Curbing Fire Outbreaks in Public Places; Case Studies of Selected Markets in Lagos

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Abstract

Fire outbreaks are frequently occurring cause of loss of property and lives in the Nigerian market scene. Although this menace of market fire outbreak has been a recurring index since the early 2000s up till now, a lot of marketplaces still do not have standard fire protection measures in place to prevent fire outbreak. A study which was carried out by the National Emergency Management Agency (NEMA) showed that some causes of fires in Nigeria include negligence and carelessness, these are found to be the root causes of fire outbreaks in general. This study identified the effects of fire outbreaks in over fifty-four market locations Lagos, Nigeria. Detailed survey was carried to ascertain research findings in three main markets in Lagos i.e., Tejuosho ultra-modern market, New Alade market and Balogun market. The study is aimed at identifying the effects of fire outbreaks and to improve on the *architectural* design typology of *market spaces*. Primary data for this research was obtained with the use of questionnaires while secondary dataset was obtained from online data mining. Aside from the general findings of fire outbreaks i.e., loss of lives, goods, property and decline in the quality of life of the market stakeholders, the study proffered different architectural design typological solutions to curb fire outbreaks in market spaces i.e., spatial mapping of market location with respect to its goods and services, engagement of well-trained technical personnel for fire control, spatial mapping, artificial intelligence e.t.c. This study recommended a holistic architectural designs and effective fire management systems in the master planning of market spaces. This study suggested that further studies be engaged to investigate other architectural design solutions to curb fire outbreaks in market spaces.

Key words: fire, fire outbreaks, market place, safety measures

1. Introduction

Asides from being a commercial space for gathering, a market place is a location for interaction between people, goods and information (Sezer & Janssens, 2013). A market as defined by Kenton (2020) is a place where two or more parties gather for the exchange of goods and services usually with a legal tender. Markets are usually represented by physical locations in the form of retail stores, shopping malls or market complexes in more recent times. They may also be virtual online places such as Amazon, eBay, Jumia and AliExpress (Kenton, 2020). In virtual markets, transactions take place online but the parties involved never meet physically. Marketplaces have always been important catalysts for urban growth and at the same time, providing solutions to accommodate the growth. Although there are numerous types of markets with various definitions, the common factor with all markets is trading.

Physical Markets in the world are classified in to three forms, that is, open air markets, closed or built-up markets and street markets (FAO, 1995). The case of fire outbreaks in the physical markets is inevitable, more so in an unplanned environment, Iyaji, Omahanna,Basiru, Anthony& Tinufa, (2016) gave common causes of fire incidence in developing countries as human factors (forgetfulness in using gas cookers, storage of fuel in areas vulnerable to fire hazards, inadequate fire prevention education), and technical errors (faulty electrical installations, incorrect storage of materials, poor lightning and thunder, system, poor maintenance of machinery etc.). In this light, (Mann, 2010) also noted that the cause of fire in public places may be as a result of indiscriminate dumping of remains of lit cigarette. Another very salient factor responsible for frequent fire disaster is the unauthorised market extension. This activity is common in underdeveloped and developing countries, as it makes it very difficult for

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market authorities to manage electrical connections within market places. Scientists have noted that unforeseen circumstances such as architectural design, building material and human error makes the occurrence of fire disasters unavoidable; but technical measures could be adduced to abate the spread (Issah and Aliyu, 2012; Iyaji et al., 2016). Iyaji et al. (2016) noted that the architectural design that could reduce fire incidence in public places includes "users' prudence, efficient designs, specification and construction management." Kaiko, Inonge, Pauline & Steriah (2020). (2020) proposed the following to cub fire outbreaks in markets located in developing countries i.e., "market fire facilities maintenance, surveillance of market environment, education and training of marketers and consumers, quality of market structures and monitoring and evaluation". Based on efficient design, Bary (2012) proposed that architectural design should have an incombustible "projections to windows that serve as a barrier to the spread of fire from one window to an adjacent window". Market design is somehow alien to most parts of developing countries due to poor urban planning (Emetere, 2019), and cases of fire disaster had been from vulnerable building materials. A field study shows a global trend of wall material in Table 1. 29% of building walls are made of wood and it accounts for high loss due to fire hazards.

Table 1. Wall Material based on the Building Inventory Source (Balasbaneh, Abidin, Ramli, Khaleghi, & Marsono (2020)

Structure	Wall Material	Number of Building	%
1	brick	32	29
2	Wood	29	27
3	concrete block	20	18
4	steel wall panels	15	13.5
5	precast concrete	12	12.5
	Total	110	100

The location of the study is Lagos-Nigeria (Figure 1). It is the commercial hub and most populated city in Nigeria. Its annual growth rates of about 600,000 persons per annum or 1,644 people daily (US Census Bureau, 2006). According to Figure 1, the land area is about 3,577sq km of mostly coastal plains, and it is embedded by lagoons which make up about 22% of the state's land mass. Due to the presence of administrative head offices of most multi-national companies and non-governmental organisations, it is believed that Lagos is the best place for developing or promoting goods and services. Lagos State has 16 Local Government Councils and 57 Local Government Development Areas. The market locations in Lagos are over a hundred i.e., most being open markets. In this study, we considered more closed or built-up markets

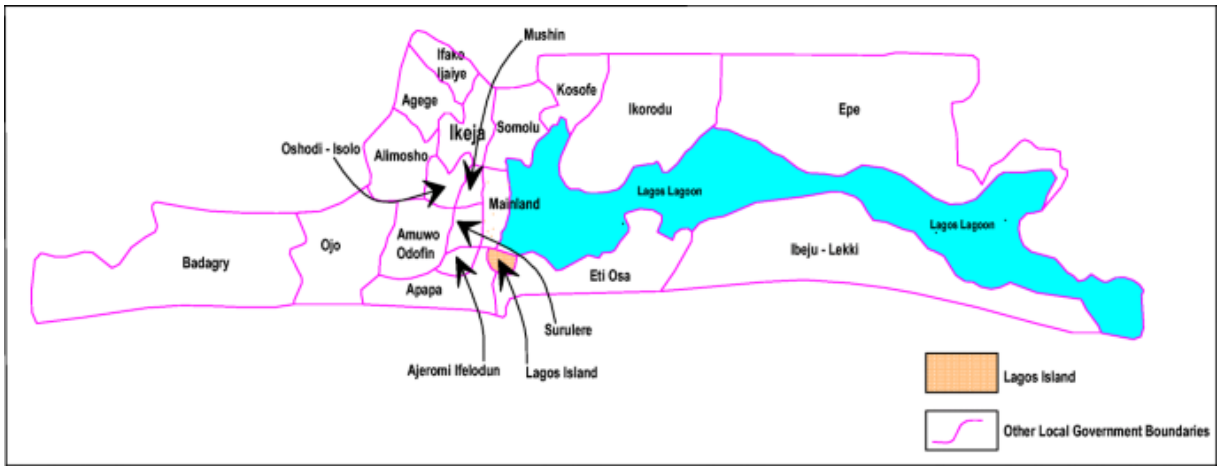

Figure 1: Location of study

WHO (2004) reported that over 95% of the deaths and burn injuries are in Low and Middle-Income Countries (LMICs), where death rates are nearly six times higher than in high-income countries. Ogunbiyi (2020) reported that deaths from fire outbreak in Lagos-Nigeria keeps growing by the day. Since, the market place is the universal location for inhabitants, visitors, and migrants, it is salient to consider the undiscussed challenge of fire outbreaks in Lagos. The solution in this research extends more than Lagos as it extends to most parts of the globe.

2. Literature Review

2.1 Fire Accidents and Incidents in Lagos

A fire is an occurrence whereby uncontrolled burning which causes destruction takes place. Urban centres are more prone to disastrous fires due to congestion as a result of lack of planning and nonchalant attitude of residents (Popoola, Adekalu, Audu, Adeleye & Jiyah, (2016).). There are a lot of causes of fire and past studies have attribute all causes of fire to be human factors which can be avoided with enough care (Ilodiuba, Nwaogazie, & Ugbebor, 2017). A study which was carried out by the National Emergency Management Agency (NEMA) showed that some causes of fires in Nigeria include negligence and carelessness, these are found to be the root causes of fire outbreaks in general. These root causes further lead to the immediate causes which directly start the fires (Adinyira, Agyekum, Baiden, Ebohon, & Ampratwum (2020). These immediate causes include accidents, faulty electrical wiring, reckless use of electrical gadgets and appliances, unattended gas cookers and stoves and improperly extinguished cigarettes among others (Popoola et. al, 2016).

Fire outbreaks happen due to human factors such as negligence, carelessness or ignorance is the form of lack of fire safety awareness (Wahab, 2015). In some cases, fires are started wilfully by individuals and referred to as arson. Recently, the occurrences of fire outbreaks have been so alarming and a serious concern to the investors, users and the Architect-designers. But in any case, the occurrences of fire outbreaks recently have been so alarming and a serious concern to the investors, users and the Architect-designers. Spatial experiences since childhood, such as playing with construction toys or having sketch experiences, can improve spatial skills, although, spatial ability could be an innate ability, but evidently, scholarly reports have established that such skills gain high-order progression as individual undergoes the curricular grains of a well-structured mode of learning-from simple to complex levels (Ilic & Djukic, 2017; Saliha, Saniye, Fatma & Ayşegül, 2020). Amongst different cognitive, metacognitive and intelligent abilities expected of a certified Architect or designer is Spatial Intelligence; for Architects deals and have rapports with intelligent spaces either in physical, virtual and psychological forms

2.2 Architectural Design and Spatial Intelligences

The multi-disciplinary nature of an Architect's training assists in the development of spatial abilities to effectively design public spaces (markets inclusive). He/she visualize, imagine, observe and predict different spatial patterns to achieve the best layout plans. This ability is one of the areas in the theory of multiple intelligences, developed by Howard Gardner.

Beyond the traditional way of designing market spaces, currently, the echo of market developments in rural, town and city areas; demands that an Architect must be conscious of his responsibilities to his clients for the purpose of sustainability and satisfactions. The Architectural designs of market spaces required more than ordinary design ability but greater cognition and spatial Intelligences. Because of the frequent fire outbreaks in market places, the currency of Architectural design is witnessing a pendulum swing from ordinary styles of designing to intelligent ones.

Market design is certainly a broad-based layout plan that extend beyond infrastructure to economic environments, institutions and allocation rules (Roth, 2015). Tanuwidjaja &Wirawan (2012) proposed that a traditional market should have the following i.e., web-GIS-based database, supply chain regulation, spatial planning and development control, supervision, revitalisation, and program evaluation. However, before economic environments, institutions and allocation rules are established, there is the need to know the architectural concepts of a local market. Nafi et al. (2015) proposed architectural design of a local market should have three main component namely local context, community, and climate. Hebatalla et al. (2019) proposed the typological of an acceptable architecturally market design as presented in Figure 2a. This design may be modified along spatial typology to fit various communities and cultures as shown in the new Nkwantanum, Akyem Oda (Ghana) neighbourhood market plan proposed by Hayden (2009) in Figure 2b. Its spatial typologies are efficient to: (i) truncate fire transport from one building to another (ii) promote diverse commercial activity (iii) simplify the upkeep of a clean and

hygienic environment and facilitate refuse management (iv) give a more pleasant shopping experience (v) enhance the business and revenue generation potential of the given site (vi) facilitate the management of emergencies such as fire.

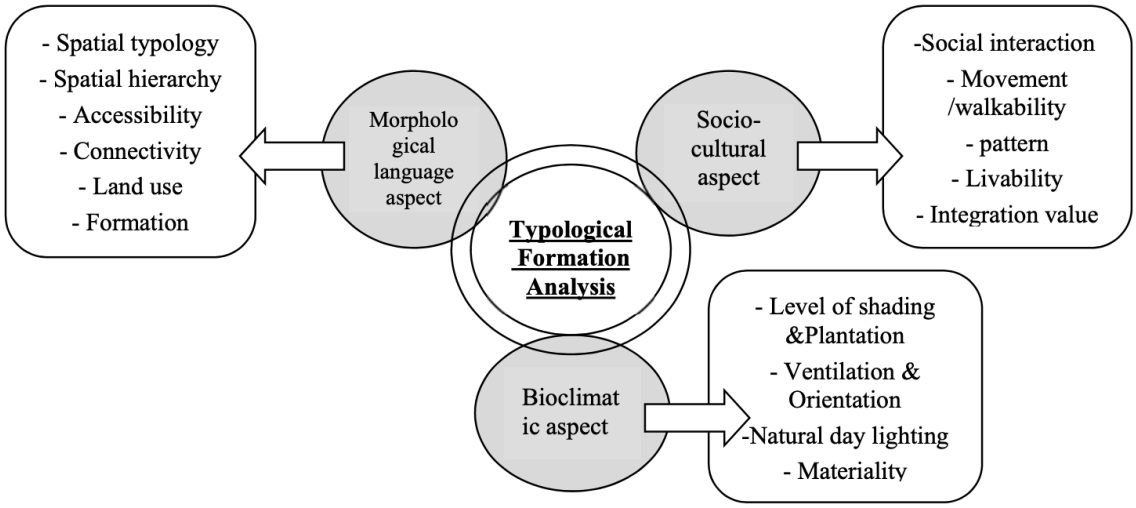

Figure 2: Typological formation analysis model (Hebatalla et al., 2019)

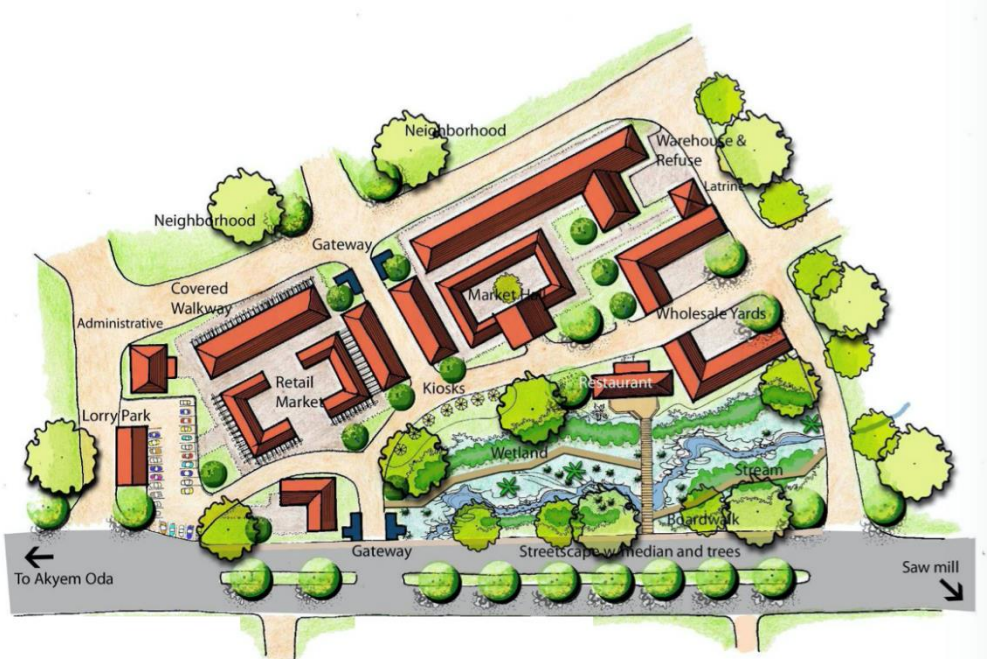

Figure 2b: New Nkwantanum neighbourhood market plan (Hayden 2009)

3. Methodology

The first method used for this study was secondary dataset (i.e., online data mining) of fire incident in fifty-four (54) local markets in Lagos. Three factors were considered i.e., fire incidence in each market, human population within market location, and elevation of the market. The results were analysed using geospatial interpolation. The second method was carried out through the survey method with the use of questionnaire surveys. Questionnaires were distributed to respondents at three market places in Lagos state. One hundred and fifty questionnaires were distributed at each of the three market places and of the questionnaires returned, 113 of them were valid. The responses were analyzed using SPSS 20 to draw up descriptive tables.

The study population consists of the users of the three market places (Balogun market, Tejuosho market and Alade market) in Lagos state. The three (3) locations were selected for the higher prevalence of previous fire incidences within the last one year of this study coupled with threat to the most populated market spaces (Lagos) in Nigeria.

4. Results and Discussion

4.1 Fire outbreak in Lagos markets: Remote sensing approach

In this section, the market was characterized according to fire incidence, population, and elevation. Figure 3 is the geospatial interpretation of fire incidence in markets around Lagos State. When compared to Figure 1, it is observed that fire incidence occurs more at city centre where beehive of commercial activities takes place. Hence, the market sites within this region are controlled by the high presence of consumers. Figure 4 shows that consumers that patronize the local markets are from the market location and influx from neighbouring location. Due to the high demand of goods and services in the market locations within the city centre, there lots of illegal buildings that are architecturally flawed as seen in Figure 5. Other main challenges in such setting are the illegal power line connection, and poor wiring system. Also, the erratic power failure and high voltages are salient factors that initiates fire outbreak. From online newspaper reports, significant number of fire outbreaks are from electrical connection.

More so, market spaces are sometimes source of accommodation for petty traders and are the second main source of fire outbreak. This domestic source includes stove, candles, heater, boiling ring, and pressing iron. Fire from the aforementioned source is significant due to the tight space of the store or sales shop. Another significant source of fire outbreak are automobile accident and fuel tanker explosion. Due to the congested nature of Lagos State, road network is still primitive as major road is by the side or centre of the market location as seen in Figure 7. As discussed in the introductory part of this research, illegal market extension makes it very difficult for market authorities to manage electrical connections within market places. Also, it makes it difficult to restrict market place to avoid fire outbreaks from automobile accident.

In coastal locations, elevation is main determinant of market location as it is necessary to avoid water-logged scenarios and flooding. The elevation of the market was geospatially analysed as presented in Figure 6. It was observed that the elevation of the market location played a significant role for its architectural setting. However, the wooden projections from each building as presented in Figure 5 are potential source of fire outbreak. Also, in markets located at low elevations, wooden structures are erected as bridges, toilets, and shop space. Fire outbreaks in such locations are usually fatal and the property losses are massive.

Figure 3: Fire outbreak incidence across markets in Lagos

Figure 4: Human population distribution across Lagos

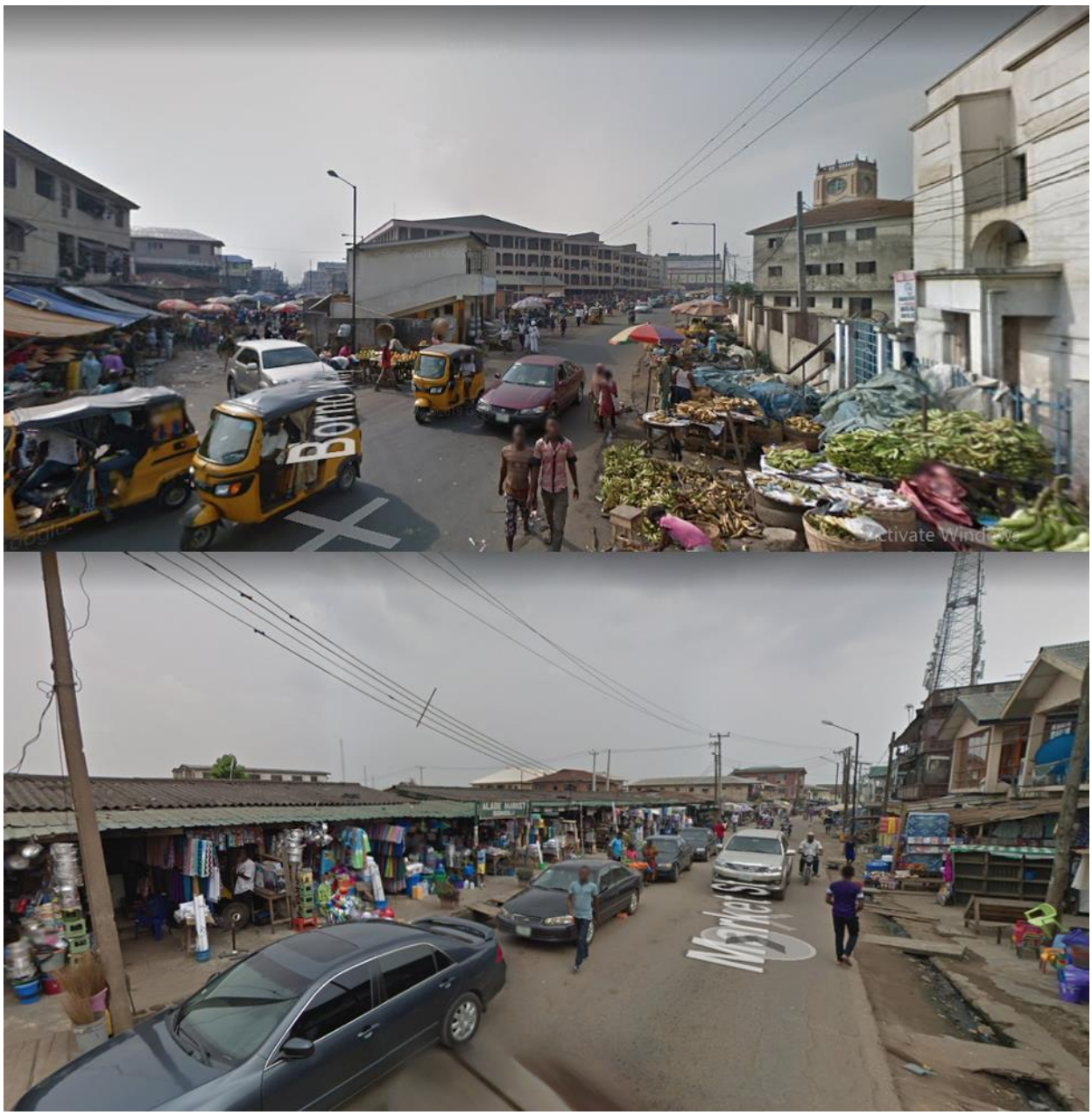

Figure 5: Architectural flaws in some markets within Lagos

Figure 6: Road network within markets in Lagos

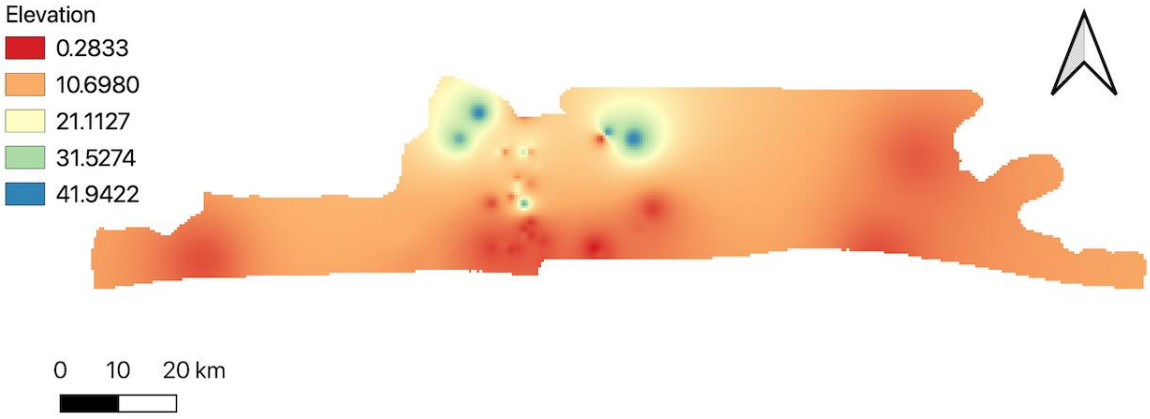

Figure 7: Elevation of market locations across Lagos

Some researcher had propounded that the size of market contributes to the activities therein. In other words, by extension, the size may determine the number of fire outbreaks. This postulation was investigated by considering the sizes of six popular markets in Lagos as shown in Figure 8. This figure was juxtaposed with its fire outbreak occurrence as presented in Figure 9. It can be inferred that the size of the market is not in any way related to the number of fire outbreaks. The sizes of markets are more related to the observation of Rajagopal (2009) that developing countries would experience growth of markets or shopping centres in most urban centres. In this study, we concentrated on the old existing markets in Lagos. It was observed that the nature of goods and services within the market determines the prevalence of fire outbreaks. This fact is quite complex in developing countries because most persons in the market are not mainly buyers or sellers but a teeming population of unemployed persons who had chosen the market as a place for survival. In this case, fake or untrained technical personnel are consulted for electrical and gas installations. This theory could be further expatiated from Figures 8 & 9, where Apapa fish market and Akodo market have no significant fire incidence as both markets deals with fish and farm produce.

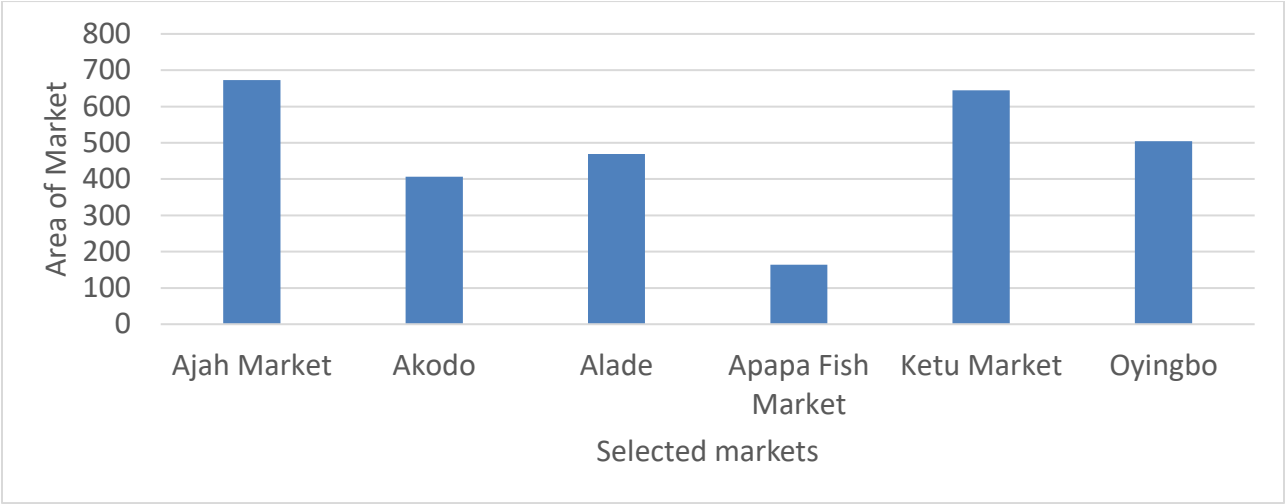

Figure 8: Sizes of selected markets in Lagos

In effect, it can be deduced from figure 8, the adverse effects of the vulnerability to fire outbreak on the market spaces. Also, in figure 9, Ajah market with the highest fire incidences and Apapa, and Akodo with the lowest fire incidences. It therefore, implied that the size, goods and services, the location and mapping of the market spaces are significant factors to be considered by Architect-designer when major design decisions are to be made in the master planning of market or any other public spaces.

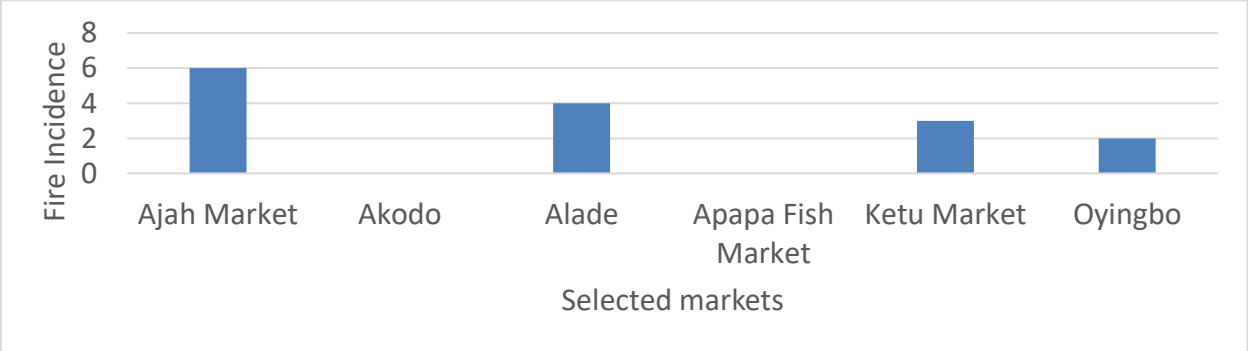

Figure 9: Fire outbreak occurrences of selected markets in Lagos

Considering the field work of Popoola et al. (2016) on the cases of fire outbreaks in Lagos presented in Figure 10 for the year between 2006-2014, a statistical projection was done on the excel to year 2027 as presented in Figure 11.

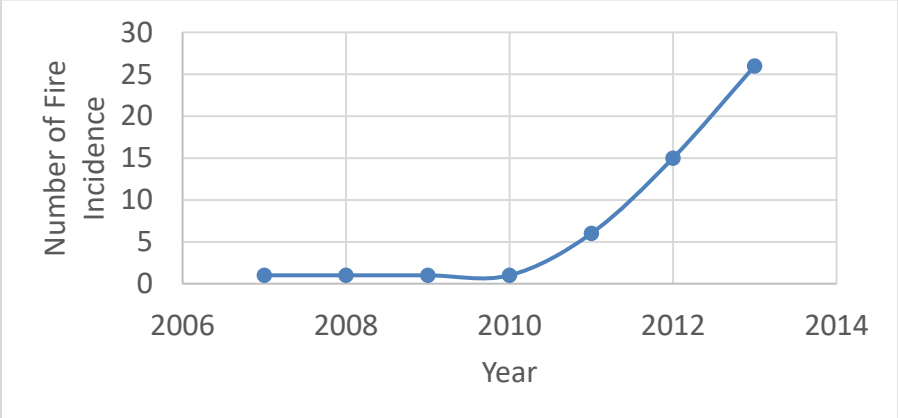

Figure 10: Total number of fire outbreak in Lagos markets (Popoola et al., 2016)

Going by the number of incidences per year occurrence, it is needful to state that, if urgent planning of market location and organisation is not carefully looked into, fire outbreaks can be as forty-five in 2020 and seventy-two by 2027. Consequently, the report by Ogunbiyi (2020) showed that this projection was very accurate.

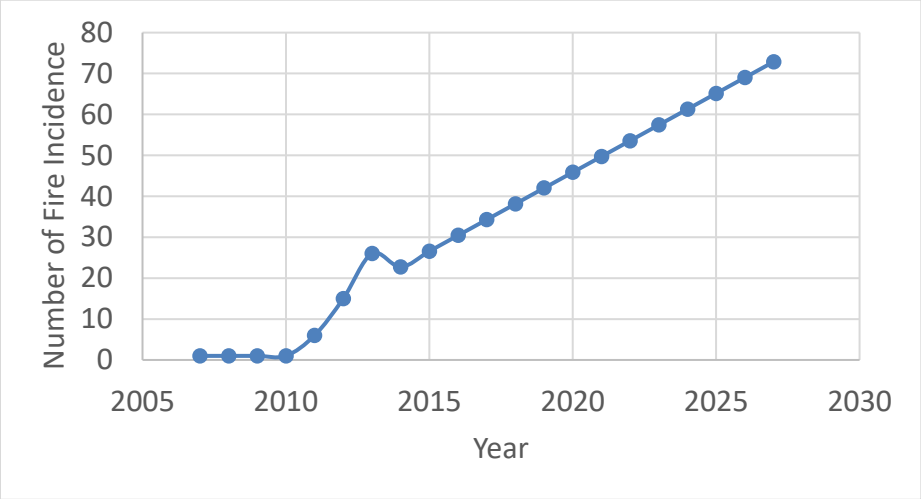

Figure 10: Projection of fire outbreak in Lagos markets (Popoola et al., 2016)

Hence, if nothing is urgently done, there would be massive loss of lives and properties. In the case of Lagos, expanding markets from kiosk to two-storey building needs to be discouraged in spatial topology of market spaces. It is also, extremely crucial in this case to apply design synthesis approaches in compartmentalising market system that could localize fire incidence when it occurs. More so, there is the need for the control of technical personnel within the market to curb the frequency of fire outbreaks due to electrical or gas installation faults. These solutions are found to be sustainable panacea to controlling fire outbreaks in markets in Lagos and applicable to physical markets in the world at large.

4.2 Effects of fire outbreak in selected market places

This section presents and discusses the data analyzed on the causes of fire outbreaks in the sampled market places. In examining the effects, the fire outbreaks have had on individuals and the markets in general, questionnaires were used to retrieve data from the respondents in selected marketplaces and the responses were analyzed using a statistical software.

Table 1 below shows the responses of the respondents who had been present when a fire occurred when asked whether or not many people were present during the fire. In majority of the fire outbreak cases (51.6%), there were numerous people in the market when the fire broke out. In 20.6% of the cases, there were not so many people in the market when the fire broke out and in 17.5% of the cases, the respondents were not sure whether or not the markets were crowded. This analysis shows that when fires break out in markets most of the time, the market places are crowded with either customers or people who work there. Also, as a market is a hub of commercial activity, it is almost always crowded at all times of the day.

Table 1: Showing how crowded the markets were when fire outbreaks occurred

		Frequency	Valid Percent
Valid	Yes	65	57.5
	No	26	23.0
	Not sure	22	19.5
	Total	113	100.0

Table 2 below shows the data retrieved from the respondents on what time of day the outbreak occurred. The majority of the fire outbreaks (30.9%) which happened took place in the middle of the night

when the markets are at their emptiest and with nobody around to raise any alarm. The effects of this include a more extensive damage to buildings and property before any action is taken in putting out the fire. 30.9% of the fires happened in the morning and afternoon which are the times of day where there are the most people in the markets. The effects of this include the fact that more people are in danger of getting hurt from the fires at those times. The least amount of fire outbreaks (6.2%) happens in the evenings.

Table 2: Showing the time-of-day fire outbreaks occurred in market places

		Frequency	Valid Percent
Valid	Morning	30	30.9
	Afternoon	30	30.9
	Evening	6	6.2
	Middle of the night	31	32.0
	Total	97	100.0

Table 3 below shows the distribution of the people who came to put out the fire in cases of fire outbreaks. The majority of the time (46.2%), the fires were put out by fire personnel and 42.3% of the time, the fires were put out by traders and workers in the market. The least percentage of fires (11.5%) were put out by passers-by. This result shows that the market places either do not have adequate fire services for the market places or the fire personnel have difficulty accessing the locations where the fire outbreaks happen.

Table 3: Category of first responders

		Frequency	Valid Percent
Valid	Fire personnel	48	46.2
	Traders	44	42.3
	Passers-by	12	11.5
	Total	104	100.0

Table 4 shows the response rate of the proper fire personnel to the scene of the fire outbreaks. The analysis of the data shows that during fire outbreaks in market places, majority of the time (57.8%) the proper fire safety team came late. In some cases (11.8%), the fire service personnel never showed up to put out the fire. Only in about a third of the cases (30.4%) did the fire safety personnel come early enough to put out the fire and prevent further damages from taking place. This shows that there is either an inadequate fire alarm system which notifies the fire service personnel, the fire service station is situated too far away from the location of the fire or the fire personnel have difficulty in getting access to the fire.

Table 4: Response rate of fire service personnel

		Frequency	Valid Percent
Valid	Early	31	30.4
	Late	59	57.8
	Never	12	11.8
	Total	102	100.0

Table 5 and 6 respectively shows whether or not there was any loss of life in the fire outbreaks which and the number of losses which occurred in the marketplaces. 29.6% of the respondents reported loss of life in the market fire outbreaks and of these, 84.4% reported losses of between 1-5 people, 9.4% reported losses of between 6-10 people and 6.2% reported losses of 11-15 people in each outbreak. 40.7% of all the respondents reported no losses in the fire outbreaks the witnessed and 29.6% reported that they were not sure if there were any losses during the fire outbreaks.

Table 5: Loss of lives in the fire

		Frequency	Valid Percent
Valid	Yes	32	29.6
	No	44	40.7
	Not sure	32	29.6

Table 6: Number of loss of lives

Was there any loss of life in the fire?	If yes, what was the average number of losses?		
	1-5	6-10	11-15
Yes	27	3	2
Valid Percent	84.4	9.4	6.2

Table 7 shows whether or not there was any damage to buildings in the fire. The analysis of the data shows that there was no case where there was a fire outbreak in the market and there was no damage to any building. 85.6% of the respondents reported that damages were made to those buildings while the remaining 14.4% were not sure if there were any damages.

Table 7: Damage to buildings in the fire

		Frequency	Valid Percent
Valid	Yes	95	85.6
	Not sure	16	14.4
	Total	111	100.0

Table 8 shows how much damage was caused to buildings by market fires. Out of the respondents that said there were damages, 8.4% reported very few damages to buildings, 10.5% reported few damages to buildings, 12.6% reported not too many damages to buildings, 35.8% reported many damages to buildings while 32.7% of all the respondents reported very many damages to the buildings occurred during fire outbreaks. This analysis shows that there is always some form of damage to the whole or parts of buildings whenever there is a fire in markets. In most cases, these damages are very extensive and render these buildings or stalls unusable and they have to be pulled down and rebuilt thereby leading to extra unplanned expenses.

Table 8: Extent of building damages caused by market fires

Was there any damage to buildings in the fire	If yes, how much damage was done by the fire?					Total
	Very few	Few	Not too many	Many	Very many	
Yes	8	10	12	34	31	95
Valid Percent	8.4	10.5	12.6	35.8	32.7	100

Table 9 shows whether or not there was property loss in the fire in the market place. The analysis of the data shows that there was no case where there was a fire outbreak in the market and there was no loss of property. 82% of the respondents reported that there was loss of property while the remaining 18% were not sure if there was any loss of property.

Table 9: Loss of property in the fire

		Frequency	Valid Percent
Valid	Yes	91	82.0
	Not sure	20	18.0
	Total	111	100.0

Table 10 shows how much property was lost in the market fires. Out of the respondents that said there were losses, 6.6% reported very few losses of property, 2.2% reported few losses of property, 7.7% reported not too many property losses, 33% reported many property losses while 50.5% of all the respondents reported very many losses of property occurred during fire outbreaks. This analysis shows that there is always some loss of property whenever there is a fire in markets. In most cases, these damages are very extensive and some traders lose their entire businesses in these fires. Those that manage to save some goods still end up losing goods worth millions of naira.

Table 10: Extent of property loss caused by market fires

Was there any loss of property in the fire?	If yes, how much property was lost?					Total
	Very few	Few	Not too many	Many	Very many	
Yes	6	2	7	30	46	91
Valid Percent	6.6	2.2	7.7	33	50.5	100

Table 11 shows whether or not there was injury of individuals in the fire in the market place. The analysis of the data shows that in the responses analyzed, 71% of the fire outbreak cases caused individuals to be injured while there were no physical injuries in 21% of the outbreaks.

Table 11: Injuries in the fire

		Frequency	Valid Percent
Valid	Yes	71	71.0
	No	29	29.0
	Total	100	100.0

5. Implication to Research and Practice

For the purpose of understanding the nature of market sites in developing countries, it was proven that market size place little role in curbing fire outbreaks. Hence, local authorities should rather think of spatial mapping of market location with respect to its goods and services.

6. Conclusion and Recommendation

In summary, this study has shown that fire outbreaks have negative effects on the users of the marketplaces as in instances where it has occurred, there are almost always losses of lives and property, injuries to individuals and damages to buildings and facilities. These in turn translate to unplanned expenses used to replace damaged items and healthcare. The study recommends that effective and well-maintained fire safety measures be put in place in public market places. Users should also be made aware of fire hazards and of the protocols to observe in the event of a fire outbreak to minimize loss of lives and property.

Also, it was observed in this study that there is the need for spatial topology in architectural design of markets. This solution would localize fire incidence and minimize losses. In this light, a scalable topology of traditional markets was proposed. Hence, the usual practice of converting kiosk to storey building will not curb losses due to fire outbreaks. It was also proposed in the research that there is the need for the control of technical personnel within the market to curb the frequency of fire outbreaks due to electrical or gas installation faults.

For the purpose of understanding the nature of market sites in developing countries, it was proven that market size place little role in curbing fire outbreaks. Hence, local authorities should rather think of decentralising market location with respect to its goods and services.

7. Future Research

This study suggested that further researches on the investigation of digital architectural design solutions (i.e simulation) to curb fire outbreaks in market spaces.

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