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Building Characteristics and Incompatible Land Uses as Drivers of Fire Disaster Risk

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ABSTRACT

Risk-based land use planning is regarded as a controlling tool for reducing environmental disasters in urban settlements. However, unsustainable land use practices allow building and infrastructural developments in fire disaster-risk areas. Losses to urban fires are largely dependent on building and land use characteristics across settlements. This paper examines the underlying characteristics that increase fire risks in urban buildings by analyzing the relationship between land use patterns, types of building use, and fire disaster risk in the metropolitan area of Ibadan, Nigeria. Data were collected through a field survey using a structured questionnaire supplemented by focus group discussion. A multistage sampling procedure was used to select 88 neighborhoods and 1,803 building occupants were selected using systematic random sampling. Findings indicate incompatible land use developments in many areas of the city. The study revealed that one out of five buildings were not accessible to fire-fighting vehicles owing to inadequate road widths (43.7%) and pot-holes (39.8%). One out of seven buildings (14.1%) had no water supply. About 10% of the buildings had emergency doors on permanent lock. About half of the building occupants relied on power supply sources that increased risks of fire occurrence (52%) and 49.4% used unsustainable waste disposal methods that threatened fire safety. The paper concluded that land use attributes, such as accessibility, compatibility of uses, water supply sources, sources of electricity supply and solid waste disposal method, and building characteristics, such as burglar proofs, nature of entrance/exit, type of lighting fuel are factors that are relevant in fire disaster risk analysis.

INTRODUCTION

Urban settlements are becoming increasingly complex as a result of rapid urbanization coupled with inadequate control of physical developments, especially in developing countries (Sakketa, 2023). The increasingly rapid urbanization 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 (Fabiyi, 2020; Aliu et al., 2021). These contemporary urban realities have commonalities of incompatible developments and low compliance with land use regulations (Mohanty, 2020; Ablo, 2023).

Land use planning is meant to ensure that developments that are carried out on land are guided to ensure safety, compatibility, and sustainability to reduce disaster risks. Risk-based land use planning is regarded as a controlling tool for reducing environmental disasters (Olcina, 2022). Land use plans provide an avenue to investigate how effective development control and planning regulations are by identifying existing areas of disaster risk (Sanchez et al., 2018). This is meant to reduce disaster risks. The analysis of the relationship between land use planning and disaster risk reduction is well-established in the literature (Dandoulaki et al., 2023).

However, inefficient and ineffective land use practices allow building and infrastructural developments in disaster-risk areas. Such cases of incompatible land uses are common in most metropolitan areas of developing countries, especially those in sub-Saharan Africa (Ugwuanyi et al., 2015; United Nations, 2021). This is because most urban areas in this region show peculiarities of informality, congestion, poor sanitation, conflicting land uses, derelict buildings, social exclusion, and overcrowding (Mottelson, 2020; Azunre et al., 2021). Most of the informal settlements (and few formal ones) show a high level of vulnerability to disasters, particularly building fires, mainly because they are located in marginal settlements (Ngau and Boit, 2020). This urban reality, coupled with an inadequate emergency response and recovery system put inhabitants at a high fire disaster risk (Richmond, 2018; Shi et al., 2022).

The 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; Zhang et al., 2023). The cause-and-effect relationship between disasters and physical, social, and economic developments is documented in the literature. For instance, recent research outcomes have established a strong connection between physical development in human settlements and the occurrence of disasters (Wahab and Falola, 2017; Padli, et al., 2018; Živković, 2019; Zerbo et al., 2020; Agbola and Falola, 2021; Chaudhary and Piracha, 2021; Jerome, 2021; Wahab and Falola, 2022). The root cause of the negative effects that are associated with the development and 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). The relationship is such that poor and unguided physical development engenders hazards and disaster risks (Adaramola et al., 2017; Chhetri et al., 2018; Adelekan, 2020; Ngau and Boit, 2020; Zerbo et al., 2020; Dandoulaki et al., 2023).

Fire hazards are ubiquitous; however, losses to urban fires are largely dependent on building and land use characteristics across settlements (Adelekan, 2020). the proliferation of incompatible land uses in rapidly urbanizing cities, especially in informal settlements means that more people are being forced to live in areas vulnerable to fire disasters (Zerbo et al., 2020).

Building fire is regarded as the most frequent fire accident in the Ibadan metropolis (Oloke et al., 2021; Falola and Agbola, 2022). Indeed, building characteristics could be a major factor responsible for the differences in the frequency of fire accidents in buildings. In this regard, Falola and Agbola (2022) established a significant variation in the frequency of building fire events across communities and local government areas, which resulted from differences in building elements, such as construction materials and household fuel usage. Some materials used for building constructions are more susceptible to fire disasters than others. For instance, windows and doors made from wood are more prone to fire spread than those made of metals (Eastman, 2021). Lighting and cooking fuel can also influence fire risks in buildings. In addition, many buildings in Ibadan are old and poorly constructed (Adelekan, 2020). They often have flammable materials such as wood and plastics, and they may not have adequate fire protection systems (Lowden and Hull, 2013). This inherently increases the susceptibility of buildings to fire disasters.

The extant literature focuses majorly on the assessment of causes, spatial distribution, and impact of fire disasters in single land-use developments, such as commercial (Oladokun and Emmanuel, 2014; Alabi et al., 2022), administrative (Onuoha, 2009), industrial (Adaramola et al., 2017), educational (Ogajo, 2013; Akumu, 2013), and residential (Chhetri et al., 2018). There is a dearth of empirical studies on fire disaster risks that capture all land uses in an urban setting. However, the available fire information from various sources in the past decades gives some insight into the unsustainable approaches to fire management in Ibadan (Egunjobi and Falola, 2017, Adelekan, 2020). With the nature of haphazard developments in the form of urban sprawl that is peculiar to major Nigerian cities, such as Ibadan and Port Harcourt, the level of vulnerability of buildings to fire hazards has continued to increase.

The concepts of urban governance and disaster risk reduction were used to anchor this study. 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 to sustainable development (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 delivery 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). Poor/weak governance exposes urban communities and inhabitants to increasing risk and vulnerability to fire disasters (Gencer et al., 2018). This is because the effective reduction of fire hazards/disasters can only be achieved by putting in place appropriate standards, rules, regulations, policies, legislations, and approaches to guide urban development and, at the same time, building urban resilience to fire disasters.

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; Hammer et al., 2019). 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, and the exclusion of poor people from fire mitigation and emergency response preparedness. Similarly, "dynamic pressures" could be: the absence of community-based organizations (CBOs) for collective efforts to prevent such conflicting land uses, rapid and uncontrolled urbanization, uncontrolled rural-urban migration, urban sprawl, epidemics, insurgency, lack of access to residential land in a safe location, and disregard for rule of law.

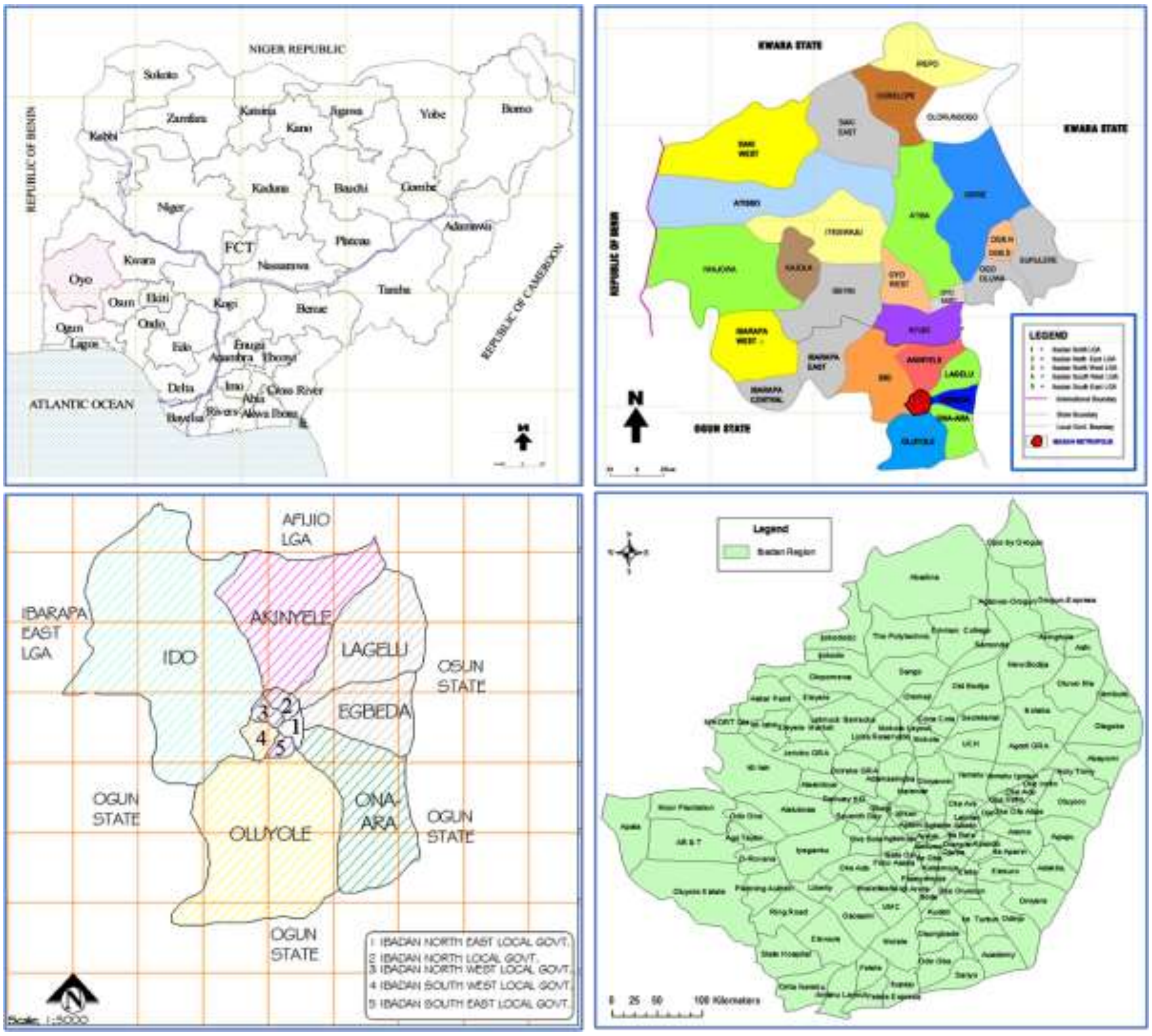
Against this backdrop, this study analyses the relationship between land use patterns, types of building use, and fire disaster risk in a metropolitan area. This is to help in identifying urban areas that are most at risk of fire, in understanding the level of susceptibility of buildings to fire disasters, and in developing strategies for reducing fire risk. Having identified building characteristics and incompatible land use developments as major fire disaster-risk factors in cities, this paper uses Ibadan, Nigeria, as a context in assessing urban fire disaster risks that are associated with building characteristics and inappropriate land use practices. The study captured all the land uses and buildings in the city, thereby allowing for comparisons between the inner and the outer parts of the city, as well as across land uses.

MATERIALS AND METHODS

The Study Area

The study area is Ibadan, one of the largest cities in sub-Saharan Africa in terms of area extent and population. It is located on Lat. (Figure 1). Ibadan City has one of the largest population densities in Nigeria with the traditional core having the highest density. Unfortunately, the densely populated settlement exists within a context of improper land use planning, which has resulted in unpleasant situations and environmental challenges, such as building fires, housing shortages, congested traffic flow, flooding, and degradation of the environment (Wahab & Falola, 2018).

Figure 1. Geographical location of the study area, Ibadan, Nigeria



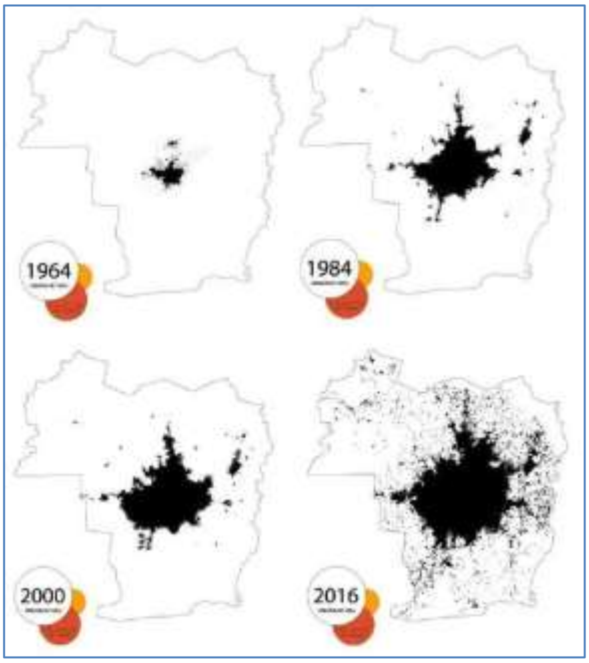
Source: Modified after Ministry of Lands, Housing and Urban Development, Oyo State (2018)

The implication of the rapid rate of urbanization, population growth, and urban expansion for fire disaster management is significant. The rapid rate of rural-urban urbanization has given rise to the development and sustenance of urban sprawl, huge slums, and squatter settlements, especially at the peri-urban interface of metropolitan Ibadan (Agbola and Alabi, 2009). The result is a city that is more prone to fire hazards/disasters than ever before.

Generally, land use in Ibadan, whether formal or informal has spatial dimensions (Agbola, 1994). The traditional core of the city exhibits some form of slummy characteristics owing majorly to the fact that buildings were built before the advent of modern physical planning. The transitional colonial areas and the modern areas have better housing quality and a more salutary environment (Agbola, 1994; Fabiyi, 2020). However, most of the existing housing units, especially those developed in private residential layouts, were built spontaneously and, therefore, lacked basic infrastructural facilities, such as electricity, water, and good access roads.

The overall pattern of land use indicates a difference between predominantly residential use in the core areas and agricultural use in the rural areas of Ibadan. The spatial expansion of the urban area with two periods standing out as times of rapid growth – 1964 to 1984 and 2000 to 2016 (Figure 2). Indeed, the city witnessed a huge rate of expansion within the last decade. Despite the alarming growth rate and the concomitant physical development, new fire service points were not introduced within the 16 years between 2000 and 2016. This implies that the city's growth and expansion were not matched with land use planning or urban management. The spatial expansion has been along the major highways with infill development then taking place. This type of ribbon expansion is indicative of ineffective planning and development control (Oyo State Government, 2016).

Figure 2. Physical Growth of Ibadan between 1964 and 2016



Source: Oyo State Government (2006)

Methodology

The data for this research were collected through a field survey. The instruments adopted for data collection include a structured questionnaire, direct observation complemented with a structured checklist, a focus group discussion (FGD) guide, and open-ended individual conversations.

A 10-member multi-stakeholders FGD session that involved 2 representatives each from the Oyo State Emergency Management Agency (OYSEMA), the Bureau of Physical Planning and Development Control (BPPDC) of the Oyo State Ministry of Lands, Housing and Survey (OMLS), Oyo State Fire Service (OSFS) and Neighbourhood Associations was conducted. The discussion included experts' views on inter- and intra-agency coordination in fire disaster risk reduction. The study also involved direct observation to understand and be familiar with the existing situation in content and context.

The questionnaire was administered to building users. The target group constituted users or inhabitants of all buildings/structures in Ibadan city. A multistage sampling procedure was adopted for questionnaire administration owing to the heterogeneity of the study area and the target population. This technique has been identified as an appropriate choice if the sampling frame is difficult to establish or expensive to carry out (Yusuf, 2013; Xu et al., 2015).

The multistage sampling process followed a stepwise order that involved 3 stages. In the first sampling stage, a community was selected from each of the political wards in all 11 LGAs by using a computer-generated random number system. Twelve wards were selected each from Akinyele, Ibadan North, Ibadan North-East, Ibadan South-East, and Ibadan South-West LGAs; eleven wards were selected from each of Ibadan North-West, Egbeda, and Ona Ara LGAs; ten wards selected from Ido and Oluyole LGAs; and fourteen wards were selected from Lagelu LGA. These make a total of 127 wards. From this stage, the total number of selected communities was compiled. The total number of buildings in each community was counted and numbered. This gave a total of 60,308 buildings from 88 communities.

At the second sampling stage, a random choice of "*n*" number of buildings corresponding to 3% of the total number of buildings was selected systematically in each of the selected communities. Within each community, separate but proportional samples were drawn (see Table 1). This gave a total of 1,803 buildings. Accordingly, 1,803 copies of the survey questionnaire were administered to residents, workers, and or users of the selected buildings. One person was randomly selected in each of the selected buildings. This made a comparative analysis between the core areas and the emerging areas of Ibadan city possible.

Table 1. Selected communities, sample frame and sample size

	LGAs	No. of Wards	No. of urban communities	No. of selected communities	No. of buildings			Sample size (3%)
					Building use	No. of buildings	Total no. of buildings	
Inner Core	Ibadan North	12	55	12	Residential Public/Commercial Industrial	4332 3077 27	7436	223
	Ibadan North-East	12	57	12	Residential Public/Commercial Industrial	5484 4003 141	9628	289
	Ibadan North-West	11	61	11	Residential Public/Commercial Industrial	3828 2754 44	6626	199
	Ibadan South-West	12	56	12	Residential Public/Commercial Industrial	4751 2854 239	7844	235
	Ibadan South-East	12	53	12	Residential Public/Commercial Industrial	5777 1602 19	7398	222
Sub-total		59	282	59		38932	38932	1168
Sub-Urban	Akinyele	12	23	4	Residential Public/Commercial Industrial	2166 1006 108	3280	98
	Egbeda	11	16	6	Residential Public/Commercial Industrial	2701 1101 233	4035	121
	Ido	10	24	5	Residential Public/Commercial Industrial	2878 362 92	3332	100
	Lagelu	14	15	4	Residential Public/Commercial Industrial	2505 469 14	2988	90
	Oluyole	10	23	5	Residential Public/Commercial Industrial	2955 1557 217	4729	142
	Ona Ara	11	17	5	Residential Public/Commercial Industrial	2094 894 33	3021	90
	Sub-total	68	68	29	Sub-total	21385	21385	641
Total		127	501	88		60,317	60,317	1,803

Source: Computed from records of OMLS and Independent National Electoral Commission (2011, 2015)

RESULTS AND DISCUSSION

Building Characteristics Associated with Fire Disaster Risks

Table 2 shows the distribution of buildings according to uses and types. Buildings that were used solely for residential purposes accounted for 59.6% of the sampled buildings. Buildings that were used only for commercial activities constituted 18.9% while 4% were exclusively for public use. The remaining buildings (17.5%) were mixed-use developments. The mixed-use development comprised residential/commercial uses (14.6%); residential and public (2.3%), commercial and public (0.2%), and commercial and industrial (2.3%). Public buildings comprise those that were used for educational purposes (1.7%), recreational uses (1.5%), administrative uses (1.4%), religious uses (1.3%) and health services (0.8%). If the mixed-used developments are included, then it means that people lived in, at least, 73.8% of the sampled buildings while commercial activities took place in not less than 34% of the surveyed buildings.

As shown in Table 2, most of the buildings surveyed (45.2%) were of Brazilian (rooming) type. Single-unit flats totaled 18.9% and commercial complexes accounted for 14.3%. Block of flats were 9.3%; duplexes were 5.2%; improvised structures, which were mostly informal and temporary accounted for 3.7%; and traditional residential compounds represented 1.1% of the surveyed buildings.

About two-thirds (66.3%) of the buildings were bungalows and about a third (30%) were storey buildings. The situation is not surprising because residential land uses were predominant and were usually not of high-rise or multiple-floor buildings. The 2-storey buildings accounted for 3.1% of the surveyed buildings. This shows that only 3.7% of the buildings were more than a storey building.

Building age is a building condition index that could influence fire risk and, at the same time, determine the level of safety of buildings for habitation, work, and recreation. As summarised in Table 2, about 80% of the buildings had existed for over 10 years and 10.7% of the buildings were built 0-10 years ago. Ages for 10.9% of the buildings could not be ascertained. It was also discovered that 18.4% of the buildings surveyed had existed for 11-20 years; 19.0% had been in existence for 21-30 years; 19.1% had been built for 31-40 years; and 10.3% had been built 41-50 years ago.

The building occupancy status shows that rented occupancy was predominant (53.3%). Self-occupancy (owner-occupied) buildings accounted for 35.9%. This implies that about two-thirds of the buildings were not occupied by landlords. Buildings that were occupied on a rent-free basis represented 4.5%. Shared ownership, which was mostly associated with buildings inherited by a group of people, accounted for 1.9%. Public-owned buildings, such as buildings in public institutions and government buildings, constituted 1% of the surveyed buildings. There were also few (0.9%) cases of squatting. Occupancy status for some (2.9%) buildings could not be established. Out of the 681 (37.8%) buildings that were owner-occupied (35.9%) and jointly owned (1.9%), about two-thirds (66.1) were built by occupants, 25.8% were inherited, 5.4% were purchased and means of acquisition was not ascertained for 2.7%.

Table 2. Building characteristics and housing facilities

Variables	No of buildings	Percentage
A. Use of building		
Residential only	1075	59.6
Commercial only	340	18.9
Public only	73	4.0
Residential/Commercial	263	14.6
Residential/Public	42	2.3
Commercial/Public	4	0.2
Commercial/Industrial	6	0.3

B.	Use of public building		
	Educational	31	1.7
	Administrative	26	1.4
	Religious	24	1.3
	Recreational	27	1.5
	Health centre/hospital	15	0.8
	Not applicable	1680	93.2
C.	Type of building		
	Brazilian type	815	45.2
	Flat	340	18.9
	Block of flats	168	9.3
	Duplex	94	5.2
	Commercial complex	258	14.3
	Temporary/ improvised structure	66	3.7
	Traditional compound	19	1.1
	Industrial complex/building in an industrial complex	8	0.4
	Hostel	12	0.7
	Classroom, laboratory, studio, workshop	9	0.5
	Place of worship	14	0.8
D.	Building height (in storey)		
	Bungalow	1197	66.3
	1-storey	541	30.0
	2-storey	55	3.1
	3-storey	6	0.3
	4-storey	3	0.2
	6-storey	1	0.1
E.	Age of building (years)		
	0-10	193	10.7
	11-20	332	18.4
	21-30	342	19.0
	31-40	345	19.1
	41-50	185	10.3
	51-60	99	5.5
	Above 60	110	6.1
	Not determined	197	10.9
F.	Status of building occupancy/ownership		
	Owner-occupier	647	35.9
	Rent	961	53.3
	Rent-free	81	4.5
	Shared ownership	34	1.9
	Public-owned	18	1.0
	Squatting	16	.9
	No response	46	2.6

G. Means of self-acquisition*		
Personally built	450	66.1*
Purchased	37	5.4*
Inherited	176	25.8*
No response	18	2.7*
Total	681	37.8
Not applicable	1122	63.2

*Applies to owner-occupier and shared ownership; % of total self-acquisition
Note: N = 1,803
Source: Field survey, 2020

Risks Associated with Building Accessibility and Condition of Access Roads

Vehicular accessibility is a major component of land use which, if absent, would increase the vulnerability of users to the impact of fire hazards. This is partly because response time to emergency calls is a function of accessibility (Falola and Agbola, 2022; Rezaeifam et al., 2023). How adequate land uses are accessible to fire-fighting vehicles determines how effective the emergency response teams can carry out rescue/recovery missions during fire disasters. It is on this note that this study presents the nature of accessibility of fire-fighting vehicles to different land uses using road access, road condition, and road width as access criteria.

Table 3 shows that 23.8% of the buildings were not accessible by road. Access to these buildings was by footpath, bicycles, and motorcycles. There were many cases in the traditional settlements of Oje in Ibadan North-east LGA and Ogunpa in Ibadan South-west LGA where passages within rooming apartments served as entrances/exits to other buildings. In this scenario, fire safety in buildings without access depends on the safety of the building providing access to it. Owing to the relatively bigger size of fire-fighting vehicles, only 65.1% of buildings could be adequately accessed by fire-fighting vehicles. One out of five buildings were not accessible while 14.8% were not adequately accessible. Three main factors were responsible for the lack of adequate access to fire-fighting vehicles. The first was inadequate road widths (43.7%), and the second factor was the deplorable conditions of the roads (39.8%). The last factor was the inadequate size of road culverts (16.5%). Only 33.5% of the buildings were serviced by tarred roads. The remaining buildings were serviced by roads that were either tarred with bad segments (30.4%) or untarred and rough (36%). Consequently, even where access roads were available, the condition of the roads made accessibility to some buildings difficult.

Table 3. Road accessibility to land uses and condition of access road

Variables	No of buildings	Percentage
A. Accessibility by road		
Accessible	1373	76.2
Not accessible	430	23.8
B. Accessibility of fire-fighting vehicle		
Accessible	1173	65.1
Not accessible	362	20.1
Accessible but not adequate	268	14.8
C. Cause of inadequate or no access		
Road widths are inadequate	275	43.7*
Inadequate size of culverts	104	16.5*
Pot-holes and gullies	251	39.8*

D. Condition of the access road		
Tarred but Rough	448	30.4**
Untarred and Rough	529	36.0**
Tarred and Smooth	492	33.5**
No access road	334	18.5
E. Width of the access road (m)		
Less than 3	334	18.5
3.00	11	0.6
4.00	56	3.1
5.00	28	1.6
6.00	87	4.8
7.00	199	11.0
7.50	73	3.9
8.00	139	7.7
9.00	272	15.1
9.50	6	0.3
10.00	122	6.8
11.00	23	1.3
12.00	99	5.5
13.00	21	1.2
14.00	2	0.1
15.00	164	9.1
18.00	14	0.8
Above 18	153	8.6

**Percentage of total buildings accessible by road*
***Percentage of buildings not adequately accessible by fire fighting vehicles*
Note: N = 1,803
Source: Field survey, 2020

Building Facilities and Fire Disaster Risks

This section presents characteristics of facilities that provide basic needs in buildings, particularly those that are relevant for fire safety. The results, as summarised in Table 3, show that 46.8% of the buildings relied solely on well water, which comprised 41.3% of buildings in the inner city and 56.8% of buildings in the outer city. Other major sources of water supply to buildings included borehole (27%) – 31.6% in the inner city and 18.6% in the outer city; pipe-borne (10.4%) – 9.9% in the inner city and 11.5% in the outer city; and community central supply (0.6%). The few cases of the dual source of water supply include pipe-borne and well (0.9%) and pipe-borne and bore-hole (0.1%). About one out of seven buildings (14.1%) had no water supply (14.8% in the inner city and 13.1% in the outer city).

Most (49.5%) of the buildings were serviced by the combination of the Ibadan Electricity Distribution Company (IBEDC) and a generator for electricity supply. Following this were those serviced solely by IBEDC (46.8%). The major source of electricity supply in the inner city was IBEDC only (50.9%), while the main electricity source in the outer city was IBEDC and generator (56.6%). Lack of access to the main electricity supply (2.5%) was found in a few buildings in the inner city (2.6%) and outer city (2.4%). This set of buildings relied solely on generators for electricity supply. During fuel scarcity, residents hoard fuel within houses and this has led to many fire disasters. For example, during an open-ended conversation with a male resident at Ogbagba community in Ido LGA, He gave an eye-witness account of how fuel-hoarding resulted in a fire disaster that claimed three lives, who were members of a family in a residential apartment within the neighborhood as follows: "...While some residents were scooping fuel from a nearby stream where NNPC (Nigerian National Petroleum Corporation) had just spilled petrol into the nearby stream, a 12-year-old member of a household just conveyed 20 liters of petrol into their apartment when NEPA [IBEDC] suddenly took the light [electricity supply]. While he was trying to pour part of the fuel into a small generating set, another young member of the household, an 8-year-old child, tried to light a kerosene lantern and the petrol exploded. The whole house, including 3 members of the household got burnt."

The methods of solid waste disposal identified in the surveyed buildings include taking wastes to designated points for collection by government agencies (33.2%); burning within the compound (14.3%); and burning outside the compound (14.3%). Occupants of some buildings engaged the services of private agency collectors, including truck/cart pushers (17.4%), while others dumped their wastes on available spaces outside their compounds (16.4%) or in streams and drainage channels (4.4%).

This study documented variations in the installation of burglar proofs in buildings. About half of the surveyed buildings had burglar proofs installed on windows (49.5%). This comprised 42.1% of the buildings in the inner city and most of the buildings in the outer city (63.6%). Only 14.6% of the buildings installed burglar-proof doors that lead to the outside of buildings. However, installation of burglar proofs in the ceiling was not a common practice, as just 5.2% and 3.9% of the buildings in the inner and outer cities, respectively, had burglar proofs installed in ceilings (Table 4). Burglar proof was installed at the edges of the veranda/balcony of some buildings (16.7%). This was the case in 21.1% of buildings in the outer city and 14.5% of the buildings in the inner city.

To complicate the fire safety situation, some buildings had one or more of their emergency doors on permanent lock. This was observed in 9.9% of the surveyed buildings – 7% of buildings in the inner city and 14.9% in the outer city. This building condition threatens the occupant's escape during a fire emergency.

One of the household heads in the buildings sampled in Agbowo in Ibadan North LGA gave a reason for leaving the emergency exit lock. He argued that "we (parents) had to lock the door and kept the keys because they (the children) always forgot to lock the door at night." In another building where an emergency door was permanently locked, it was observed that what was initially designed to serve as an emergency exit was found to lead to another apartment. This was so because the building had been modified and the initial design altered.

The majority of the land uses in both the inner part (86.5%) and the outer part of the city (85.1%) used electricity as the major energy for lighting (Table 3). These jointly accounted for 84% of all the surveyed land uses. Some buildings (2.7%) relied on solar energy for lighting, some (3.0%) used kerosene lanterns as a source of light to buildings at night, and 1.2% lighted candles at night. Buildings where kerosene, gas, and candles were combined with electricity represented 3.1%, 2.6%, and 0.7%, respectively. However, no source of lighting energy/fuel could be established for 2.5% of the buildings. Occupants of these buildings, which were mostly commercial, claimed that they only occupied the buildings during the day while they left for homes in the evening.

Table 4. Building facilities in the city core and outer city

Building facilities	No. of buildings (%)		Total
	Inner city	Outer city	
(i) Water supply			
Pipe-borne	115 (9.9)	73 (11.5)	188 (10.4)
Well	482 (41.3)	361 (56.8)	843 (46.8)
Bore-hole	369 (31.6)	118 (18.6)	487 (27)
None	172 (14.8)	83 (13.1)	255 (14.1)
Community central supply	11 (0.9)	-	11 (0.6)
Rainwater harvest	6 (0.5)	1 (0.2)	7 (0.4)

Pipe-borne and well		10 (0.9)	-	11 (0.6)
Pipe-borne and bore-hole		1 (0.1)	-	1 (0.1)
(ii) Electricity supply				
IBEDC only		594 (50.9)	249 (39.2)	843 (46.8)
Generator only		30 (2.6)	15 (2.4)	45 (2.5)
IBEDC & Generator		533 (45.7)	360 (56.6)	893 (49.5)
Solar only		2 (0.2)	-	2 (0.1)
IBEDC, solar & Generator		8 (0.7)	12 (1.9)	20 (1.1)
(iii) Solid waste disposal method				
Govt. agency collector		391 (33.5)	208 (32.7)	599 (33.2)
Burning within the compound		135 (11.6)	123 (19.3)	258 (14.3)
Burning outside the compound		163 (14)	94 (14.8)	257 (14.3)
Private agency collector		189 (16.2)	125 (19.7)	314 (17.4)
Dumping in available site		214 (18.3)	82 (12.9)	296 (16.4)
Dumping in streams/drains		75 (6.4)	4 (0.6)	79 (4.4)
(iv) Installation of burglary proofs				
Windows	Yes	500 (42.1)	392 (63.6)	892 (49.5)
	No	687 (57.9)	224 (36.4)	911 (50.5)
Ceilings	Yes	60 (5.2)	25 (3.9)	85 (4.7)
	No	1100 (94.8)	618 (96.1)	1718 (95.3)
Doors	Yes	154 (13.3)	109 (17.1)	263 (14.6)
	No	1005 (86.7)	535 (82.9)	1540 (85.4)
Veranda/balcony	Yes	168 (14.5)	134 (21.1)	302 (16.7)
	No	992 (85.5)	509 (78.9)	1501 (83.3)
(v) Entrance/exit door on permanent lock				
Doors on permanent lock		82 (7.0)	97 (14.9)	179 (9.9)
Doors without permanent lock		1068 (91.7)	540 (84.9)	1608 (89.2)
No emergency exit/door		15 (1.3)	1 (0.2)	16 (0.9)
(vi) Lighting fuel/energy				
Electricity		983 (86.5)	532 (85.1)	1515 (84.0)
Solar		32 (2.8)	17 (2.7)	49 (2.7)
Kerosene		47 (4.1)	7 (1.1)	54 (3.0)
Candle		17 (1.5)	4 (0.6)	21 (1.2)
Gas		-	4 (0.6)	4 (0.2)
Electricity and Kerosene		24 (2.1)	32 (5.1)	56 (3.1)
Electricity and Gas		25 (2.2)	22 (3.5)	47 (2.6)
Electricity and candle		5 (0.4)	7 (1.1)	12 (0.7)
None		18 (1.6)	27 (4.2)	45 (2.5)
Total		1167 (100)	636 (100)	1803 (100)

Source: Field survey, 2020

The analysis of building characteristics is relevant in understanding the level of vulnerability of buildings to fire hazards and will determine the level of preparedness of building users/occupants for fire accidents. Fire accidents are likely to occur more frequently in residential buildings owing to their dominance (59.6%). This explains why fire events in residential land uses took the largest proportion of all fire events in metropolitan Ibadan. Special attention is, therefore, required for fire disaster mitigation and prevention in residential land uses. Since most of the available building types involved multiple users (especially, rooming apartments, hostels, commercial complexes, and blocks of flats), there is a higher tendency for fire outbreaks and fire spread. This was supported by a 10-member multi-stakeholders session that involved 2 representatives each from OSFS, OYSEMA, BPPDC, and Neighbourhood Associations, it was emphasized that fire risk associated with buildings occupied by multiple households is usually more because of the presence of more than one possible source of fire accidents. Also supporting this assertion, a male representative of OSFS argued that it takes fire safety practices of all occupants of the building to reduce fire risks in such buildings. For example, the unsafe handling of fuel and inflammable materials by a single household in a multi-household building subject all households/persons in the building to fire risks. In this regard, a representative of OYSEMA revealed that in several fire emergency events in buildings, fire often started small from a room (bedroom, kitchen, or shop) of a "careless member of a household". An FGD participant from BPPDC noted that "fire disasters in buildings, especially markets and blocks of apartments often ended up as tragedy of the common as most of the people affected were not the cause of the fire disaster. Such fire often begins from one apartment and extends to others, sometimes extending to multiple buildings."

Building height is an important factor in fire management. For example, only special fire-fighting vehicles are suitable for high-rise buildings and fire safety requirement varies for different building heights. The number of storeys that is predominant in a community determines the number of pumper or hose companies and the number of ladder companies that will be required. However, building heights did not pose a significant threat to fire safety as buildings were predominantly one-floor. This implies that ladder companies might not be required in most parts of the city.

The occupancy/ownership status of building users/occupants can affect their commitment to building maintenance, which, in turn, affects how well necessary mitigating and preventive measures are carried out in the building. In most cases, buildings that are occupied by landlords usually receive better attention in terms of maintenance and upgrading. During an FGD session with representatives of community/landlord associations, it was gathered that buildings that were occupied by tenants deteriorated faster as a result of poor maintenance culture. They argue that there might be little commitment/willingness from building occupants/users to engage in measures that would guarantee fire safety.

Virtually all the land uses were not serviced by the community's central water supply and more than half (52%) relied on generating sets for electrical power supply. Buildings without water supply would be short of water to extinguish a fire in case of emergency while the use of a generator increases the risks of fire occurrence owing to the fuel that would be used to power the generating set. Out of the six methods of solid waste disposal identified, only two (waste collection by government and private agencies) could be said not to pose fire risks to buildings. This implies that about half (49.4%) of the buildings involved unsustainable waste disposal methods that threatened fire safety.

As one of the common security measures in Ibadan city, buildings are often installed with burglary proofs on major outlets/openings. Although this measure prevents intruders, it, however, makes evacuation and rescue activities during fire emergencies difficult. This result revalidates the findings of Bukowski (1996) where most of the houses surveyed in the city of Osogbo, Nigeria, had "burglary proofs" installed on windows. Unlike the windows, there were fewer cases of burglary proof on doors. When asked why burglary proofs were installed on windows and not on the doors, an occupant of a building in Oluyole Estate, in Ibadan South-west LGA stated that "since metal doors were installed on the entrance and exit of the building, there was no need to install additional burglary proofs." In buildings where burglary proofs were installed on verandas/balconies, and in buildings with locked emergency doors, access into such buildings by firefighters and rescue agents and emergency exit from the buildings by occupants in the event of a fire accident would be difficult. Oduor and Atsiaya (2004) had expressed a similar situation on the usability of doors for escape purposes during emergencies in most of the buildings in Nairobi, Kenya, where locks were observed on doors and grilled outdoors were also locked.

These burglar-proof practices have contributed to many fatal fire accidents. A typical example is the fire disaster that occurred on the 3rd of January, 2020, which led to the death of three siblings in a residential community at the back of Ibadan Grammar School, Molete. The mother had left the house on the evening of 2nd January 2020 for a night-shift job while the father locked the children inside their one-room apartment while he left for an early-morning engagement the following morning. When fire broke out in the early hours of 3rd January, the children could not escape because the only exit was locked from the outside and the two windows had burglary proofs.

Many instances of incompatible land use developments were observed in the city. For instance, there are cases of liquefied natural refilling plants and filling stations that are sited in residential neighborhoods. In areas such as Oluyole Estate, Iyaganku GRA, and Odo-Ona in Ibadan South-west LGA, buildings were developed under high-tension power transmission lines. Situations like this make certain communities prone to fire disasters. In some cases, the available spaces around buildings in the core area of the city have been developed to provide more buildings. This will aggravate fire spread should a fire disaster occur.

The findings of this study are suggestive of Wisner et al.'s (2004) account of the vulnerability process that explains how fire disasters occur when fire hazards affect vulnerable people. It is similar to the "progress of vulnerability" that was developed in the Disaster Pressure Model (DPM) (Blaike et al., 1994). The DPM shows how vulnerability (pressure), which is rooted in socio-economic and political processes, has to be addressed to reduce the risk of disaster (Hai and Smyth, 2012; Hammer et al., 2019). The root causes, dynamic pressures, and unsafe conditions are conceptualized as indicators of social processes that influence vulnerability (Hai and Smyth, 2012). The root causes, as established in this paper, are a lack of political will to enforce fire safety laws and codes and poor access to resources by building occupants. The dynamic pressures include a lack of framework for fire management, an insufficient partnership among stakeholders in fire management, and rapid urbanization. The unsafe conditions are the substandard buildings; residential land uses located in close proximity to an LPG plant, fuel station, and power line; vulnerable groups, such as the aged, children, and physically challenged; people living below the poverty line; and low level of individual and community preparedness for fire disasters. The combination of these factors explains the high level of fire disaster risks in the city.

The types and patterns of fuel usage in buildings present a complex dimension of vulnerabilities to fire hazards since different fuels create different fires and require different types of fire extinguishers. The types of fuel usage should guide the type of fire extinguisher that should be required in such buildings. Once a household changes from one fuel to another, such household should also change the type of fire extinguisher and the safety precautions required.

CONCLUSION

This study reveals critical fire risk factors that are associated with building characteristics and their relationship to the urban landscape. Land use attributes, such as accessibility by road, compatibility of uses, water supply sources, sources of electricity supply and solid waste disposal method, and building characteristics, such as burglary proofs, nature of entrance/exit, type of lighting fuel, and adherence to space standards are factors that are relevant in fire disaster risk analysis. This study underscores the intertwined nature of urban planning, building design, and fire safety. Fire disaster risk reduction should not be an afterthought; it must be central to sustainable urban management that is centered on the protection of lives and property.

These findings should inform land-use planning and fire safety regulations in cities of developing countries, especially, those in sub-Saharan Africa. Residential land uses dominate the urban setting and the high frequency of fires within residential areas requires targeted fire mitigation efforts. This must include education campaigns, building code enforcement, and strategic placement of fire response resources. Buildings that house multiple households and mixed-use developments are particularly vulnerable to both the outbreak and spread of fire. Collective fire safety, accountability measures, and evacuation protocols should be mandatory within such buildings. The lack of reliable water supply and the reliance on generators increase fire risks. Investment in water infrastructure and the exploration of safer energy sources are necessary. In the same vein, improved waste management systems are required to curtail unsafe waste disposal which could increase fire risk. There is a need to revise and remodel land use regulations and enforcement mechanisms that will address the siting of gas stations within residential areas and construction under power lines. Alternative security measures to burglar proofs that will balance protection with safe emergency evacuation should be explored.

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