equally at multiple levels (e.g. Mitigation, preparedness, response and response). The factor is attributed to the lack of fire safety norms, codes, byelaws, standards, guidelines, building regulations & Legislations, etc. in informal settlements, resulting in the lack every aspect of management framework.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Lack of control & funding **(MPA2)**	The critical factor, **'Lack of control & funding (MPA2)'** also impacts the fire risk management processes (FRMP) equally at multiple levels (e.g. Mitigation, preparedness, response and response). The factor is attributed to the lack of funding and lack of development and municipal and fire safety regulation enforcement. The factor collectively complicates the implementation of risk management framework, making the informal settlements more susceptible towards fire hazards.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**

2.4.5 Critical factor of informality (CFOI) attributed to Environmental Risk Factors (RE), Impacting fire risk management processes (FRMP)

The current research suggests that all the identified CFOI attributed to Environmental Risk Factors (RE), indicates impact (directly and Indirectly) and strong correlations with fire risk management processes (FRMP). However, most of the CFOI attributed to environmental risk factors impacts the response during a fire hazard in an informal settlement. The Rising temperature /heat (MPE1) mostly impacts at the ignitions phase of fire and fire spread and impacts the mitigations measures and response operations. However, Wind velocity/speed and wind direction (MPE2) also impacts they fire spread and is negatively correlated to the preparedness and fire controlling response operations, like the CFOI Humidity/Moisture (MPE3). Slope/Topography (MPE4), Month of the year (MPE5), Time of the day (MPE6) and lastly Presence of potential wild land-urban interfaces (WUI) (MPE7) are all strongly and negatively correlated to the Response measures complicating the fire rescue operations by both the informal dwellers and the fire rescue teams at times of fire hazards. Therefore, the fire safety plan and mitigations strategies pertaining to fire risk management processes must entail the alignments with these areas must be entail these critical factors to achieve the comprehensiveness in fire safety.

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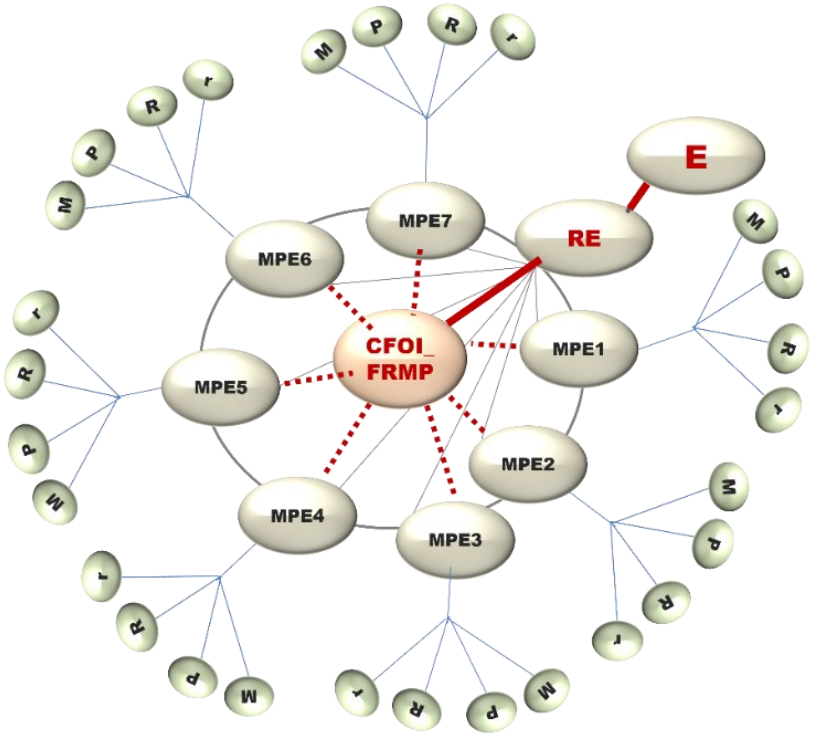

Figure 2-10 Theoretical Attribution model: CFOI attributed to Environmental Risk Factors (RE), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements (M=Mitigation, P=Preparedness, Response=R & Recovery=r)

Table 5 - CFOI attributed to Environmental Risk Factors (RE), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements

Critical Factors Of Informality (CFOI)	Attributes Of Critical Factors Of Informality (FOI) Impacting Fire Risk Management Processes (FRMP) ~ CFOI_FRMP	Nature of Correlation with Process 1 **'Mitigation (M)'**	Nature of Correlation with Process 2 **'Preparedness (P)'**	Nature of Correlation with Process 3 **'Response (R)'**	Nature of Correlation with Process 4 **'Recovery (r)'**
Rising temperature /heat **(MPE1)**	The critical factor, **'Rising temperature /heat (MPE1))'** directly impacts the fire risk management processes (FRMP) at the mitigation and Response level and indirectly on Preparedness and Recovery. The factor is attributed to the increased heat exposure, drought and dry conditions often resulting in electrical overload, ignition, and multiple behavioral factors. that exacerbate the risk of fire hazards in informal settlements, complicating the implementation of mitigation measures. The factor also contributes to the challenges of controlling fire as to when the temperature is very high reaching to the ignition level, it not just exacerbates the fire extinguishing but also facilitates the secondary fires, complicating the fire rescue operations done by the fire safety team and informal dwellers, impacting the Response measures. The factor also contributes to the possibility of high damage ensuring prolonged recovery. Therefore, the factor is negatively correlated to all the fire risk management processes.	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Wind velocity/speed and wind direction	The critical factor, **'Wind velocity/speed and wind direction (MPE2)'** directly impacts the fire risk management processes (FRMP) at the Preparedness and Response level. However, indirectly impacts the	**Indirect Impact &**	**Direct Impact & Negative Correlation**	**Direct Impact &**	**Indirect Impact &**

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(MPE2)	Mitigation and recovery measures. The factor is attributed to the effect of wind speed and direction on the behavior of informal fires. The factor effects the intensity and rate of fire spread, challenging the preparedness and complicating the deployment of firefighting and fire safety equipment/ resources, impacting the evacuation operations and collective response measures in informal settlements.	**Negative Correlation**		**Negative Correlation**	**Negative Correlation**
Humidity/ Moisture **(MPE3)**	The critical factor, **'Humidity/Moisture (MPE3)'** impacts the fire risk management processes (FRMP) at the preparedness and Response level. The factor is attributed to the scenario of reduced humidity levels, adversely affecting the spread of fires by promoting faster combustion and fire growth. Particularly in informal settlements with dense and flammable building materials, the factor complicates fire rescue, control operations, Response time and measures.	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Slope/ Topography **(MPE4)**	The critical factor, **'Slope/Topography (MPE4)'** impacts the fire risk management processes (FRMP) at the preparedness and response level. The Steep slopes or undulated topographies may restrict the access for firefighting vehicles and personnel, delaying response times. Residents living on steep slopes may face increased difficulty in evacuating during fire emergencies, especially if pathways are narrow, and obstructed.	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Month of the year **(MPE5)**	The critical factor, **'Month of the year (MPE5)'** impacts the fire risk management processes (FRMP) at the response and preparedness level measures. The factor is attributed to the Seasonal variations challenging and impacting emergency response capabilities of fire rescue team and other factors concerning the weather and climatic variations e.g. accessibility of roads during rainy and flood-prone months, high temperatures during peak summer times, availability of water for firefighting etc.	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Time of the day **(MPE6)**	The critical factor, **'Time of the day (MPE6)'** impacts the fire risk management processes (FRMP) at the response measures and recovery. Fires that start at night may not be immediately detectable, delaying emergency response and allowing fires to grow in intensity before intervention, resulting in high damage and prolonged recovery. The time of the day also impacts the communication systems e.g. it is hard to communicate with people during nighttime due to lack of daylight and streetlights in informal settlements. The factor also impacts the evacuation operations for the people who are asleep.	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Presence of potential wild land-urban interfaces (WUI) **(MPE7)**	The critical factor, **'Presence of potential wild land-urban interfaces (WUI) (MPE7)'** impacts the fire risk management processes (FRMP) at multiple levels (e.g. Mitigation, preparedness, response and recovery) both positively and negatively e.g. The difficult terrain and transitional landscape may hinder fire safety and rescue operations in informal settlements complicating the response, but the presence of potential interfaces can often act as refugee areas and may help the possibility to strengthen the preparedness.	**Direct Impact & both Negative and positive Correlation**	**Direct Impact & both Negative and positive Correlation**	**Direct Impact & both Negative and positive Correlation**	**Indirect Impact & both positive and Negative Correlation**

2.4.6 Critical factor of informality (CFOI) attributed to Risk factors of fire safety Infrastructure (RF), Impacting fire risk management processes (FRMP)

The current research suggests that all the identified CFOI attributed to Risk factors of fire safety Infrastructure (RF), indicates impact (directly and Indirectly) and strong correlations with fire risk management processes (FRMP). Most of the attributed CFOI attributed directly impacts the response during a fire hazard in an informal settlement and are negatively correlated to it by complexifying and obfuscating the response measures during the fire hazards. However out of the critical factors attributed to the Risk factors of fire safety Infrastructure (RF), Lack of publicly provided fire safety infrastructure (Protection, suppression & evacuation plan) (MPF1), Lack of community-based fire awareness & fire management training programs (MPF2) and Lack of fire data, analysis and availability (MPF10) are the factors which impacts the fire risk management processes(FRMP) at all the process levels equally, there fore they must be prioritized while framing the mitigations strategies and inclusive fire risk management framework.

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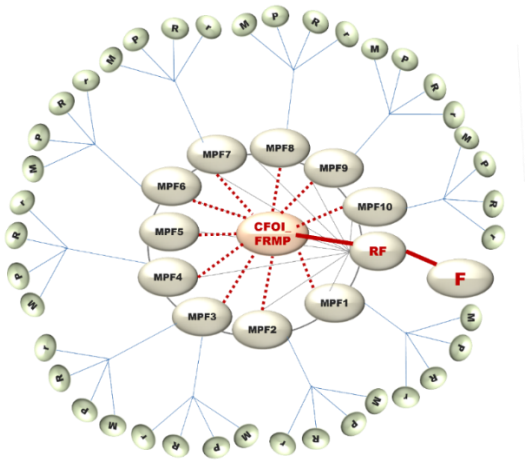

Figure 2-11 Theoretical Attribution model: CFOI attributed to Risk factors concerning fire safety Infrastructure (RF), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements (M=Mitigation, P=Preparedness, Response=R & Recovery=r)

Table 6 - CFOI attributed to Risk factors concerning fire safety Infrastructure (RF), Impacting Fire Risk Management Processes (FRMP) in Informal Settlements

Critical Factors Of Informality (CFOI)	Attributes Of Critical Factors Of Informality (FOI) Impacting Fire Risk Management Processes (FRMP) ~ CFOI_FRMP	Nature of Correlation with Process 1 **'Mitigation (M)'**	Nature of Correlation with Process 2 **'Preparedness (P)'**	Nature of Correlation with Process 3 **'Response (R)'**	Nature of Correlation with Process 4 **'Recovery (r)'**
Lack of publicly provided fire safety infrastructure (Protection, suppression & evacuation plan) **(MPF1)**	The critical factor, **'Lack of publicly provided fire safety infrastructure (Protection, suppression & evacuation plan) (MPF1)'** impacts the fire risk management processes (FRMP) significantly at all the levels (e.g. Mitigation, preparedness, response and recovery). The factor is inclusively attributed to multiple factors e.g. to Poor Allocation of Resources, lack of funding & lack of Services and basic fire safety infrastructure. The factor is majorly responsible for the lack of fire safety plans pertaining to mitigation, preparedness, response and recovery.	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Lack of community-based fire awareness & fire management training programs **(MPF2)**	The critical factor, **'Lack of community-based fire awareness & fire management training programs (MPF2)'** impacts the fire risk management processes (FRMP) at all the levels (e.g. Mitigation, preparedness, response and recovery). However, the factor is strongly attributed to Preparedness and Response. Providing fire safety training to residents (specifically women), employees, and emergency personnel, and Conducting regular fire drills ensure everyone knows what to do in case of a fire hazards and strengthens the preparedness. With the acquired training and knowledge, the community can be a great asset to **expediting** the fire rescue operations, impacting response and reducing the response time	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Lack of communication systems & linguistic **(MPF3)**	The critical factor, **'Lack of communication systems & linguistic (MPF3)'** impacts the fire risk management processes (FRMP) at all the levels (e.g. Mitigation, preparedness, response and recovery). However, the factor is strongly affecting the preparedness and Response during a fire hazard. The factor is attributed to Limited or absent means to communicate and notify informal dwellers during the fire safety and rescue operations due to many factors e.g. lack of early warning systems, Linguistic barriers, Lack of education or low level of education	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**

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	etc., making it challenging for the informal dwellers to understand certain commands or techniques during fire rescue operations, resulting in possible miscommunications or misunderstandings or communication lag, impacting the Response . Lack of communication systems & linguistic also signifies the incapacitated preparedness.				
Non-competence of fire rescue team & firefighting infrastructure **(MPF4)**	The critical factor, **'Non-competence of fire rescue team & firefighting infrastructure (MPF4)'** impacts the fire risk management processes (FRMP) strongly at response level and recovery level during a fire hazard in informal settlements. The factor is attributed to the possibility that Firefighters may not be trained enough or well-equipped to deal with informal fires due to the complexities of informal settlements and the inadequate publicly available fire safety infrastructure. The factor may result in delay responses and high damages resulting in prolonged recovery.	**Indirect Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Equipment faults and non-compliance **(MPF5)**	The critical factor, **'Equipment faults and non-compliance (MPF5)'** also impacts the fire risk management processes (FRMP) strongly at response level and recovery level during a fire hazard in informal settlements. The factor is attributed to the possible faults in equipment (e.g. malfunctioning of electrical components and internal faults) used for fire safety operations resulting in failed functioning. The factor is also attributed to the non-compliance of equipment in informal settlements (e.g. insufficient length of the hose, insufficient space for fire tenders, fire trucks or fire vehicle and extinguishers etc.). All the factors collective impact the response and contributes to delay in response, causing high damage and prolonged recovery.	**Indirect Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Equipment vandalization & thievery **(MPF6)**	The critical factor, **'Equipment faults and non-compliance (MPF5)'** impacts the fire risk management processes (FRMP) strongly at response level during a fire hazard in informal settlements. The factor is attributed to the observed behavior of vandalization and thievery of equipment during the fire rescue operations, impact the response measures and contributing to delay for time being.	**Indirect Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Speed of response and rescue **(MPF7)**	The critical factor, **'Speed of response and rescue (MPF7)'** impacts the fire risk management processes (FRMP) strongly at response level and recovery level. The factor is attributed to the response time, the more the time, the delay the response and more the damage causing prolonged recovery.	**Indirect Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**
Distance from fire stations and response time **(MPF8)**	The critical factor, **'Distance from fire stations and response time (MPF8)'** impacts the fire risk management processes (FRMP) strongly at all the levels (e.g. Mitigation, preparedness, response and recovery). However, the factor is strongly correlated to the response measures. The factor is attributed to the direct distance between the settlements and the allotted fire stations and the average time in which the fire stations respond. The more the distance the more is the response time, causing delays and high damage. However, one research finding indicates that despite having the shorter distance, the response time is elongated due to other physical complexities e.g. narrow roads, undulated and kutcha roads, obstructed pathways, spatial features like presence of drain (nalahs) and topography etc.	**Indirect Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Lack of firebreaks/buffer zones and open areas **(MPF9)**	The critical factor, **'Lack of firebreaks/buffer zones and open areas (MPF9)'** impacts the fire risk management processes (FRMP) strongly at preparedness and response levels. The factor is attributed to inadequate evacuation spaces, lack of refugee areas, lack of open spaces, or punctures, resulting in limited access for fire-fighters to evacuate, the factor also contributes to developing challenges in creating fire containment lines	**Indirect Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Indirect Impact & Negative Correlation**
Lack of fire data, analysis and availability **(MPF10)**	The critical factor, **'Lack of fire data, analysis and availability (MPF10)'** impacts the fire risk management processes (FRMP) significantly at all the levels (e.g. Mitigation, preparedness, response and recovery). The factor is attributed to the lack of data related to the	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**	**Direct Impact & Negative Correlation**

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	occurrences of fire hazards and which is crucial element in post-hazard nvestigations., can be useful in Risk Assessment, planning /strategizing o strengthen the mitigation measures. The historical database can be ıtilized as a learning and for the training as a part of preparedness neasures. The data can help to relocate better resources and required ire safety infrastructure to facilitate the response measures. Most mportantly, the data can used for the damage assessment and reinforced nitigation measures. The collective understanding of the data can be ısed for Fire research and development (R&D) for the review and future mprovements pertaining to fire safety in informal settlements				

3. RESEARCH METHODOLOGY

The objective of the research is to establish the theoretical constructs between the pre-established critical factors of informality (CFOI) and Fire risk management processes (FRMP) by identifying their respective impacts and correlations. However, the research does not intent to quantify the impacts and correlations but rather to provide a qualitative overview with the help of instigated systematic literature overview, case studies (primary and secondary), Interviews and focus group discussions with community members, local leaders, and emergency responders and the responses from the mixed method Delphi survey (including the fire fighters and fire rescue team members) reciprocated from 85 experts and three site surveys to assess community awareness, preparedness levels, and resource availability during a fire safety and research. The established impacts and correlations between the critical factors of informality (CFOIs) and fire risk management processes (FRVs) have a strong potential in providing a strategic roadmap to build a fire risk management plan in sync with the understanding of challenges of implementation of each disaster management cycle (e.g. mitigation, preparedness, response and recovery) for fire risk reduction in informal settlements.

4. CONCLUSION

Investigating the impacts and correlations of critical factors of informality (CFOI) with fire risk management processes propounds valuable insights into the complexities of fire risks and fire safety challenges in informal settlements. This research has illuminated the correlations and impacts of these factors across various cycles of disaster management —Mitigation, preparedness, response and recovery. By addressing these impacts and correlations, stakeholders can enhance planning and resilience, improve safety outcomes, and support sustainable or at least mindful development in vulnerable informal communities. The relationship between critical factors of informality and fire risk management processes in informal settlements necessitates a nuanced, systems-oriented approach. Understanding the impact and correlation between these factors enables the development of tailored and context-specific fire risk management strategies and framework that leverage local and technical knowledge of existing underlying complexities of informal settlements e.g. women may face unique vulnerabilities in informal settlements, and addressing these can enhance overall community resilience and recovery, Providing training and resources to enhance community preparedness and response capabilities and engaging residents in the planning and implementation of fire risk management initiatives to foster ownership and effectiveness etc. The research can enhance capacity-building efforts and promote adaptive resilience by taking appropriate risk management measures, optimizing resource allocation and implement proactive measures, ultimately reducing fire incidents and mitigating their impacts in informal settlements. This conclusion supports the necessity of targeted research and interventions, emphasizing that a one-size-fits-all approach is inadequate for addressing the unique fire safety challenges in informal settlements. It calls for comprehensive, Context-centric strategies to improve or to draw fire management processes to advocate fire safety and resilience in informal settlements.

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