Assessing The Fire Risk Level of Public Buildings in Sri Lanka

[1] N.P.J Liyanapeli*, [2] Amiya Bhaumik , [3] U.I.K Galappaththi , [4] Deepthi Wickremasinghe ,

[1] *Department of Management, Lincoln University College, Malaysia,*

[2] *Department of Business and Accountancy, Lincoln University College, Malaysia.*

[3] *Department of Mechanical Engineering, Sri Lanka Institute of Information Technology (SLIIT)*

[4] *Department of Science, University of Colombo, Sri Lanka*

Abstract:

This study evaluated fire risk levels in Sri Lankan public buildings, revealing widespread deficiencies relative to national regulations, British Standards, and international best practices. Key risk factors included inadequate fire protection systems, structural design shortcomings, poor fire safety management, unsafe occupant behavior, and weak policy enforcement. Facilities with large occupant loads, such as cinemas, sports complexes, and passenger terminals, were particularly vulnerable due to limited evacuation routes and compromised visibility. To address assessment challenges, a semi-quantitative, checklist-based fire risk assessment tool was used and applied to ten public buildings. Validated through over 50 prior case studies, the tool employed Relative Importance Index (RII) scoring across five domains: means of escape, structural protection, detection systems, suppression systems, and fire safety management, with compliance evaluated across four levels to enable objective, inspection-based judgments. Results indicated alarmingly low compliance, with active protection systems falling below 35% and passive systems 26.4% below standards. Compliance with CIDA regulations averaged 45%, while adherence to British and best practice standards reached only 49%. No building achieved a low-risk rating; half were classified as high risk, and 30% as moderate risk, with older pre-1997 buildings and government-owned facilities exhibiting the lowest compliance. The findings highlighted urgent needs for regulatory reform, stronger enforcement, and strategic investment in comprehensive fire safety management.

Keywords: *Building fire risk, Checklist-based fire risk assessment tool, Fire risk assessment, public building,*

1. INTRODUCTION

Fire incidents remain one of the most destructive hazards in the built environment, causing over 300,000 deaths annually and ranking as the fourth leading cause of accidental injury [1]. Over the past two decades, the scale and complexity of fire hazards in buildings have increased significantly[2]. In densely populated public facilities such as cinemas, transport terminals, universities, and stadiums, fire risk is elevated by complex human behavior, congested evacuation routes, and inadequate safety infrastructure. These multifunctional spaces often challenge standard fire safety requirements due to spatial complexity, functional zoning, and architectural constraints [3]. The urban concentration of people and assets complicates emergency response and heightens the potential for large-scale casualties and severe property loss [4].

Sri Lanka’s rapid urbanization has produced diverse public buildings with widely varying fire risk management capacity. National fire regulations classify public buildings as transportation hubs (railway stations, bus terminals, airports), entertainment venues (cinemas, theatres, stadiums), educational facilities (colleges, universities), and community spaces (libraries, conference halls, public clubs). Many regularly host large crowds; however, they lack adequate fire safety systems, reflecting inadequate regulations that fail to address evolving occupancy patterns. Although Sri Lanka has not experienced a major fire disaster in public buildings, international events provide clear warnings.

Global tragedies illustrate the consequences of inadequate fire safety. The Kemerovo cinema fire in Russia caused 64 deaths, while the Karamay Friendship Pavilion fire in China, exacerbated by locked exits, killed 325. In cinemas and enclosed venues, most fatalities stem from smoke inhalation, burns, and evacuation injuries [5]. Transport hubs have also suffered catastrophic fires, such as the 2006 Brooklyn subway blaze that injured at least 25 and required the evacuation of 4,000 passengers. Similarly, London’s King’s Cross Underground fire (1987) killed 31, demonstrating how confined, crowded environments complicate evacuation [6].

Research shows that many Sri Lankan public buildings fail to comply with fire safety regulations, exposing deficiencies in active, passive, and management systems [7][8]. Although national fire regulations exist under the Construction Industry Development Authority (CIDA), implementation and enforcement remain inconsistent[9]. The lack of a systematic assessment of fire safety deficiencies in various types of public buildings in Sri Lanka is the driving force behind this study. The objectives of this research are to identify critical gaps in fire safety compliance in public buildings and to develop a systematic approach that encourages building owners to conduct regular fire risk assessments using the proposed tool and implement corrective measures promptly. Furthermore, the study seeks to provide evidence-based insights for regulatory authorities to strengthen existing fire safety standards and improve their implementation processes. It also aims to guide building designers in integrating appropriate fire safety considerations into design practices and to support approval authorities in rigorously evaluating compliance with fire safety requirements during building plan approvals and the issuance of Certificates of Conformity. Ultimately, the study aims to reduce the risk of life losses and property damage by enhancing the resilience and preparedness of public buildings against fire emergencies in Sri Lanka.


Low-capacity fire


Fire exits open inward


Blocked fire exit


Low stack gaps
With lights

Incorrect location of

Inward open and no exit sign

Fire panel is out of order

Exit signs are not working

Figure 1. Fire Safety Gaps in Public Buildings

1.1 Fire Risk Challenges and Management in Public Buildings

Despite formal codes, Sri Lanka continues to face frequent and sometimes severe fire incidents [10]. Public building emergencies stem from inadequate protection systems, complex layouts, poor fire safety management, occupant behavior, and weak policy enforcement [11]. Buildings with high occupancy cinemas, sports complexes, and passenger terminals pose heightened risks due to limited escape options and reduced visibility in smoke. Historical disasters reveal that obstructed exits, poor signage, and delayed evacuations have caused significant fatalities[12][6]. Architectural limitations in transportation hubs, educational institutions, and recreational facilities impede fire containment and emergency response [13]. Toxic combustion byproducts and high heat release rates (HRR) significantly contribute to casualties [14], while cinemas and large halls frequently contain flammable sound-absorbing materials that accelerate fire spread [15]. Even small ignition sources, such as smoking residues, can ignite seating, curtains, or panels, triggering complex combustion dynamics [5].

Occupant behavior further undermines safety. People often underestimate early fire cues, delay evacuation, or head toward familiar entrances rather than emergency exits unless guided by staff [16] [6]. Smoke reduces visibility, causing disorientation and crowding, while alarms are frequently ignored in large venues where routine activities continue despite warnings [17]. Clear signage is vital yet often insufficient in Sri Lanka's public buildings. Globally, smoke inhalation rather than burns remains the leading cause of fire deaths, accounting for over 75% of fatalities [18].

Many Sri Lankan facilities also lack critical planning measures, such as occupancy load limits and fire load calculations required for determining evacuation timelines and suppression system capacity[7] [3]. Airport terminals highlight these vulnerabilities: complex layouts, long exit routes, and security constraints complicate evacuations, while passengers carrying luggage delay egress and increase fire load [11]. In transport hubs and large venues, inadequate fire compartmentation and poorly designed ventilation may intensify fires by feeding oxygen [15]. Large openings often compromise containment, and real conditions, such as excess passenger baggage, can exceed design fire loads, emphasizing the need for continuous reassessment of assumptions [3]. Cinemas face unique hazards from enclosed layouts, low lighting during screenings, combustible interiors, and high seating density. Poor emergency signage and a lack of portable extinguishers exacerbate evacuation delays and overcrowding risk [19]. Overall, gaps in Sri Lankan fire safety standards, weak enforcement, and limited resources mirror problems seen across many developing nations, where inconsistent regulation and poor compliance elevate risk [2].

Thorough risk assessments identify hazards, evaluate vulnerabilities, and guide mitigation strategies to ensure rapid evacuation [20]. However, occupant behavior remains unpredictable; only 38% of people notice static emergency signs in large, unfamiliar venues [6]. Dynamic wayfinding, such as flashing green lights, improves visibility and speeds evacuation [5]. High-density spaces like sports halls require integrated passive and active systems aligned with behavioral patterns and layouts, supported by multi-agency coordination and human-centered planning [21][22].

Weak legislative oversight, poor certification, and insufficient fire incident data hinder both risk assessment and policy development [23]. Holistic approaches must blend regulatory compliance, behavioral insight, real-time communication, and recurring assessments to improve resilience [24]. Analytical tools and structured checklists are essential for evaluating fire protection and regulatory compliance [25]. Yet in resource-constrained countries, such tools remain underused due to cost and data limitations [1]. Existing methodologies lack standardized, code-compliant procedures for facility managers, maintenance engineers, and safety officers [26]. Regular, methodologically robust assessments are needed to detect flaws early and enable timely interventions.

1.2. Rationale for the Development of a New Tool

Risk assessment techniques are essential for identifying, evaluating, and controlling fire hazards [27]. They prioritize fire causes by significance and guide targeted control measures, helping determine whether current safety strategies adequately manage risk and forming the basis for comprehensive fire management [28] [29]. Despite its importance, no universally accepted method for fire risk analysis exists, highlighting the need for standardized criteria to improve decisions [30]. Fire risk assessment evaluates risks to people and property from unwanted fires by identifying hazards, estimating likelihood and consequences, and verifying whether existing measures are adequate [29][28][31].

The checklist method is widely used, offering structured criteria to verify whether safety components meet standards [32]. Checklists, developed from experience or codes, are efficient, systematic, and provide valuable baseline data. Because many property managers lack technical knowledge of fire codes [33], code-aligned checklist systems offer user-friendly tools that support safety officers and facility managers. Properly designed, they reduce fire risk and ensure compliance [2].

Risk assessment and management are powerful tools for hazard identification, prioritization, and mitigation [20]. In Sri Lanka, conducting comprehensive assessments is difficult due to the absence of reliable incident records and failure data [34]. Many methodologies are resource-intensive, demanding substantial data, expertise, and investment [35]. In prescriptive environments like Sri Lanka, compliance with codes is often assumed to guarantee safety [36], making checklist evaluations common [37][2].

However, conventional checklists have major limitations. They assign equal weight to all items regardless of impact, obscuring critical deficiencies, and fail to incorporate building-specific variables or fire safety management quality. The absence of nuanced scoring systems hampers the accurate assessment of partial compliance [38].

2. METHODOLOGY

To address these issues, the author developed a semi-quantitative checklist-based fire risk assessment tool for all 54 officially recognized building categories in Sri Lanka. By accounting for variations in severity and relevance of fire risks by building type, use, and context, the tool delivers a more precise, actionable assessment [39]. This method overcomes the rigid comply-or-not-comply format of conventional checklists, enabling nuanced evaluations [40][41]. Risk Assessment Tool, which is built upon three core modules: Database, Interface, and User Interaction. These modules work together to support a structured, evidence-based evaluation of fire safety compliance.

The database module consolidates regulatory requirements, standards, and expert knowledge necessary for reliable fire risk evaluation. It primarily draws on the CIDA Fire Regulations Database, Sri Lanka's national fire safety standards, and the wider regulatory framework. Where CIDA regulations are incomplete, British Standards supplement the data, with additional guidance from BS 9999 and accepted industry practices. From these sources, 221 fire risk assessment attributes were identified: 126 "standard" attributes derived from CIDA and British Standards, and 85 additional attributes reflecting fire safety management and best practices. These attributes are grouped under 12 critical risk factors—established in prior research through expert interviews and aligned with the design, construction, and maintenance stages of a building's lifecycle. Findings emphasize that fire risks vary by context, with major drivers in Sri Lanka including poor building design, approval of unsuitable plans, inadequate maintenance of fire safety systems, weak safety management, non-compliant materials, insufficient infrastructure, poor housekeeping, unsafe practices, inadequate training, non-adherence to specifications, limited awareness, and improper installation of fire protection systems (Prasanna et al., 2023).

The interface module links this knowledge base to users through an intuitive platform for building-specific fire risk assessments. Fifty-four customized checklists were developed to correspond to Sri Lanka's recognized building categories, classified by height, habitable floor area, and occupancy group. These categories reflect varying fire safety requirements; for example, super high-rise buildings require refuge areas, high-rise buildings require firefighting shafts, and medium-rise buildings need only protected shafts. Detention facilities above 18 m and 800 m² require landing valves, while hotels, hostels, or offices of similar scale are exempt. The module dynamically filters out non-applicable items from the 221 attributes and integrates additional provisions where necessary. Each checklist is automatically assigned based on user input, with Relative Importance Index (RII) weightings identified by previous research, ensuring risk-based prioritization rather than simple compliance counts.

The user interaction model governs system access and operation. Upon login, users acknowledge operating instructions before proceeding. Key building data, such as name, address, height, floor area, occupancy characteristics, fire growth rate, management level, and travel distances, are collected to select the appropriate checklist automatically. Users then refine the choice by selecting the category and sub-category via drop-down menus supported by on-screen descriptions, enabling accurate use even by non-specialists. Once confirmed, the corresponding checklist loads automatically, streamlining the assessment process and ensuring consistency across different building types.

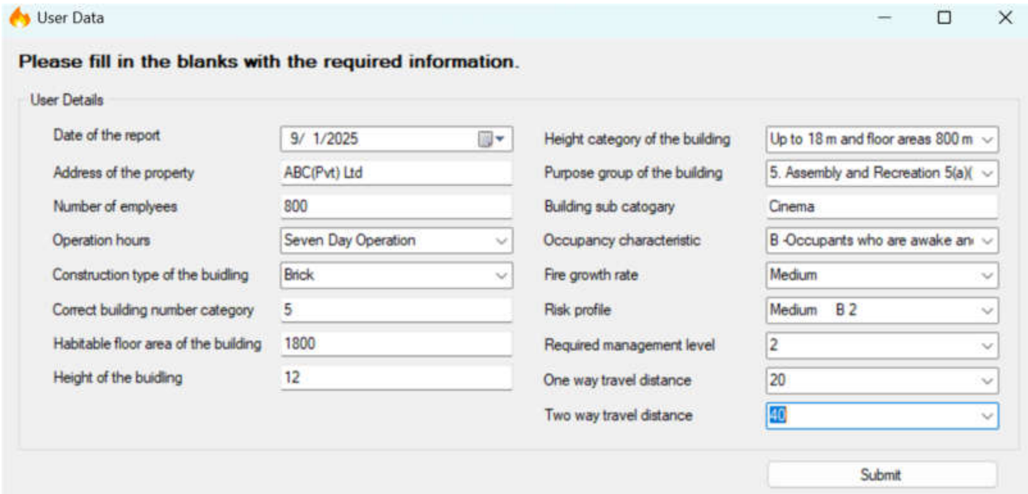

Figure 2. Basic Data Input Interface

Each checklist contains attributes grouped into five main fire safety areas: means of escape, structural fire protection, fire detection systems, fire protection systems, and fire safety management. In total, up to 221 attributes may be covered, depending on the building category. Users progress through these sections by answering structured questions designed to determine both applicability and compliance level. The software assumes that all attributes are relevant because the checklist has already been tailored to the building category, requiring users to flag only the rare cases where a requirement does not apply, such as basement-specific measures in a building without a basement. For each applicable attribute, compliance is assessed on four defined levels: non-compliant (0 marks), partially compliant (25 marks), moderately compliant (50 marks), or fully compliant (75 marks) [42]. These defined levels guide users to make objective judgments based on physical inspections and clear criteria, rather than requiring them to interpret regulatory standards directly. This structured scoring method aligns with the point-based approaches recommended in fire safety literature [41][43].

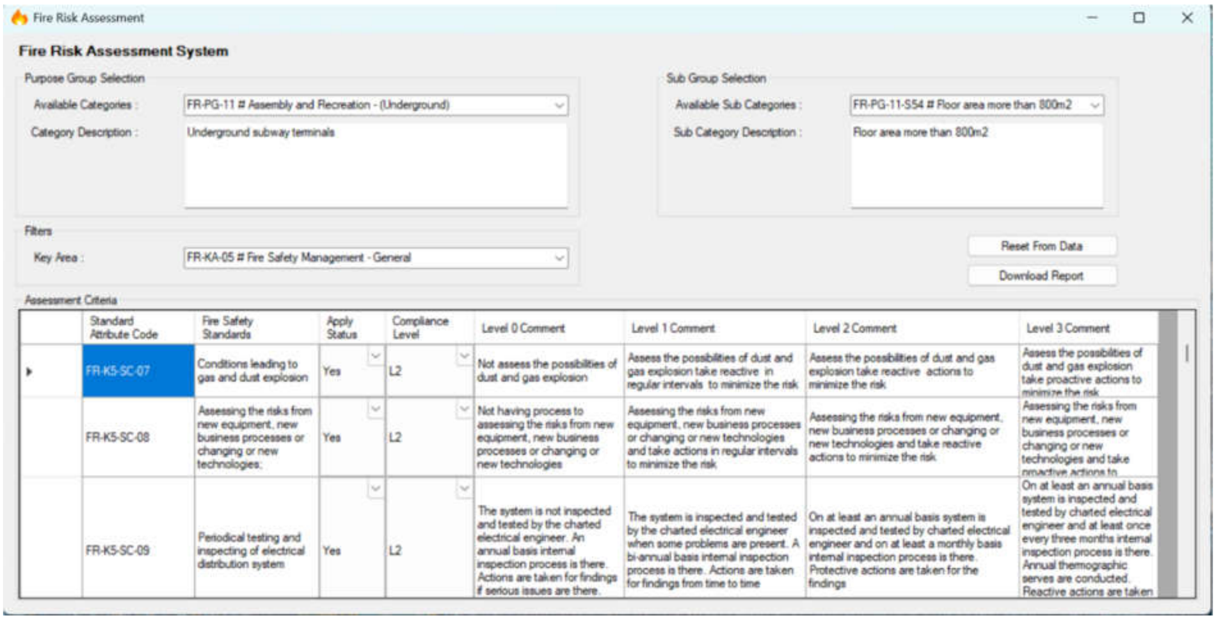

Figure 3. Selection of Purpose Group, Subcategories, Key areas, Compliance Level Selection

Once all sections are completed, the software automatically applies embedded Relative Importance Index (RII) weightings to calculate a weighted compliance score. This score is compared against the theoretical maximum to determine the compliance gap as a percentage. Users can then generate and download the final report, which summarizes findings and highlights priority actions for risk mitigation. By combining prescriptive checklists with risk-weighted scoring, the tool provides a simple, structured, and scalable approach to fire risk assessment. This is particularly valuable in Sri Lanka, where fire safety awareness is limited, professional expertise is scarce, and regulatory enforcement remains in its early stages.

2.1 Output Visualization

The final output is presented as a clear, comprehensive, and actionable report that combines quantitative analysis with visual clarity. It features domain-specific graphs and compliance charts, a color-coded overall risk rating, summarized compliance percentages, and a prioritized list of identified deviations. The report details fire safety performance across key areas: compliance levels for means of escape, structural fire precautions, fire detection and alarm systems, extinguishers and fixed protection systems, and fire safety management are represented as bar charts. Compliance levels for active and passive fire protection systems, adherence to local standards, and alignment with British or best industrial practices are displayed as pie charts. Additionally, an overall fire risk level is presented through a risk level chart, while major and minor deviations are itemized in dedicated lists. This format ensures that decision-makers can quickly interpret the results, identify critical gaps, and prioritize corrective actions.

2.2 Implementation of Case Study Findings in Operational Public Buildings

Ten public facilities were selected as case studies to demonstrate the practical application of the Fire Risk Assessment Tool. These facilities represent a diverse cross-section of public buildings in Sri Lanka, varying in architectural design, construction methods, operational scale, and functional use. The selection was intentionally designed to encompass a broad spectrum of fire risk factors across different industry contexts. Details of the selected facilities are as below

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Table 01. Details of The Selected Case Studies

Number	Building	Nature of the public buildings
1	A	International cricket stadium
2	B	Modern shopping mall
3	C	Private clubhouse
4	D	Highway resting area
5	E	Public Library
6	F	International conference hall
7	G	Passenger Terminal
8	H	Cinema hall
9	I	Government University
10	J	Railway station

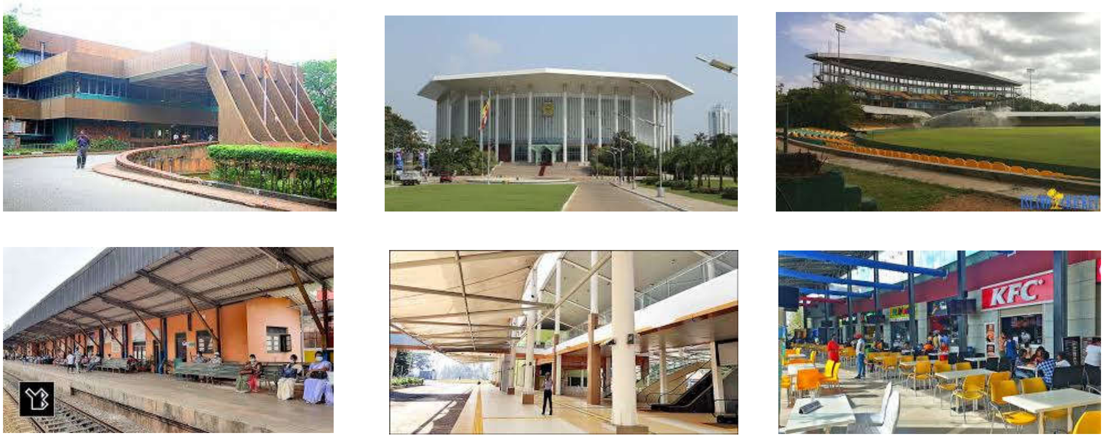

Figure 4. Some of the selected public buildings

2.3 Methodological Framework Used for the Case Study

To ensure a comprehensive understanding of every parameter within the newly developed fire risk assessment tool, an extensive preparatory review was conducted on all 221 attributes incorporated into the system before initiating field inspections. This step was crucial to clarify the technical definitions, regulatory requirements, and performance benchmarks associated with each attribute, ensuring consistency and objectivity during subsequent evaluations.

Following this preparatory stage, detailed inspections were carried out across the selected public buildings. A systematic attribute-by-attribute evaluation was undertaken to assess compliance with regulatory standards and best practices. Key physical parameters, including staircase widths, travel distances to exits, floor-to-floor heights, and the spatial distribution of hose reels, fire hydrants, and fire detection systems, were verified using a combination of on-site measurements and cross-referencing with approved architectural drawings. These assessments ensured that both the design intent and actual implementation were accurately captured

To evaluate the operational and management aspects of fire safety, service and maintenance records, testing logs, and inspection checklists were reviewed to verify the reliability of installed systems. Complementing these reviews, structured interviews were conducted with a range of stakeholders, including fire team members, emergency response personnel, safety officers, and building maintenance staff. Their inputs provided qualitative insights into the practical functioning of fire protection measures and validated observations made during physical inspections. Photographic documentation was systematically collected to record instances of non-compliance, deterioration of fire safety equipment, and the physical condition of evacuation routes and emergency exits, thereby creating a verifiable audit trail.

All gathered data were subsequently digitized and entered into the fire risk assessment software. Upon initiating the tool, users are prompted to input basic building information such as name, address, height, total floor area, and occupancy classification. The tool then guides the user to select the appropriate purpose group and subgroup, after which a structured, attribute-based checklist organized under five major categories is automatically generated. Each of the 221 attributes is assessed individually, with compliance levels classified from Level 0 (L0) to Level 3 (L3). These ratings are determined through field measurements, supporting documentation, and predefined software descriptors that explain the performance criteria for each level.

Furthermore, the tool incorporates a weighting mechanism based on the Relative Importance Index (RII) assigned to each attribute. This ensures that attributes with greater significance to fire safety exert a proportionally higher impact on the overall risk assessment outcome. Once all attributes have been evaluated and rated, the software automatically compiles the results into a detailed output sheet. This sheet provides a comprehensive summary of the building's fire safety status, highlighting areas of non-compliance, quantifying the overall risk level, and supporting prioritization for remedial actions.

4 FINDINGS AND DISCUSSION

Following the analysis of fire risk levels in the ten selected case study buildings, the results are as follows.

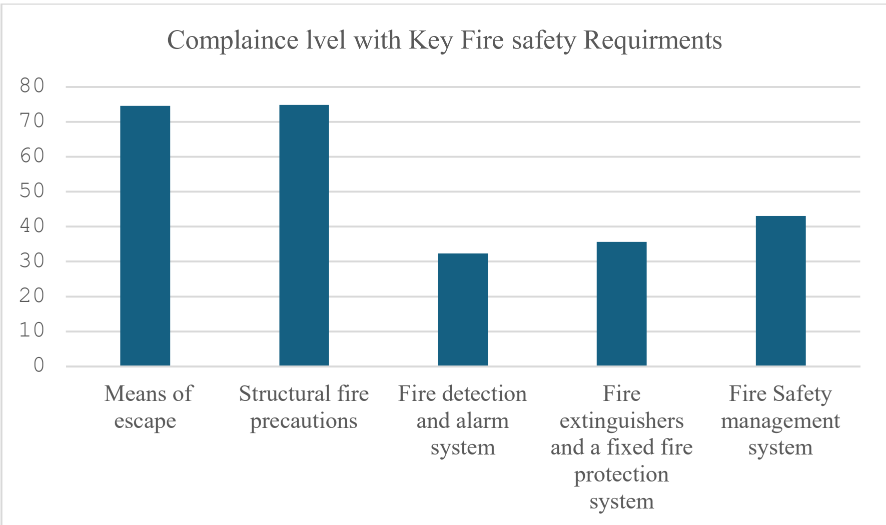

Figure 04. Compliance level with key fire safety segments

The analysis shows that most public buildings in Sri Lanka fall far short of standard fire safety requirements. Compliance with critical safety components—fire detection and alarm systems, portable extinguishers, and fixed protection systems (hose reels, hydrants, sprinklers)—remains below 40%, with detection and alarm systems lowest at 32%. This is alarming given their role in enabling the safe evacuation of unfamiliar occupants. These findings align with Prasanna et al. (2023), who reported critically inadequate fire protection measures and broad expert consensus on widespread non-compliance. The author's professional observations during site inspections further confirm these deficiencies and strongly motivated this research. The lack of detection and alarm systems, combined with poor emergency lighting and exit signage, greatly increases evacuation risks, especially under low-visibility conditions. Addressing these deficiencies through reliable detection systems, enhanced alarms, and strategic placement of emergency signage must be prioritized in both design and building management.

Compounding the problem, many public buildings lack robust fire safety management measures such as routine servicing and maintenance of protection systems, periodic inspections, staff training, and oversight of occupancy and fire loads. These practices are essential for timely evacuation and effective early-stage fire suppression. Research indicates only 43% compliance with fire safety management systems, highlighting both the severity of the issue and the overall inadequacy of fire safety provisions in Sri Lankan public buildings.

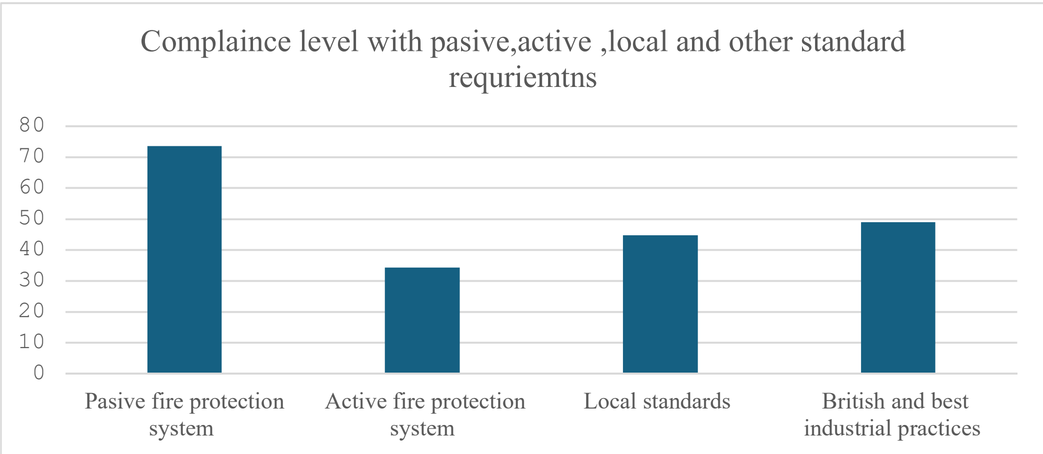

Figure 05. Compliance with passive, active, local, and British standards

The analysis shows that most public buildings in Sri Lanka exhibit higher compliance with passive than active fire protection systems. These buildings are typically constructed with solid walls or load-bearing concrete or steel structures, configured as enclosed or open layouts based on use. Operational needs often require solid masonry party walls, inherently integrating many structural fire safety features during construction to meet functional and regulatory requirements. However, a 26.4% gap remains in meeting passive fire protection standards. More critically, overall compliance with Construction Industry Development Authority (CIDA) fire safety regulations is only 45%, reflecting a substantial 55% shortfall from mandated standards.

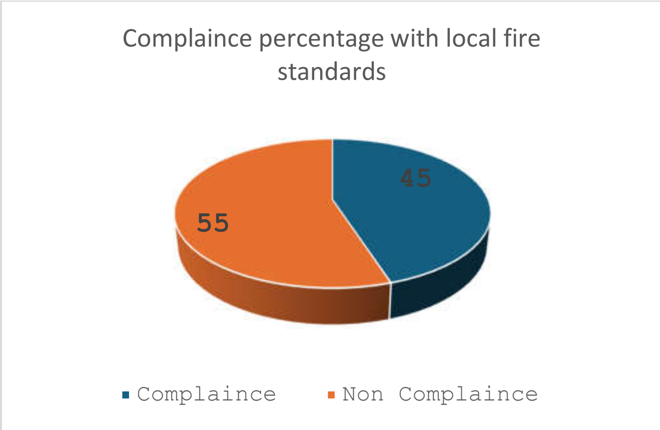

Figure 06. Compliance Level with Local Fire Standards

This deficiency highlights a serious fire safety concern requiring urgent action by authorities. The analysis also shows 49% compliance with British standards and international best practices, a comparatively higher level driven by service, maintenance, and management practices that demand minimal cost but receive little emphasis in local regulations. While Sri Lankan public buildings achieve partial compliance with passive fire protection through inherent construction features, these findings reveal the need for stronger regulatory enforcement and greater investment in active fire protection systems and comprehensive fire safety management to ensure a significantly higher level of overall building safety

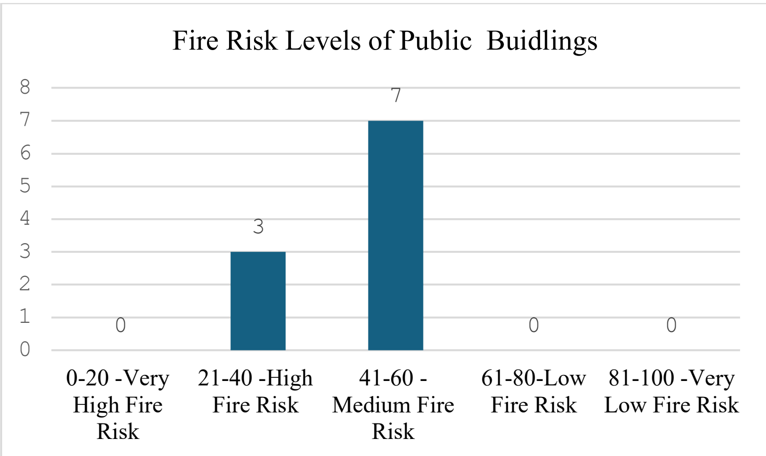

Figure 07. Fire Risk Levels Distribution

An analysis of fire risk levels in the ten selected public buildings revealed that none qualified as having a 'low' or 'very low' fire risk, underscoring widespread non-compliance with both local fire regulations and internationally recognized standards, such as British Standards and best industry practices. Within the sample, 50% of the buildings were categorized as high risk, 30% as moderate risk, and only 20% as low risk. These findings align with the literature, which identifies key fire safety issues in Sri Lankan public buildings, including the absence of fire protection systems, complex architectural designs, occupant behavior, and inadequate enforcement of fire safety management policies.

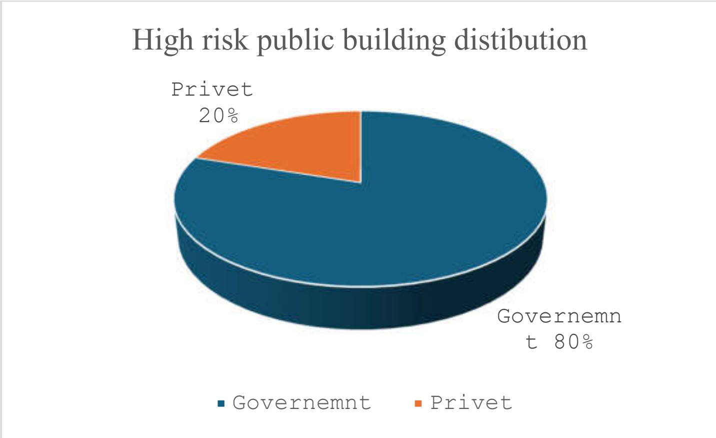

Figure 08. Risk Level Distribution in privet and Government Buildings

The research confirmed that 80% of high-risk buildings are government-owned. Site inspections and fire risk assessments revealed that many government facilities, hospitals, railway stations, public libraries, and passenger terminals fail to meet even basic fire safety requirements. Most lack essential active protection systems such as extinguishers, detection and alarm systems, hose reels, hydrants, and sprinklers. As these facilities serve large public crowds, their fire risk exposure is alarmingly high, demanding immediate government action.

Further analysis shows that buildings constructed before fire regulations were introduced in 1997 have particularly low compliance. Post-1997 buildings perform better but still meet only 58% of requirements, reflecting a substantial shortfall. These findings underscore that, despite Sri Lanka's well-established fire regulations, major implementation gaps persist due to inadequate resources, weak enforcement, and the absence of a robust legal framework.

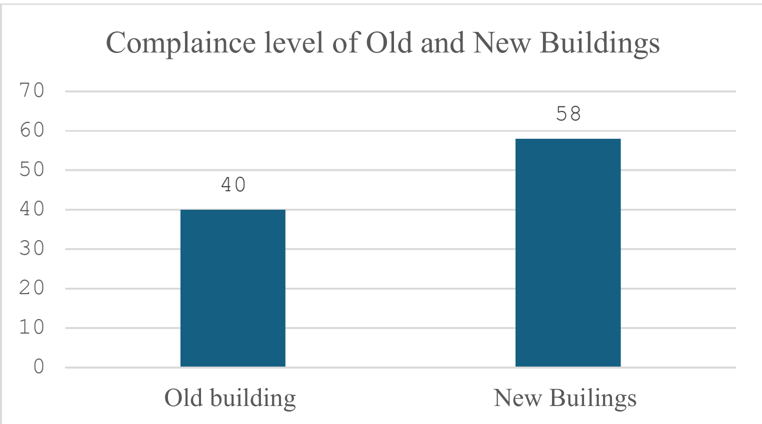

Figure 09. Compliance Level with Old and New Buildings

The developed assessment tool supports the systematic evaluation of compliance and risk across active, passive, and structural fire protection measures, as well as fire safety management practices. By identifying existing gaps, this tool enables building owners and relevant stakeholders to take timely corrective actions, thereby addressing the core research problem and validating broader findings concerning fire safety in Sri Lankan public buildings.

5. CONCLUSION

Research findings show that many public buildings in Sri Lanka fail to meet essential fire safety requirements, falling short of national regulations, British Standards, and international best practices. Risks are intensified by inadequate fire protection systems, poor safety management, unsafe occupant behavior, and weak policy enforcement. High-occupancy facilities cinemas, sports complexes, and passenger terminals, are particularly vulnerable due to limited evacuation options and poor visibility during emergencies. Although Sri Lanka has yet to experience major disasters in such settings, global events reveal the potential severity.

To address shortcomings in current assessments, a semi-quantitative, checklist-based fire risk assessment tool was applied to ten public facilities. Validated through more than 50 prior case studies, it uses the Relative Importance Index (RII) scoring across five domains: means of escape, structural protection, detection, suppression, and fire safety management. Attributes are rated at four compliance levels, enabling objective, inspection-based judgments without requiring specialized expertise.

Results indicated critically low compliance with active fire protection systems detection, alarms, extinguishers, hose reels, and hydrants, averaging below 35%. Passive safety measures fell 26.4% short of standards. Overall compliance averaged 45% with national CIDA regulations and 49% with British and international standards. None of the buildings qualified as “low risk”; 50% were high risk, 30% moderate, and 80% of high-risk facilities were government-owned. Older buildings built before 1997 performed worst, while newer ones met only 58% compliance. These findings underscore urgent regulatory reform, stronger enforcement, and strategic investment in holistic fire safety management.

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Declaration

This study only uses AI technologies for the English Language proficiency.
All authors declare that they have no conflicts of interest

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