Reviewing Fire Disasters at Traditional Markets: Causes, Impacts, and Remedies

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Abstract. Despite the busy activities of traditional markets, the physical condition and fire protection system of traditional markets are generally poor, making it vulnerable to fire incidents. This study aims to identify and map the causes and impacts of fire incidents on traditional markets in various countries. Data was collected through a systematic literature review from 100 references, with a total of 60 fire incidents at the traditional markets in various countries. The research found that the main causes of traditional market fires were: electricity, negligence, and arson attacks. This study also identified general conditions and problems in traditional markets related to fire incidents, and found 6 vulnerable factors of fire risk, i.e. building, social, institutional, environmental, health, and economic factors, which later mapped in the form of cause and effect diagrams. Based on the research findings, a recommendatio n on fire prevention strategy for traditional markets is proposed.

Keywords: fire disaster, traditional market, vulnerable factors

1 Introduction

Traditional markets are one of public buildings that are most vulnerable to fire. In Indonesia, for example, throughout 2015 there were 283 casesof market fires with an estimated loss of Rp. 377 billion. This is a significant increase compared to 2014 of 140 cases with an estimated loss of Rp. 212 billion [1]. Whereas the number of cases in 2019 is lower with 200 cases were recorded [2]. The fire incidents in traditional markets cause loss of lives, damage to environmental and assets, disruption on the production activities, and job losses [3, 4]. These incidents also cause psychological distress to the victims [5]. They also demonstrate negative impacts on the economy in various countries, as traditional markets are notably one of the highest contributors to regional income [6].

To maintain the sustainability of traditional markets, it is very important to comprehensively understand the situation, issues, and factors related to the fire incidents, so that lessons can be learned. This study aims to map the causes and impacts of traditional market fires in various countries, as well as to identify the vulnerability factors, so that remedies can be strategically recommended to lower the risks of fire incidents in traditional markets.

2 Method

This research was conducted using qualitative approach through a systematic literature review on traditional market fires in various countries, covering both developed and developing countries.

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A comprehensive analysis was carried out based on 100 references related to market fire incidents, consisted of 31 journal papers and 69 news from national and international media to identify the causes, impacts and vulnerability factors of fire incidents at traditional markets. A fish bone diagram was later developed to map the causes and effects of fire incidents in traditional markets.

3 Results and Discussion

The followings are the results of the identification of causes and losses of traditional market fires, existing problems, and vulnerability factors.

3.1 Causes and losses of traditional market fires

Learning from 60 cases of fire incidents at the traditional markets in various countries as shown in Tables 1 and 2, in general the fire incidents are mostly caused by electrical faults, negligence and arson attacks, resulting in huge material losses. Other minor causes include gas stoves, smoking, and burning rubbish, all of which are related to activities of the market occupants. In China, 70% of the fire incidents were suspected to be caused by electrical faults, improper use of fire in daily life, smoking, and ignorance of fire safety regulations [7]. China's Yuquan Furniture Shopping Centrecaught fire in 1998 due to an electrical fault with an estimated loss of 20.88 million yuan [7].

The main factor causing traditional market fires in Korea was also related to electricity. The Seomun Daegu market fire in 2016 was caused by electrical faults, as the high use of electric heating equipment during cold weather increases the risk of fire [8]. In addition, the market buildings that were more than 20 years old are more prone to fire, the distance between shops was close, and the selection of building materials or types of goods sold causes the fire to spread rapidly. The estimated total losses due to traditional market fires in Korea in the past five years have been around 13.36 million won [8]. As for the Kumasi Central market in Ghana, possible factors of fire in 2009-2012 include power fluctuations 26.32%, cooking with naked fire in the market 18.95%, overloading of electrical appliance 15.79%, improper and old electrical wiring system 12.63%, illegal tapping of electrical power from the national grid 10.52%, use of substandard electrical materials 8.42%, and use of defective generators 7.37%[9, 10].

In Kolkata, India, fire incidents in Nandaram Market in 2008 were caused by electrical faults with estimated losses of Rs 600 crore, whereas in 2013 the Surya Sen Market fires were caused by electrical short circuits [11]. In 2018 Bagree Market caught fire with an estimated loss of ₹ 20-25 crore and no known cause of fire [12]. In 2018 the Siliguri Bidhan Market, India fire was caused by an electrical short circuit [13]. Gariahat Market caught fire in 2019 caused by electrical short circuits [14]. Whereas the Jankara Market fire in Nigeria in 2012 was caused by fireworks [15]. Abubakar Rimi Market and Birnin Kebbi Central Market caught fire in 2016 caused by electrical faults [16].

Table 1. Some examples of fire disasters of traditional markets globally

Fire disaster	Year	Location	Estimated loss	Cause of fire	Ref
Yuquan Furniture Shopping Center	1998	China	20,88 million yuan	Electrical fault	[7]
Seomun Daegu Market	2005	Korea	168,9 billion won	-	[8]
Camden Canal Market	2008	UK	£30million	Gas heater	[17]
Nandaram Market	2008	India	Rs 600 crore	Electrical fault	[18,19]

Fire disaster	Year	Location	Estimated loss	Cause of fire	Ref
Kumasi Central Market	2009	Ghana	-	Electrical fault and negligence	[9, 10]
Kumasi Central Market	2010	Ghana	-	Electrical fault and negligence	[9, 10]
Kumasi Central Market	2012	Ghana	-	Electrical fault and negligence	[9, 10]
Super Suwedru Melcom Market	2012	Ghana	-	-	[20]
Jankara Market	2012	Nigeria	-	Fireworks or firecrackers	[15]
Surya Sen Market	2013	India	-	Electrical short circuit	[21]
Chatucak Market	2013	Thailand	20 million baht	Electrical short circuit	[22]
Camden Stables Market	2014	England	-	-	[23]
Sango Plank Market	2015	Nigeria	N250 million	-	[24]
Seomun Daegu market	2016	Korea	-	Electrical fault	[8]
Jurong West Market	2016	Singapore	$6 million	Arson attack	[25]
Abubakar Rimi Market	2016	Nigeria	N2 trillion	Electrical fault	[16]
Birnin Kebbi Central Market	2016	Nigeria	-	Electrical fault	[16]
Tsukji Fish Market	2017	Japan	-	-	[26]
Sunrise Oriental Market	2017	US	$250,000	-	[27]
Mercado Oriental Market	2017	Nicaragua	-	-	[28]
Camden Lock Market	2017	England	-	-	[29]
Seremban Market	2017	Malaysia	RM6 million	Arson attack	[30]
Bagree Market	2018	India	₹20-25 crore	-	[12]
Siliguri Bidhan Market	2018	India	-	Electrical short circuit	[13]
Sango Plank Market	2018	Nigeria	-	Arson attack	[31]
Gariahat Market	2019	India	-	Electrical short circuit	[14]
La Merced Market	2019	Mexico	-	Electrical fault	[32]
Odawna Market	2019	Ghana	-	Electrical fault	[33]
Sentul Market	2019	Malaysia	-	-	[34]
Kalibo Public Market	2019	Philippines	P35 million	Electrical wiring	[35]

Similarly, traditional market fires in Indonesia were mostly caused by electricity, negligence and arson attacks (Table 2). Gede Bage market in Bandung has experienced fire incidents three times in the last five years. In 2015 it was caused by an electrical fault with estimated losses of 19.4 billion rupiah [36, 37], then in 2018 two incidents due to electrical faults with estimated losses of 6 billion rupiahs and burning garbage with estimated losses of 4.5 billion rupiah [38, 39, 40]. The Johar Market fire of Semarang in 2015 was caused by an electrical fault with an estimated loss of 350 billion rupiah [41]. The unavailability of fire protection systems, unclear merchant zones arrangement, and lack of residents' awareness of fire hazards make the Bandung Andir Market vulnerable to fire hazards [42]. Similar to the Market in Malang, the unavailability of a fire protection system, lack of awareness of visitors and the messy arrangement of stall are the cause of the market being vulnerable to fire hazards [43]. Turi Market fire in 2012 caused huge losses to traders, it was not equipped with a fire protection system, so the fire quickly spread [44].

Table 2. The fire disasters of traditional markets in Indonesia

Fire disaster	Year	Location	Estimated loss	Cause of fire	Ref
Gede Bage market	2015	West Java	19,4 billion rupiah	Electrical fault	[36, 37]
Caringan market	2015	West Java	5 billion rupiah	Electrical fault	[45]
Pelita market	2015	West Java	20 billion rupiah	Electrical fault	[46]
Johar market	2015	Central Java	350 billion rupiah	Electrical fault	[41]
Kebayoran Lama market	2017	Jakarta	1 billion rupiah	Electrical fault	[47]
Karamat Jati market	2017	Jakarta	9 billion rupiah	Electrical fault	[47, 48]
Sorowako market	2017	Sulawesi Selatan	5 billion rupiah	Electrical fault	[49, 50]
Semin market	2017	Yogyakarta	475 million rupiah	Gas stove canister	[51, 52]

Fire disaster	Year	Location	Estimated loss	Cause of fire	Ref
Bukittinggi market	2017	Sumatera Barat	1,5 trillion rupiah	Electrical fault	[53]
Pasrepan market	2017	East Java	1,6 billion rupiah	Electrical fault	[54, 55]
Gede Bage market	2018	West Java	6 billion rupiah	Electrical fault	[38, 39]
Gede Bage market	2018	West Java	4,5 billion rupiah	Burning garbage	[40]
Wiradesa market	2018	Central Java	7 billion rupiah	Electrical fault	[56]
Boom Lama market	2018	Central Java	50 million rupiah	Electrical short circuit	[41]
Malaka market	2019	Jakarta	50 million rupiah	Electrical fault	[57]
Eviles market	2019	Jakarta	500 million rupiah	Burning garbage	[58]
Lawang market	2019	East Java	9 billion rupiah	Electrical fault	[59]
Patemon market	2019	Central Java	11 million rupiah	Electrical fault	[60]
Kosambi market	2019	West Java	20 billion rupiah	Electrical fault	[61]
Nglangon market	2019	Central Java	1 billion rupiah	Electrical fault	[62]
Mungkid market	2019	Central Java	3 billion rupiah	Electrical fault	[63]
Ngunut market	2019	East Java	80 billion rupiah	Arson attack	[64]
Baros market	2019	West Java	10 billion rupiah	Smoke	[65]
Bendul Merisi market	2019	East Java	30 million rupiah	Burning garbage	[66]
Guntur Ciawitali Blok D market	2019	West Java	300 million rupiah	Electrical fault	[67]
Jatingaleh market	2019	Central Java	20 million rupiah	Electrical short circuit	[41]
Kedungmundu market	2019	Central Java	300 million rupiah	Gas stove canister	[41]
Porda Juwana market	2020	Central Java	2 billion rupiah	Electrical fault	[68, 69]
Way Jepara market	2020	Lampung	2,5 billion rupiah	Electrical fault	[70, 71]
Lodoyo market	2020	East Java	150 million rupiah	Electrical fault	[72]

3.2 Existing conditions and inhibiting factors in the traditional market fire

The unavailability of fire protection systems and the lack of knowledge of market occupants of the use of fire extinguishers are factors that inhibit the evacuation process and cause fires to spread rapidly [7, 9, 42, 43, 77, 81]. The unavailability of accesspoints for firefighters and poor road conditions, as well as poor performance of active and passive protection systems have causedthe evacuation process of victims to be hampered in the event of a fire [8, 9, 10, 43, 73, 77, 81]. Whereas the function and performance of building facilities are a benchmark for the design stages of a building in preventing and overcoming fire hazards [74, 80]. The surrounding conditions of traditional markets, such as illegal vehicle parking and traders selling outside the market are a hindering factor in the process of extinguishing fires [8 , 9, 10, 79]. In addition, the height of the building and the speed of the wind affect the level of difficulty in the process of extinguishing the fire. The higher the building, the time needed for the evacuation of occupants the longer, and the height of the building serves as a determinant of the fire protection system that will be used from a building [75, 76, 78, 80, 82]. Arrangement of traders according to the type of goods sold and the wet or dry zone reduce the risk s of fire and facilitate the evacuation process [42, 43, 78].

3.3 Vulnerability factors of traditional markets to fire risk

Traditional markets have a high level of activity and complexity that causes vulnerability to fire disasters. In this case, vulnerability is defined as pre-disaster condition that has the potential to become a disaster when it encounters danger. The vulnerability factors can be classified into building, social, institutional, environmental, health and economic (Table 4). Building factors include the age of the building, the narrow fire extinguisher access point, the use of electric heaters, and damage to goods stored on the market [8]. Distances between buildings and fire protection systems that do not function properly have the potential to pose a risk of fire [77]. The

number of floors, the use of flammable building materials, and the unavailability of fire communication tools affect the occupant's evacuation process and slow down information to residents in the event of a fire [83].The social factors are associated with occupant activities, the occupant densities and the lack of knowledge of the dangers of fire and safety procedures [8, 80], including the use of cooking equipment on the market and illegal connection of cables increase the risk of fire [10].

Table 3. Vulnerability factors of traditional markets to fire risk

Vulnerability Factor	Reference																													
	[5]	[7]	[8]	[10]	[44]	[73]	[74]	[76]	[77]	[78]	[79]	[80]	[83]	[84]	[85]	[86]	[87]	[88]	[89]	[90]	[91]	[92]	[93]	[94]	[95]	[96]	[97]	[98]	[99]	[100]
Building																														
Electrical cable connection	▪	▪	▪	▪					▪	▪				▪				▪	▪											
Type of building material			▪				▪	▪		▪									▪	▪		▪	▪				▪			
Access points inside and outside the building			▪	▪		▪			▪	▪	▪		▪	▪	▪				▪	▪	▪		▪							
Installation and fire protection system not working	▪			▪	▪	▪	▪	▪	▪	▪		▪	▪		▪					▪			▪		▪					
No fire communication system													▪																▪	
Number of floors							▪	▪				▪	▪																	
Distance with other buildings							▪		▪		▪		▪		▪								▪							
Age of the building	▪		▪				▪																							
Social																														
Lack of knowledge of fire safety management		▪	▪	▪		▪		▪	▪	▪																				
Misuse of fire		▪		▪														▪												
High activity							▪				▪	▪	▪		▪								▪	▪						
Number of occupants							▪					▪																		
Institutional																														
No role of government		▪	▪			▪	▪		▪																					
No routine maintenance													▪	▪														▪		
Limited funds														▪				▪												
No building insurance				▪																					▪				▪	▪
Environmental																														
Far from the fire station					▪																									
Lack of water supply				▪											▪															
Traders outside market			▪																											
Parking improperly			▪																											
Traffic density				▪						▪																▪				
Health																														
Less air circulation									▪	▪			▪	▪		▪							▪							
Dirty location																▪														
Less lighting										▪																				
Economic																														
Operational hour																	▪							▪						
Type of item																	▪													
Average transaction																	▪							▪						

Institutional vulnerability factor is related to the role of government as typically the owner of traditional markets in the implementation and control of routine maintenance of market buildings and the availability of costs [84]. As the traditional markets are considered vulnerable to risk of fire, building insurance is required as a form of protection, and this needs an understanding of insurance of the relevant party [10]. Environmental factors are associated with surrounding conditions of the market, including street vendors and illegal vehicle parking [8]. The distance of the fire brigade station to the market influences the time travel of the firefighters to the location, as once occurred in Turi marketin Surabaya, in which fire was rapidly spreading as thefire fighters arrived late [44]. In addition, the high traffic density surrounding the market may also cause congestion, thus affecting the time travel of the fire fighters to reach the market location [10]. The unavailability of fire extinguishers and the lack of local water sources can inhibit the process of extinguishing the fire [85]. The health factors are associated with health requirements, such as the availability of air circulation in the market buildingand a clean location [86]. Poor ventilation is

one of the causes of a fire, as the room becomes humid, making it more vulnerable to fire [78]. Economic factors include market operating time and types of goods sold, which affect the average transaction value. The higher the average transaction value indicates the higher trading activities in the market, thus reflecting higher risks of fire incidents [87]. Figure 1 shows the map of causal relationship of the six vulnerability factors identified above.

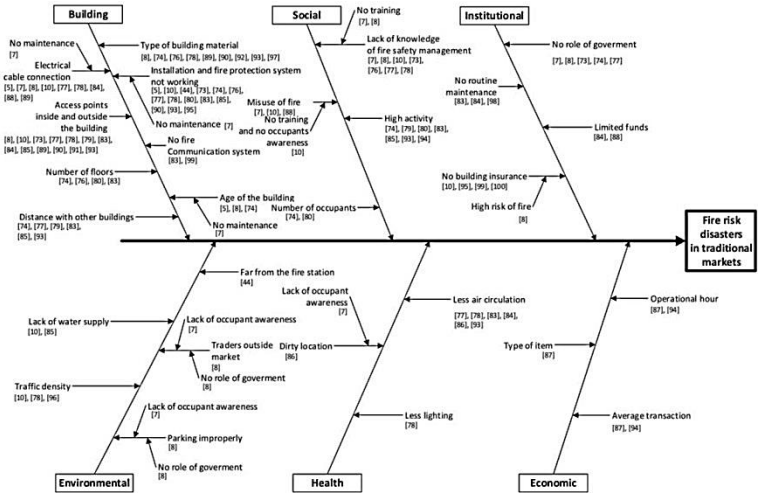

Fig.1. Cause and effect diagram of fire disaster of traditional markets

3.4 Strategies to minimize the vulnerability factors of traditional market fires

To reduce the fire incidents in traditional markets, prevention strategies can be formulated based on the identified vulnerability factors. In terms of the building factors, remedies can be done by providing an active protection system and a fire communication system that functions properly. Routine maintenance of market building facilities and supported by the government in terms of control and supervision since the planning stage of traditional market buildings.

The social vulnerability factors can be minimized by conducting training on fire safety management and limiting the operating hours of traditional markets to reduce the high number of occupants at a certain time. In relation to the institutional factors, the government is expected to play an active role in the implementation of fire prevention in traditional markets, provide funds for the procurement and maintenance of fire protection systems, and provide building insurance as a form of risk transfer to third parties and asset protection. Minimizing the vulnerability of the environmental factors can be done by providing access to information and facilities to market residents, thereby reducing the level of fire risks and the ease of occupants obtaining information. Ensuring the building's circulation and ventilation in accordance with the regulation, providing and maintaining evacuation routes, gathering points, and cleaning facilities are part of strategies related to the health factors. In relation to the economic factors, the arrangement of trading zones in the market based on the types of goods sold, not only will attract visitor to higher transaction, but also will provide sufficient access to fire brigades in a case of fire.

4 Conclusions

This research identified 60 casesof traditional market fires in various countries, including Indonesia. Themain causes of traditional market fires were found related to electrical faults, negligence, and arson attacks. The general condition and problems include the unavailability of or non-functioning fire protection systems, the lack of knowledge of market occupants, and the non-ideal surrounding environment. Six traditional market vulnerability factors to fire risk were identified, i.e. building, social, institutional, environmental, health and economic factors, which were mapped with relevant sub factors using fish bone diagram to understand the cause and effect relationship. Strategies were later formulated based on the findings of the vulnerability factors, e.g. the provision of active protection system, routine maintenance, provision of building insurance, etc. The findings of this research are expected to be beneficial for stakeholders of traditional markets in understanding and anticipating fire incidents at traditional marketsin the future.

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