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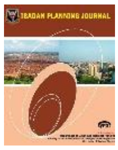

Fire Safety Implications of Non-Compliance with Space Standards in Urban Communities

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Abstract
Space standards and safety codes are stipulated to ensure that physical developments are resilient against environmental hazards like building fires; however, the effectiveness of these planning regulations hinges on strict compliance. Anchored in the theoretical frameworks of urban governance and disaster risk reduction, this study assesses the compliance of urban buildings with space standards relevant to fire safety in Ibadan, Nigeria. The study utilized a cross-sectional survey design, collecting data via structured observation checklists from 1,803 buildings selected through multistage systematic random sampling across 88 non-overlapping communities in eleven Local Government Areas (LGAs). Results indicate a critical deficit in regulatory adherence regarding minimum "building space," maximum "plot coverage," and minimum "road setback". The mean observed building separation was just 3.35m (±2.47m), creating a high risk for rapid fire propagation. Spatial analysis revealed that plot coverage was significantly higher in the high-density inner city (74.79%) compared to the outer city (70.72%). Conversely, the mean road setback was significantly higher in the inner city (7.5m) than in the outer city (5.4m). Furthermore, compliance varied by land use; public (68.5%) and industrial (66.7%) facilities demonstrated higher adherence due to stricter institutional monitoring, whereas residential and commercial sectors largely failed to meet safety criteria. The study concludes that the prevailing disregard for space standards constitutes a "dynamic pressure" that engenders unsafe conditions, impeding emergency response and increasing community vulnerability. Consequently, the research advocates for a paradigm shift from top-down regulatory enforcement to participatory urban governance that integrates community-based risk awareness and inclusive disaster mitigation planning.

Keywords
Disaster risk reduction; Fire safety; Land use compliance; Space standards; Informal settlements

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1. Introduction

Human settlements are now predominantly urbanised, with developing countries contributing more to the recent upward trends. The increasingly rapid urbanisation being witnessed in developing countries has outpaced the ability and capability of urban managers to address some land use problems, such as urban sprawl, informal settlements, urban squalor, squatter settlements, and development in areas that are liable to environmental disasters (Aliu et al., 2021). These contemporary urban realities have commonalities of incompatible developments and low compliance with land use regulations (Mohanty, 2020; Falola et al., 2024).

Incompatibility of urban land use developments is a major concern for professionals, policymakers, and urban dwellers as evidence abounds in recent studies (Kalfas et al., 2023). Consistent evidence has emerged that such developments pose high risks to occupants' livelihoods from external shocks, such as fire disasters (Richmond et al., 2018; Agbola and Falola, 2021). The cause-and-effect relationship between disasters and physical, social, and economic developments is documented in the literature. Recent research outcomes have established a strong connection between physical development in human settlements and the occurrence of disasters (Wahab and Falola, 2017; Adaramola et al., 2017; Zerbo et al., 2020; Wahab and Falola, 2022; Falola and Agbola, 2022). The relationship is such that poor and unguided physical development engenders hazards and disaster risks. Many homes are lost in the first several hours of a fire, which indicates that during the early periods of a fire, the only protection a structure has is the fire safety approaches that were implemented beforehand (National Association of Counties et al., 2010).

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The root cause of the negative effects that are associated with the development-fire disaster risk interlink has been attributed to a lack of compliance with relevant safety regulations and or inadequate enforcement of codes, standards, and legislations that are meant to guide physical developments (Fashina et al., 2020). Previous studies have investigated these cause-and-effect relationships (Adaramola et al., 2017; Chhetri et al., 2018; Adelekan, 2020; Ngau and Boit, 2020; Zerbo et al., 2020; Dandoulaki et al., 2023). However, while most of the related studies focused on compliance across a single land use and or a single section of the city, this study makes a case for variations across communities, land uses, and administrative sections within an urban setting. Thus, this study intends to fill this gap in the literature by assessing the level of compliance with physical planning regulations and space standards that are relevant to fire safety. The study further investigates the difference in the level of compliance with fire safety codes and planning regulations across housing densities, LGAs, and building use.

The relationship between non-compliance with space standards and increased fire safety risks in urban areas can be examined through multiple conceptual lenses. The concepts of urban governance and disaster risk reduction were used to anchor this study. Urban governance plays a fundamental role in shaping the urban landscape and regulating building practices (Wahab and Falola, 2018). When non-compliance with space standards becomes prevalent, it is important to examine this dynamic within the broader context of how cities are governed. A strong and determined integration that involves the state, the local community, and the private sector has been identified as an essential requirement for tackling the challenges of sustainable development (United Nations, 2013; Badach and Dymnicka, 2017). In the course of governing cities, physical planners and urban managers make and enforce policies of development control and space standards to shape the accessibility, attraction, interlink, and distribution of housing allowable in a particular area (Nuissl and Siedentop, 2021; Odekunle et al., 2022). Ensuring fire safety and security of urban lives and properties is a prime indicator of good urban governance (Badach and Dymnicka, 2017). Weak governance exposes urban communities and inhabitants to increasing risk and vulnerability to fire disasters (Gencer et al., 2018). This is because effective reduction of fire hazard/disaster can only be achieved by putting in place appropriate standards, rules, regulations, policies, legislation, and approaches to guide urban development (Ajijola et al., 2024) and, at the same time, building urban resilience to fire disasters. The absence of an effective enforcement mechanism for building codes and space standards contributes to non-compliance, which then increases the presence of unsafe structures and practices, increasing fire risks (Oteng-Ababio et al., 2016). Decentralized urban governance models often involve diverse stakeholders with fragmented authority over planning, regulations, and enforcement. This can result in varying degrees of compliance with building codes and space standards, amplifying fire risk in certain areas (Osei et al., 2023). Lack of coordination and consistency across different urban management bodies creates gaps that result in non-compliant practices and leave room for unsafe construction or informal modifications that increase fire hazards (Ahmed and McEvoy, 2021).

The concept of disaster risk reduction shows that vulnerability (pressure), which is often shaped by social, economic, and political factors, has to be tackled (released) to lower disaster risk (Hai and Smyth, 2012). The root causes, dynamic pressures, and unsafe conditions are identified as the three layers of social processes that cause vulnerability (Wisner et al., 2004; Dintwa et al., 2019). The root causes result in dynamic pressures that describe the nature of and the reason for the recurring unsafe conditions (Hai and Smyth, 2012). In the context of this study, the "root causes" in the context of fire disasters would be: institutional negligence of development control, lack of legislation on building codes and space standards, political interference in urban planning, exclusion of poor people from fire mitigation and emergency response preparedness, etc. Similarly, "dynamic pressures" could be: absence of community-based organisation (CBOs) for collective efforts to prevent such conflicting land uses, rapid and uncontrolled urbanisation, uncontrolled rural-urban migration, urban sprawl, epidemics, insurgency, lack of access to residential land in a safe location, disregard for the rule of law, etc. Wisner et al. (2004) contend that these dynamic pressures generate physically- and socially-unsafe conditions, such as dangerous locations, derelict buildings, ineffective emergency management, and uncoordinated firefighting service. For residential houses located near a filling station, “unsafe conditions” may be: closeness to a filling station, incompatible land uses (Falola et al., 2024), unsafe location, dangerous living, fire-prone building materials, use of inflammable lighting fuel, etc.

2. Materials and Methods

Ibadan, which is a typical traditional African city, is the study area. Ibadan is in the south-western part of Nigeria, which is located approximately 144.84 kilometres away from the Gulf of Guinea. The city performs the dual functions of the administrative and commercial capital of Oyo State, one of the 36 states in Nigeria. The settlements that make up Ibadan are highly socio-culturally heterogeneous. The Ibadan region currently exhibits an interesting blend of modern and traditional city qualities. The inner core of the city is dominated by traditional communities. Ikporukpo (1994) argues that the miscellaneous geographical setting and multifarious cultural identity of Ibadan offer an exciting basis for research. The city comprises 11 local government areas (LGAs). These are Akinyele, Egbeda, Ido, Lagelu, Ibadan North, Ibadan North-east, Ibadan North-west, Ibadan South-west, Ibadan South-east, Oluyole, and Ona-Ara. As illustrated in Figure 1, five LGAs are located in the core area of the city, while the remaining six encircle and core five LGAs and form the boundaries of the city.

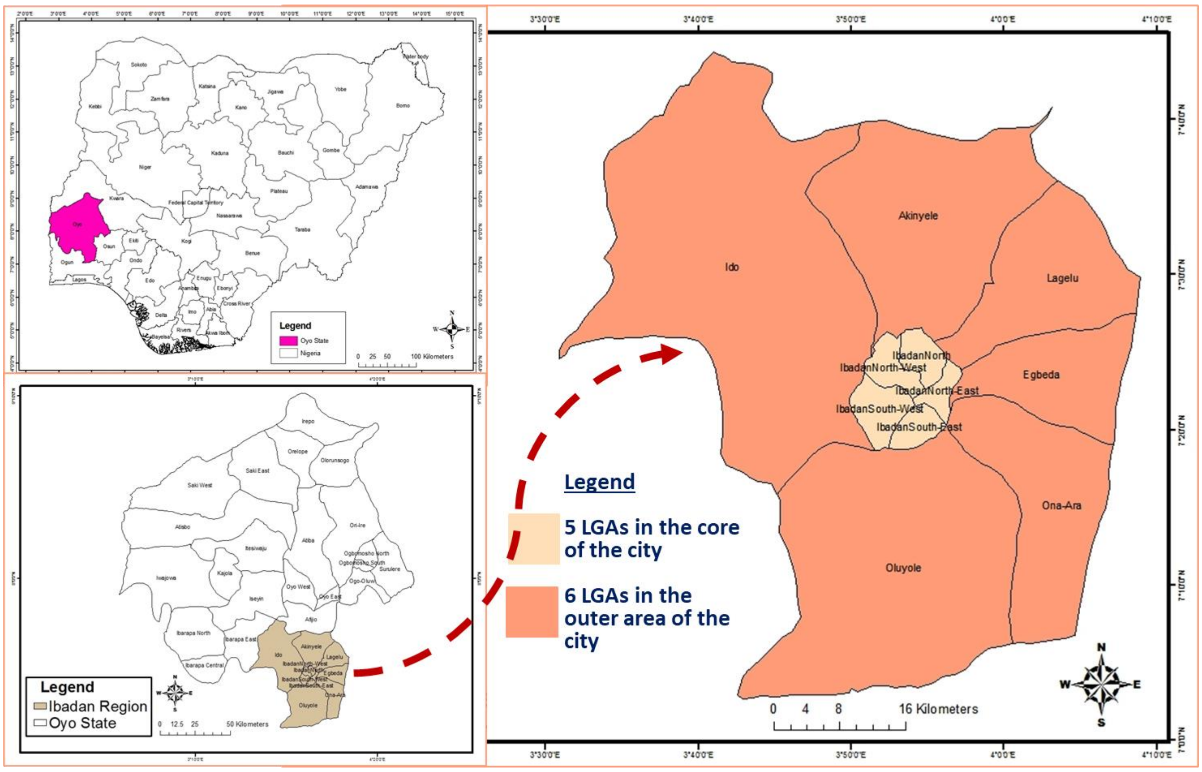

Figure 1: Geographical location of the study area

The population of Ibadan has been growing with an increasing growth rate. The last statutory census in 2006 put the population at 2,630,754 (NPC, 2010). However, the population is estimated to be 6,017,709 in 2016 and projected to be 11,315,025 by 2036 (Oyo State Government, 2017). The built-up area has also been expanding rapidly along major transport routes forming a circular pattern. However, most of these expansions are not adequately controlled and, thus fraught with sprawl and informal developments.

The study is survey-based and cross-sectional in nature. Data were collected from primary and secondary sources. The secondary source includes the Bureau of Physical Planning and Development Control (BPPDC) of the Oyo State Ministry of Lands, Housing and Survey (OMLS), which supplied the space standards for physical development.

Primary data were collected with the aid of a structured observation checklist and open-ended individual conversations. The observation checklist contained an inquiry into relevant fire prevention and mitigation measures that were put in place in the surveyed buildings. The checklist was designed in the English language and was administered by trained field assistants. Where necessary, individual conversations were carried out in the Yoruba language and were translated into English. This involved face-to-face interactions with selected building occupants. Interview sessions were conducted with officials of the Oyo State Fire Safety and those of the BPPDC. During direct observation, measurement of road widths and the observed setbacks, measurement of air space, and other spatial standards were taken.

The target population was urban buildings. This comprised the total number of buildings, regardless of the use to which the structures are put. The choice of sample size was guided by 4 key factors as recommended by Morenikeji (2006) and Yusuf (2013). These are: available resources for collecting and processing the data, the amount of data to be collected from each unit of the sample, the number of categories to be used for data analysis, and the homogeneity of the group being surveyed. This choice was based on similar considerations that guided the choice of sample size made by previous related studies, such as Murphy et al. (2009), Gautam (2011), Murage (2012), and Xu et al. (2015). A sample size of 1,803 (3%) buildings was taken using a 4-step multistage sampling technique. The first stage involved the selection of all 11 LGAs in metropolitan Ibadan. The second stage encompassed the selection of 88 wards that are within the urban interface in the 11 LGAs. The wards were then grouped into non-overlapping communities. At the third stage, a community was randomly selected from each of the 88 wards. At the fourth stage, systematic random sampling was adopted to select 1,803 buildings from 60,317 buildings. The sample size for each sampled community ranged from 6 to 44 buildings, while the sample size for each LGA ranged from 90 to 289 buildings. A copy of the building observation checklist was completed for each of the selected buildings.

3. Results

3.1 Plot coverage and minimum setback for land use

Space standards provide standard criteria for assessing urban systems and a yardstick to measure compliance of development projects with statutory regulations. In this section, four major space standards that are relevant to fire safety are considered. These are minimum airspace, shortest distance from the building to the nearest road, plot/site coverage, and number of exits in the building. The plot/site coverage is defined by the Oyo State Government (2001, p. 4) as "the permissible percentage of the area of the site or parcel of land which is covered by building or structures erected over it, including auxiliary uses and out-houses, garages and stables." The maximum permissible plot coverage and the minimum space between two buildings for different land uses are illustrated in Table 1.

Table 1: Plot coverage and minimum setback for land use development

Type of land use		Maximum plot coverage (%)	Minimum space between two buildings (m)	Minimum setback from property line (m)
Residential	Low density	35	4.5	6
	Medium density	40	3	6
	High density	45	3	4.5
Commercial	Corner shops	30	3	7.5
	Office complex	45	3	15
	Others	35	6	15
Industrial	Light	30	9	15
	Medium	30	10	20
	Heavy	30	15	30
Educational	Elementary	30	n/a	n/a
	Primary	30	n/a	n/a
	Secondary	30	n/a	n/a
	Polytechnic	35	n/a	n/a
	University	30	n/a	n/a

Source: Oyo State Government (2011)

3.2 Locational variation in building compliance with planning standards

Using a building observation checklist, surveyed buildings were evaluated for compliance with relevant space standards for physical development in Oyo State. The results are summarised in Table 2. A very low level of conformity to minimum "building space" standards (space between two buildings) was observed. The largest portion (45.6%) of the buildings observed was between 0 and 2m building space. Another 37.2% observed between 3m and 4m building space. This implies that about 82.8% of the buildings did not have more than 4m of building space. The maximum and minimum building space observed were 0 and 25m, respectively, with a mean of 3.35m and a standard deviation of 2.47m. The observed building space varied across LGAs. 0-2m was the commonest building space that was observed in the inner city LGAs of Ibadan North-East, Ibadan North-West, and Ibadan South-West LGAs, which had 155 (18.8%), 112 (13.6%), and 115 (14%) buildings, respectively, in this category.

All 6 LGAs in the outer part of the city recorded 0-2m as the most common building space, except Ona-Ara LGA, which had 3-4m as its highest cases of building space. The outer LGAs jointly accounted for 17.5% and 11.1% of all cases of 0-2m and 3-4m building space, respectively. While the lowest cases of building space (0-2m) were observed mostly in the traditional core areas of the city (28.1%), such as Oje, Beere, and Labiran, larger building spaces, such as 7-8m (1.9%), were found mostly in the outer LGAs of the city.

The result of one-way analysis of variance (ANOVA), as summarised in Table 3, confirmed that observed building space varied significantly across LGAs (F = 19.378, $p < 0.001$), across communities (F = 17.396, $p < 0.001$), and among housing densities (F = 405.302, $p < 0.001$). However, the result of the t-test of independent samples indicated no significant variation in the observed building space between the outer and the inner LGAs ($t(1704) = -0.420$, $p = 0.674$). This implies that observed building space in the outer and inner LGAs was statistically the same.

Also illustrated in Table 3 is the distribution of buildings according to plot coverage (building to plot ratio). The minimum plot coverage recorded was as low as 1% while the maximum plot coverage was 100%. The mean plot coverage was 73.41% and the standard deviation was 15.82. This implies that, on average, buildings failed to comply with plot coverage standards. There were a few cases of plot coverage that were not more than 20% as only 1.2% of the buildings had between 0.1% and 20% plot coverage. It was surprising because all these cases were found in the denser inner LGAs of the city, while none were found in the outer LGAs, where it was believed that land availability was not a major issue. Only 1.6% of all the surveyed buildings (0.7% in the inner LGAs and 0.9% in the outer LGAs) observed 20.1-30% plot coverage. Similarly, only 0.7% of the surveyed buildings observed 30.1-40% and 3.7% observed 40.1-50% plot coverage. This also means that buildings that observed between 1% and 50% plot coverage accounted for just 7.5% of the total surveyed buildings.

Most of the surveyed buildings (61.5%) had between 70.1% and 100% plot coverage, which comprised 30.4% for 70.1-80% plot coverage and 31.1% for 80.1-100% plot coverage. Buildings that observed 50.1-60% and 60.1-70% plot coverage jointly accounted for 31.2% (10.1% and 21.2%, respectively). However, the situation was not the same across the study area. For instance, while the inner LGAs had plot coverage of 80.1-100% as their highest contribution, which accounted for 22.2% of surveyed buildings, the outer LGAs had plot coverage of 60.1-70% as their largest contribution (10.9%). In the same vein, while 60.1-70% was the largest plot coverage in Ibadan North (15.7%), Ido (11.3%), Lagelu (7.6%) and Ona Ara (9.2%) LGAs, 70.1-80% was the largest in Ibadan North-East (21.7%), Ibadan South-East (24.6%) and Egbeda (7.3%).

The results of ANOVA presented in Table 3 show that there was significant variation in the observed plot coverage across the eleven LGAs (F = 16230, $p = 0.000$), across communities (F = 7.629, $p = 0.000$), and across housing densities (F = 127.075, $p = 0.000$). Further tests showed a significant difference in plot coverage between the inner LGAs and outer LGAs ($t(1704) = 5.465$, $p = 0.000$). This implies that plot coverage was significantly higher (74.7913%) in the inner city than in the outer city (70.7241%).

Table 2: Space between two buildings and plot coverage

Minimum building space (m)		Local Government Area (LGA)													Total
		Inner LGAs						Outer LGAs							
		Ibadan North	Ibadan North-East	Ibadan North-West	Ibadan South-East	Ibadan South-West	**Sub-total**	Akinyele	Egbeda	Ido	Lagelu	Oluyole	Ona Ara	**Sub-total**	
0-2	Freq. (%)	70 (8.5)	155 (18.8)	112 (13.6)	55 (6.7)	115 (14.0)	**507 (28.1)**	75 (9.1)	73 (8.9)	50 (6.1)	29 (3.5)	48 (5.8)	41 (5.0)	**316 (17.5)**	823 (45.6)
3-4	Freq. (%)	72 (10.7)	114 (17.0)	58 (8.7)	157 (23.4)	69 (10.3)	**470 (26.1)**	19 (2.8)	26 (3.9)	49 (7.3)	23 (3.4)	39 (5.8)	44 (6.6)	**200 (11.1)**	670 (37.2)
5-6	Freq. (%)	38 (23.3)	15 (9.2)	16 (9.8)	6 (3.7)	25 (15.3)	**100 (5.5)**	4 (2.5)	23 (14.1)	13 (8.0)	10 (6.1)	7 (4.3)	6 (3.7)	**63 (3.5)**	163 (9.0)
7-8	Freq. (%)	13 (21.7)	4 (6.7)	5 (8.3)	-	3 (5.0)	**25 (1.4)**	-	9 (15.0)	6 (10.0)	17 (28.3)	3 (5.0)	-	**35 (1.9)**	60 (3.3)
9-10	Freq. (%)	10 (23.3)	-	4 (9.3)	4 (9.3)	20 (46.5)	**38 (2.1)**	-	-	3 (7.0)	-	2 (4.7)	-	**5 (0.3)**	43 (2.4)
Above 10	Freq. (%)	19 (43.2)	-	4 (9.1)	-	4 (9.1)	**27 (1.5)**	-	4 (9.1)	-	12 (27.3)	1 (2.3)	-	**17 (0.9)**	44 (2.4)
Total	Freq. (%)	222 (12.3)	288 (16.0)	199 (11.0)	222 (12.3)	236 (13.1)	**1167 (64.7)**	98 (5.4)	135 (7.5)	121 (6.7)	91 (5.0)	100 (5.5)	91 (5.0)	**636 (35.3)**	1803 (100)
Plot coverage (%)															
0.1-20.0	Freq. (%)	5 (22.7)	-	1 (4.5)	1 (4.5)	15 (68.2)	**22 (1.2)**	-	-	-	-	-	-	**-**	22 (1.2)
20.1-30.0	Freq. (%)	6 (20.7)	5 (17.2)	2 (6.9)	-	-	**13 (0.7)**	-	-	2 (6.9)	14 (48.3)	-	-	**16 (0.9)**	29 (1.6)
30.1-40.0	Freq. (%)	1 (7.7)	-	3 (23.1)	-	1 (7.7)	**5 (0.4)**	-	-	3 (23.1)	-	4 (30.8)	1 (7.7)	**8 (0.4)**	13 (0.7)
40.1-50.0	Freq. (%)	12 (18.2)	-	21 (31.8)	-	10 (15.2)	**43 (2.4)**	-	2 (3.0)	3 (4.5)	5 (7.6)	8 (12.1)	5 (7.6)	**23 (1.3)**	66 (3.7)
50.1-60.0	Freq. (%)	36 (19.7)	17 (9.3)	11 (6.0)	6 (3.3)	34 (18.6)	**104 (5.8)**	17 (9.3)	22 (12.0)	11 (6.0)	15 (8.2)	8 (4.4)	6 (3.3)	**79 (4.4)**	183 (10.1)
60.1-70.0	Freq. (%)	60 (15.7)	36 (9.4)	39 (10.2)	7 (1.8)	44 (11.5)	**186 (10.3)**	27 (7.1)	37 (9.7)	43 (11.3)	29 (7.6)	25 (6.5)	35 (9.2)	**196 (10.9)**	382 (21.2)
70.1-80.0	Freq. (%)	49 (8.9)	119 (21.7)	26 (4.7)	135 (24.6)	64 (11.7)	**393 (21.8)**	13 (2.4)	40 (7.3)	41 (7.5)	14 (2.6)	22 (4.0)	25 (4.6)	**155 (8.6)**	548 (30.4)
80.1-100	Freq. (%)	53 (9.5)	111 (19.8)	96 (17.1)	73 (13.0)	68 (12.1)	**401 (22.2)**	41 (7.3)	34 (6.1)	18 (3.2)	14 (2.5)	33 (5.9)	19 (3.4)	**159 (8.8)**	560 (31.1)
	Total	**222 (12.3)**	**288 (16.0)**	**199 (11.0)**	**222 (12.3)**	**236 (13.1)**	**1167 (64.7)**	**98 (5.4)**	**135 (7.5)**	**121 (6.7)**	**91 (5.0)**	**100 (5.5)**	**91 (5.0)**	**636 (35.3)**	**1803 (100)**

Source: Field survey, 2022

Table 3: ANOVA for locational variation in observed space standards in buildings

		Sum of Squares	df	Mean Square	F	Sig.
Min. road setback (m)						
LGA	Between Groups	5417.349	10	541.735	12.889	.000
	Within Groups	67334.415	1602	42.031		
	Total	72751.764	1612			
Community	Between Groups	15314.565	84	182.316	4.850	.000
	Within Groups	57437.199	1528	37.590		
	Total	72751.764	1612			
Housing density	Between Groups	1268.708	2	634.354	14.287	.000
	Within Groups	71483.056	1610	44.399		
	Total	72751.764	1612			
Min. building space (m)						
LGA	Between Groups	1069.789	10	106.979	19.378	.000
	Within Groups	9357.398	1695	5.521		
	Total	10427.187	1705			
Community	Between Groups	4943.418	84	58.850	17.396	.000
	Within Groups	5483.769	1621	3.383		
	Total	10427.187	1705			
Housing density	Between Groups	3362.631	2	1681.316	405.302	.000
	Within Groups	7064.555	1703	4.148		
	Total	10427.187	1705			
Plot coverage						
LGA	Between Groups	37284.344	10	3728.434	16.230	.000
	Within Groups	389377.891	1695	229.721		
	Total	426662.235	1705			
Community	Between Groups	120881.417	84	1439.064	7.629	.000
	Within Groups	305780.818	1621	188.637		
	Total	426662.235	1705			
Housing density	Between Groups	55405.036	2	27702.518	127.075	.000
	Within Groups	371257.199	1703	218.002		
	Total	426662.235	1705			
Number of exits in the building						
LGA	Between Groups	69.978	10	6.998	7.745	.000
	Within Groups	1619.181	1792	0.904		
	Total	1689.159	1802			
Community	Between Groups	484.968	84	5.773	8.237	.000
	Within Groups	1204.191	1718	0.701		
	Total	1689.159	1802			
Housing density	Between Groups	62.133	2	31.066	34.369	.000
	Within Groups	1627.027	1800	0.904		
	Total	1689.159	1802			

Source: Field survey, 2022

Table 4 shows other aspects of the space standard that were considered – setback to road and exits per building. Road setback was measured in terms of the shortest distance between a building and the road that served it. Setbacks could not be measured for 190 buildings (10.5%), owing mainly owing to lack of road accessibility. The measured setbacks for the remaining 1,613 buildings were regrouped for ease of presentation. The results showed that most of the buildings (46.8%) observed a 3-5.9m road setback (29.4% in the inner LGAs and 17.4% in the outer LGAs). Setbacks of between 3m and 5.9m were also the highest in virtually all the 11 LGAs – Ibadan North had 13.6% buildings in this category, Ibadan North-East had 14%, Ibadan North-West 11%, Ibadan South-East had 14.8%, Ibadan South-West had 9.4%, Akinyele had 4.1%, Egbeda had 7.8%, Ido had 7.7%, Lagelu had 3.3%, Oluyole had 6.9% and 7.3% was also highest in Ona Ara. A total of 296 (18.4%) of the surveyed buildings observed less than 3m road setback in the 11 LGAs. This was the second highest in both the inner LGAs (10.6%) and outer LGAs (7.7%). Merging these two categories, more than half of the buildings (56.2%) observed road setbacks of less than 4m. The results further showed that 13% of the buildings observed 6-8.9m setback from building line; 5.7% observed 9.0-11.9m setback; 2.3% maintained 12.0-14.9m setback; 4.2% had 15.0-17.9m setback; 4.4% observed 18.0-20.9m setback; and those that observed 21m or more constituted 5.3%.

Using the absolute measurements of setbacks per building, the observed variation across LGAs was verified using the one-way ANOVA (Table 4). The result showed a significant variation in the observed minimum setback to road from building line across the 11 LGAs (F = 12.889; p = 0.000), across communities (F = 4.85; p = 0.000), and across housing densities (F = 14.287; p = 0.000). Furthermore, a significant variation was found in the minimum road setback observed from the building line between the outer and inner LGAs (t(1704) = 6.586, p = 0.000). Thus, the mean minimum road setback observed in the inner city (7.5m) was significantly higher than that of the outer city (5.4m).

Table 4 also shows the distribution of surveyed buildings across the 11 LGAs according to the number of exits. It shows that exits per building ranged from one to ten. Most of the buildings (63.2%) had 2 exits per building, with a mean of 2.09 and a standard deviation of 0.97. Two exits per building were the commonest in all the LGAs. One exit per building accounted for 20.1% of the buildings. Generally, buildings that had 3, 4, 5, and 6 exits accounted for 8.4%, 6.3%, 0.6% and 1.1% buildings, respectively.

3.3 Variation in minimum space standards across land use types

Further investigation showed that compliance with minimum space standards varied across land use types. The results illustrated in Tables 2 and 4 were used to evaluate the level of compliance with space standards based on the statutory standards presented in Table 1.

As depicted in Figure 2, the majority of the buildings in residential (76%), commercial (75.3%), residential/ commercial (72.6%), residential/ public (57.1%), and commercial/public (100.0%) land uses did not comply with the minimum space standard. In almost all mixed-use buildings that involved residential uses, non-compliance with the building space standard was prevalent. The situation was statistically the same across categories of land use as revealed by the ANOVA results summarised in Table 5 (F = 14.137; p = 0.000). However, the result revealed that there was a relatively high compliance rate with the minimum building space standard in buildings in public (68.5%) and in industrial (66.7%) land uses.

In relation to compliance with maximum plot coverage, the result of the evaluation showed that a significant percentage of the buildings (87.3%) did not comply. Only 12.7% observed the maximum plot coverage standard. The cross-tabulation of building use with compliance with maximum plot coverage showed that most of the buildings in all categories of use failed to meet the required standard. These categories are residential only (87.1%), commercial only (83.2%), public only (68.5%), residential/commercial (96.6%), residential/public (97.6%), commercial/public (100%), and commercial/industrial (100%). A significant variation was established in the compliance with the plot coverage standard across categories of land use (Table 5).

The minimum setback to the road from the building line was also analysed. A larger percentage of the buildings (80.5%) did not comply with the minimum setback to the road. This comprised the following categories: residential only (49.4%), commercial only (16.1%), public only (2.3%), residential/commercial (10.6%), residential/public (1.4%), commercial/public (0.2%), and commercial/ industrial (0.3%). The average road setback across building uses was 7.15m for residential only, 5.11m for commercial only, 8.37m for public only, 6.86m for residential/commercial, 7.81 m for residential/public, 1.5m for commercial/ public, and 2.67m for commercial/industrial building uses. Although virtually all building uses had a larger percentage of non-compliance with statutory setback, the situation in public buildings was relatively better with 42.5% and 38.1% of the buildings complying with the minimum setback to road in public-only and residential/public buildings, respectively. However, the result of ANOVA illustrated in Table 5 revealed that the low compliance level with road setback was the same across categories of land uses (F = 9.319; $p > 0.01$).

Table 4: Setback to road from building line and exits per building

		Local Government Area (LGA)													
		Inner LGAs						Outer LGAs							
		Ibadan North	Ibadan North-East	Ibadan North-West	Ibadan South-East	Ibadan South-West	**Sub-total**	Akinyele	Egbeda	Ido	Lagelu	Oluyole	Ona Ara	Sub-total	Total
A. Setback to the road from the building line															
Less than 3	Freq. (%)	35 (11.8)	48 (16.2)	59 (19.9)	5 (1.7)	24 (8.1)	**171 (10.6)**	15 (5.1)	38 (12.8)	23 (7.8)	8 (2.7)	21 (7.1)	20 (6.8)	125 (7.7)	296 (18.4)
3.0-5.9	Freq. (%)	103 (13.6)	106 (14.0)	83 (11.0)	112 (14.8)	71 (9.4)	**475 (29.4)**	31 (4.1)	59 (7.8)	58 (7.7)	25 (3.3)	52 (6.9)	55 (7.3)	280 (17.4)	755 (46.8)
6.0-8.9	Freq. (%)	19 (9.0)	18 (8.6)	9 (4.3)	16 (7.6)	36 (17.1)	**98 (6.1)**	24 (11.4)	17 (8.1)	23 (11.0)	27 (12.9)	12 (5.7)	9 (4.3)	112 (6.9)	210 (13.0)
9.0-11.9	Freq. (%)	11 (12.0)	11 (12.0)	6 (6.5)	23 (25.0)	17 (18.5)	**68 (4.2)**	-	9 (9.8)	2 (2.2)	10 (10.9)	1 (1.1)	2 (2.2)	24 (1.5)	92 (5.7)
12.0-14.9	Freq. (%)	5 (13.5)	11 (29.7)	6 (16.2)	-	11 (29.7)	**33 (2.0)**	-	2 (5.4)	1 (2.7)	1 (2.7)	-	-	4 (0.2)	37 (2.3)
15.0-17.9	Freq. (%)	17 (25.4)	8 (11.9)	4 (6.0)	10 (14.9)	14 (20.9)	**53 (3.3)**	-	5 (7.5)	4 (6.0)	5 (7.5)	-	-	14 (0.9)	67 (4.2)
18.0-20.9	Freq. (%)	11 (15.5)	12 (16.9)	4 (5.6)	1 (1.4)	24 (33.8)	**52 (3.2)**	2 (2.8)	3 (4.2)	3 (4.2)	9 (12.7)	2 (2.8)	-	19 (1.2)	71 (4.4)
21 & above	Freq. (%)	15 (17.6)	51 (60.0)	3 (3.5)	1 (1.2)	7 (8.2)	**77 (4.8)**	-	-	2 (2.4)	-	5 (5.9)	1 (1.2)	8 (0.5)	85 (5.3)
	Total	**216 (13.4)**	**265 (16.4)**	**174 (10.8)**	**168 (10.4)**	**204 (12.6)**	**1027 (63.7)**	**72 (4.5)**	**133 (8.2)**	**116 (7.2)**	**85 (5.3)**	**93 (5.8)**	**87 (5.4)**	586 (36.3)	1613 (100)
B. Exits per building															
1	Freq. (%)	38 (10.5)	53 (14.6)	63 (17.4)	30 (8.3)	76 (21.0)	**260 (14.4)**	11 (3.0)	43 (11.9)	13 (3.6)	12 (3.3)	13 (3.6)	10 (2.8)	102 (5.7)	362 (20.1)
2	Freq. (%)	132 (11.6)	187 (16.4)	124 (10.9)	153 (13.4)	124 (10.9)	**720 (39.9)**	84 (7.4)	85 (7.5)	82 (7.2)	56 (4.9)	61 (5.4)	52 (4.6)	420 (23.3)	1140 (63.2)
3	Freq. (%)	24 (15.8)	13 (8.6)	6 (3.9)	1 (0.7)	19 (12.5)	**63 (3.5)**	3 (2.0)	5 (3.3)	19 (12.5)	17 (11.2)	18 (11.8)	27 (17.8)	89 (4.9)	152 (8.4)
4	Freq. (%)	13 (11.5)	27 (23.9)	4 (3.5)	36 (31.9)	12 (10.6)	**92 (5.1)**	-	-	6 (5.3)	5 (4.4)	8 (7.1)	2 (1.8)	21 (1.2)	113 (6.3)
5	Freq. (%)	5 (45.5)	3 (27.3)	-	-	2 (18.2)	**10 (0.6)**	-	-	1 (9.1)	-	-	-	1 (0.1)	11 (0.6)
6	Freq. (%)	5 (25.0)	5 (25.0)	2 (10.0)	2 (10.0)	3 (15.0)	**17 (0.9)**	-	2 (10.0)	-	1 (5.0)	-	-	3 (0.2)	20 (1.1)
10	Freq. (%)	5 (100.0)	-	-	-	-	**5 (0.3)**	-	-	-	-	-	-	-	5 (0.3)
	Total	**222 (12.3)**	**288 (16.0)**	**199 (11.0)**	**222 (12.3)**	**236 (13.1)**	**1167 (64.7)**	**98 (5.4)**	**135 (7.5)**	**121 (6.7)**	**91 (5.0)**	**100 (5.5)**	**91 (5.0)**	**636 (35.3)**	**1803 (100)**

Source: Field survey, 2022

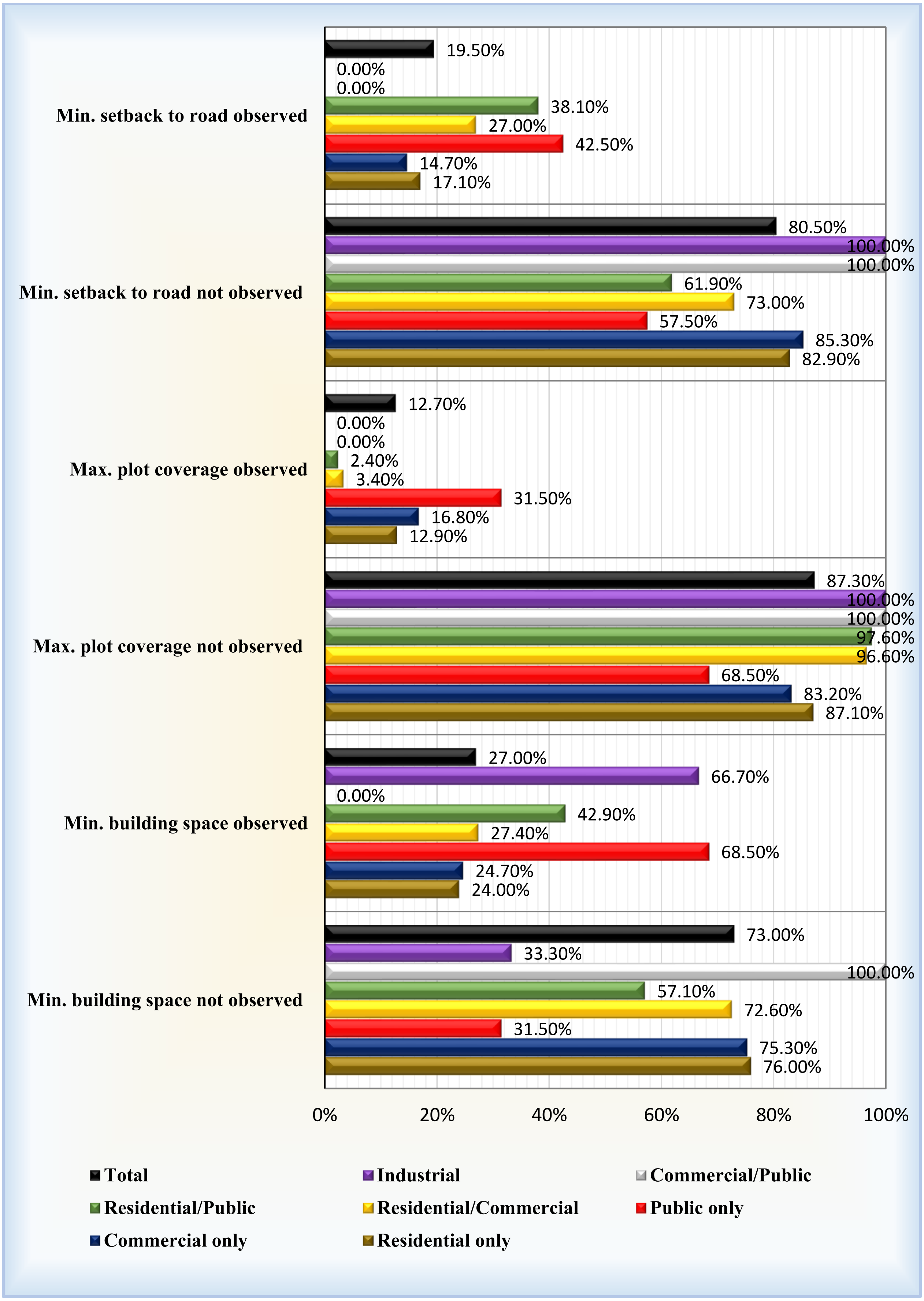

Figure 2: Compliance with planning/space standards by land use types
Source: Field survey, 2022

Table 5: ANOVA for compliance with planning standards across land use

		Sum of Squares	df	Mean Square	F	Sig.
Compliance with the minimum building space standard	Between Groups	16.010	6	2.668	14.137	.000
	Within Groups	338.989	1796	.189		
	Total	354.998	1802			
Compliance with the maximum plot coverage standard	Between Groups	6.022	6	1.004	9.297	.000
	Within Groups	193.893	1796	.108		
	Total	199.915	1802			
Compliance with the minimum setback from the road	Between Groups	8.553	6	1.425	9.319	.000
	Within Groups	274.726	1796	.153		
	Total	283.279	1802			
Number of exits in the building	Between Groups	161.995	6	26.999	31.752	.000
	Within Groups	1527.164	1796	.850		
	Total	1689.159	1802			

Source: Field survey, 2022

4. Discussion and Conclusion

4.1 Discussion

In a multiple land use setting that comprises buildings with multiple users/occupants, a more complex analysis of fire risks emerges. Land use planning is often executed by making and applying space standards. Low level of compliance with space standards was observed in virtually all land use categories. This aligns with the findings of Yunus (2019) that half of commercial land uses did not comply with minimum space standards in Dutse, Nigeria. It also confirms Koffi and Willie's (2021) submission that there was a low level of compliance with space standards in commercial buildings in Ikot Ekpene, Nigeria. Compliance with space standards varied across communities and regions within the city. Plot coverage, for instance, recorded lower compliance in the inner-city land uses than in the outer parts of the city. These results have fire-risk implications. The violations of minimum plot coverage standards pose a greater risk of building-to-building fire spread during fire events. Fire spreads faster when buildings are built too close together. These violations were more common in the inner city than in the outer city. Going by the statutory standard, most of the buildings failed to observe minimum setbacks from the road to property lines. A relatively lower level of compliance with road setbacks was observed in land uses in the inner part of the city compared with those in the outer part of the city. Apparently, enforcement of space standards was less stringent in some LGAs. More relaxed enforcement in the outer part of the city may contribute to more variation in compliance across LGAs.

An indicator of how safe a building is during a fire emergency is the number of functional exits in the building. While the number of exits per building varied significantly across LGAs, the variation in the number of exits per building between the city core and the outer city was not significant. The observed variation can be attributed to the fact that buildings designed for public or high occupancy use generally have stricter exit requirements than smaller residential buildings, as established by Stauffer et al. (2021). In this case, the mix of building types differs across LGAs but remains uniform between the city core and outer city. Regulatory and enforcement variations across LGAs and building types can translate into varying standards for exit numbers within LGAs, but these inconsistencies did not show a strong correlation with geographic location relative to the city core.

The level of compliance with the minimum building space standard was very low across all land use categories. However, the level of compliance varied across land use types. Higher compliance rates were observed in buildings in public and commercial land uses. One major reason for a higher compliance rate in industrial buildings is that stringent enforcement and monitoring activities are often targeted at industrial establishments by the regulatory agencies. Also, relatively more regulatory agencies are associated with industrial establishments compared with other uses. Owing to this, they are often compelled to adhere strictly to relevant space standards. Another factor responsible for higher compliance rates in public buildings and industrial buildings is that most of these buildings were located in government-owned estates, which were laid out according to space standards and were under close monitoring by the Oyo State Housing Corporation. Examples of such estates include Oluyole Estate in Ibadan South-west LGA and Olubadan Estate in Egbeda LGA.

The essence of the plot coverage standard is to make enough space available for important ancillary facilities/services, such as parking, fire hydrants, muster point, and buffers, within the site where the building is located. Most of the buildings in all land use categories exceeded the maximum plot coverage standard. The implication of the low level of compliance with the maximum plot coverage standard for fire safety is that plot densities will increase, air-space will reduce, space will be insufficient for fire hydrants and assembly points, and response time during a fire emergency will increase. This could also be linked to congestion and overcrowding, as such areas are densely populated as pointed out by one of the directors of Development Control in the BPPDC. This is in line with the submission of Badland et al. (2014) that overcrowding and high plot densities hinder effective firefighting operations and emergency evacuations. In the same vein, fire is likely to spread more rapidly since the proximity of structures in non-compliant areas will facilitate rapid fire spread between buildings. This corroborates the thoughts of Kinateder et al. (2014) that insufficient space reduces defensible space and increases the challenge of containing a fire.

A similar situation was observed concerning compliance with the road setback from the building line. Generally, four out of five buildings did not have adequate setback from the road. On the average road setback, only buildings in residential land uses complied with the statutory standard. The implication is that when road setback standards are not observed, affected buildings become more vulnerable to fire disasters triggered by road crashes and accidents from other incompatible uses, such as high-tension power lines as rightly observed by Falola et al. (2024).

A consensus exists among fire safety officials that non-adherence to space standards is a primary driver of the high building density and increased fire incidence observed in the city core. Corroborating this view, personnel from the Bureau of Physical Planning and Development Control (BPPDC) noted that structural vulnerability escalates significantly when developments contravene building codes and planning regulations. Consequently, fire risks are disproportionately elevated in settlements where minimum building space standards are disregarded. Substandard buildings – buildings built without appropriate fire safety standards – present unsafe conditions, which Hai and Smyth (2012) described in the Disaster Pressure Model. In communities with high non-compliance, residents may take on unsafe practices as a result of necessity. Overcrowded buildings in the city core encourage unsafe practices such as overloading electrical circuits or relying on open flames within confined areas. These findings were substantiated by officials at the Oyo State Fire Service Headquarters, who explicitly attributed a 2012 fire incident in Yemetu, Ibadan, to short-circuiting resulting from illegal electrical connections. Furthermore, an official interviewed at the Molete Fire Service Station observed that such hazardous behaviours have become so entrenched that residents now perceive these unsafe practices as norms. This further reiterates the findings of Mansuri et al. (2023), which revealed that previous experience with fire risks can diminish people's perception of fire risk.

The foregoing suggests a need for good urban governance frameworks that will prioritize risk awareness and community participation in fire safety planning. This is because the absence of public education and a weak perception of fire risk in under-regulated, non-compliant communities can propagate unsustainable fire safety practices and exacerbate vulnerabilities. Thus, there is a need to prioritize participatory governance strategies in vulnerable areas, including informal settlements, fostering collaborative disaster preparedness, risk mitigation, and building community resilience.

4.2 Conclusion

The city's urban form is characterized by a pervasive disregard for statutory space standards, creating a landscape of systemic risk. Specifically, the widespread violation of minimum building space and the extensive non-compliance with plot coverage limits constitute "unsafe conditions" as conceptualized in the Disaster Pressure Model. The widespread disregard for building space standards significantly intensifies fire risks in multiple land-use settings. This issue is particularly acute within the city core, where dense development and non-compliance create a potential fire disaster. The low compliance rates point to systemic problems within the regulatory framework. This encompasses issues like inadequate enforcement capacity, loopholes in regulations, or a lack of clarity in the available fire safety standards. The study highlights a governance paradox where industrial and public land uses achieve higher compliance through stringent monitoring, while the residential sector, which houses the majority of the population, remains largely unregulated and vulnerable. Ultimately, the normalization of these unsafe spatial practices among residents, coupled with institutional fragmentation, underscores that fire vulnerability in Ibadan is not merely a physical challenge but a failure of urban governance.

A comprehensive review of both regulations and their implementation processes is crucial. Non-compliant buildings don't exist in isolation. In the context of informal settlements, they are often coupled with poor infrastructure, substandard construction materials, and unsafe practices driven by necessity. These factors interact to create a complex web of exponentially increased fire risk. Addressing this situation demands targeted policy and practical interventions. In areas with the highest cases of violations, a holistic enforcement approach might prove counterproductive. Instead, community engagement initiatives should focus on raising awareness of fire risks, promoting safer construction practices, and working collaboratively to develop realistic and achievable safety plans, especially in the city core. The city core, with its informal settlements and high density, requires the most urgent attention. Fire safety investments in these areas must go beyond individual buildings to address community-wide factors. This could include improving access for fire services, creating designated safe zones, and establishing community fire response teams.

This paper calls for a holistic approach to urban fire safety. The existence of building regulations and space standards is not enough to achieve sustainable fire disaster risks management. Effective enforcement, risk-aware community planning, and investments in fire safety infrastructure are all essential components of a resilient urban environment.

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Data Availability Statement
The data that support the findings of this study are available from the corresponding author, [Falola, O.J.], upon reasonable request.

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