RESEARCH ARTICLE

Fire Hazard, Vulnerability, and Fire Protection Assessment in North Jakarta

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ABSTRACT

Jakarta as the capital of Indonesia is progressing in the industrial and economic fields, facing problems in rapid population density and settlement. Dense population and housing in Jakarta increase the risk of fire. The objective of this study is to conduct hazard mapping, vulnerability, and fire protection assessment in Cilincing, Tanjung Priok, dan Penjaringan, North Jakarta. This study used cross-sectional method with non-probability sampling: stratified sampling. Data were collected using Fire Risk Assessment checklist, focus group discussion, and questionnaire. Instrument was developed using disaster Fire Risk approach including Fire Hazards, Vulnerability and Fire Protection / Fire Management. The instrument consists of Fire Risk Assessment Checklist for Local Government Fire Department and Questionnaire for Head of Neighborhood (*Ketua RW*). Data were then analyzed using descriptive analysis, bar chart and spider web diagram. The 15 areas of Cilincing, Tanjung Priok, dan Penjaringan were categorized at 9 medium risk and 6 high risk area. It is recommended to improve urban fire management, including provide additional city hydrants and ensure adequate and accessible city hydrant, and maintain regular program for hydrant inspection and testing. Fire Department also need to ensure proper fire protection in place for high-risk community activities, disseminate information regarding the use of building compartments with non-combustible materials, and educate residents about fire prevention and extinguishing, as well as community empowerment to be involved in fire emergency drill.

Keywords: fire hazard; fire vulnerability; fire protection assessment

INTRODUCTION

Modernization in urban areas and the industrial development increase the risk of fire disaster. Fire cause loss of life (death and injuries), damage to buildings, equipment, materials, products, production processes interuption and work activities, environmental pollution, social and reputational impacts. According to the International Association for the Study of Insurance Economics, known as the Geneva Association, fire losses in developed countries reached for roughly 0.05% to 0.22% of Gross Domestic Product (GDP)[1]. Fire case is the highest disaster potential in urban areas, related to high population density, complexity of land use, concentration of urban population activities, use of building materials, and the presence of urban slum areas[2].

Jakarta as the capital city, with the highest density level in Indonesia, fires occurred every day, due to large number of dense and slum settlements. As refer to Badan Pusat Statistik, there were 3,412 fire disaster cases in 2021, majority occurred in North Jakarta (68%) compared to another Jakarta administrative city. Related to the fired object in DKI Jakarta, 2.333 fires occured in housing, 910 cases of public buildings, 15 cases of industrial buildings, and 154 cases of motor vehicles. Population and building density, non permanent housing, and slum condition made them vulnerable to fires. Fires disaster in DKI Jakarta majority caused by electricity (67%), compared to another causal factor, gas explosions and leaks, waste burning activities, candle, and cigarette[3]. The highest fire incidents during 2019-2021 in North Jakarta occurred in Cilincing, Penjaringan, and Tanjung Priok sub-districts as shown in the following figure.
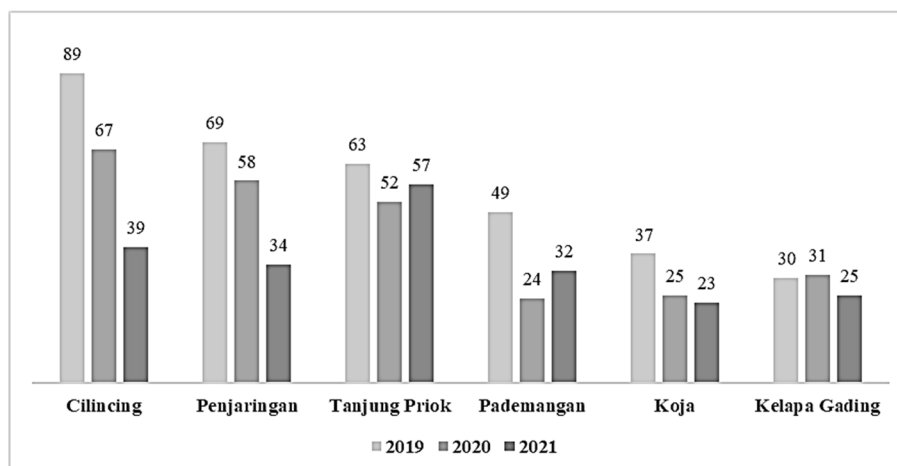
Figure 1. Fire incident in North Jakarta, 2019-2021 [4]

Fire vulnerability related to the rapid development of the population in DKI Jakarta, where in 1980 the population reached 5.3 million people and until 2021 it has reached 10.6 million people[3,5]. The increase in population has encouraged the development of urban areas and densely populated settlements in DKI Jakarta. In certain areas it was developed into slum areas. Population development encourages dense settlements, which in turn is the cause of urban/settlement fire disasters that occur every year in DKI Jakarta[6]. The density level of population of DKI Jakarta included Kepulauan Seribu reaches 15,978 people/km2[3]. The number is much higher than the Indonesia's population density of 142 per sq.km[7]. Population density can increase the potential for fire hazards, especially for dense residential buildings that use flammable building materials[8]. In addition, the conditions of dense and slum settlements with semi-permanent materials made of wood are fuel conditions that encourage fires to occur easily. Fire disaster in Jakarta are also caused by dry weather conditions and strong winds during the dry season[6].

To improve efforts to reduce fire risk in Jakarta, leading program that needs to be considered is the availability of information related to fire hazard mapping. Fire risk mapping can determine the characteristics of the incident objectively and comprehensively. The implementation of fire analysis in a statistical form can play an important role in understanding the trend of fire cases. American Fire Protection Association (NFPA) conducted fire analysis by collecting fire data on a regular basis to further estimate future events to design fire prevention and control programs[9]. According to Head Regulation of National Board for Disaster Management (BNPB) No.2/2012, the priority of disaster risk reduction programs is the availability of disaster risk studies based on hazard and vulnerability data[10]. Therefore, the implementation of fire data analysis to determine the classification of potential fire hazards in the North Jakarta City area is one of the priorities program for the Fire Department.

METHODS

This study used cross-sectional design with a non-probability sampling: stratified sampling approach. The study was conducted in 15 *Rukun Warga* (RW) / neighbourhood group from 3 sub-district in North Jakarta in the period of April to June 2021. Data were collected using fire risk assessment checklist and document review. Then, the data obtained through focus group discussion (FGD) and filling out questionnaires, to examine fire risk in the specific area of RW in the perspective of Fire and Rescue Department in North Jakarta. FGD was performed online through the zoom application and led by facilitators and attended by Heads of Sector and Commanders of the Firefighter Station. Questionnares were distributed and filled out online by the Head of RW. The Instrument was developed using a disaster Fire Risk approach including Fire Hazards, Vulnerability and Fire Protection / Fire Management.

The areas in this study are Cilincing, Tanjung Priok, and Penjaringan Subdistricts, which experienced the highest fire events in the 2018-2020 period. In addition, the three sub-districts are the areas with the largest population in North Jakarta. Details of the research area can be described as follows:

a. Tanjung Priok sub-district involve area of Tanjung Priok, Papanggo, Sungai Bambu, Sunter Agung, and Sunter Jaya.

b. Penjaringan sub-district involve area of Pluit, Pejagalan, Kapuk Muara, Penjaringan, and Kamal Muara

c. Cilincing sub-district involve area of Semper Timur, Marunda, Rorotan,Kalibaru, and Semper Barat

The instrument of study examines categories in 3 aspects as follow: 1) aspects of potential fire hazard, 2) aspects of vulnerability and 3) aspects of fire protection facilities. Potential fire hazard assessment has 4 aspects related to: (a) community activities that can cause fire, (b) electricity usage, (c) open fire usage, and (d) hazardous

and toxic materials. Vulnerability assessment encompasses 7 aspects related to: (a) population density, (b) building density, (c) building quality and slum rate, (d) frequency of fires, (e) area size and loss, (f) fire propagation and building quality, (g) obstacles faced by fire station in handling fires. Fire protection assessment covers 11 aspects related to: (a) distance between buildings, (b) environmental fire resistance system / building fire safety management, civil participation, and fire volunteers, (c) emergency communication, (d) early fire extinguishing, (e) preparedness of fire station, (f) fire station operational access, (g) fire station response time, (h) fire stations' service, (i) operational for further extinguishing and availability of fire-extinguishing water resources, (j) ease of access to extinguishing tools and (k) city hydrants.

Each question had an assessment score with a range of 1 – 5. The higher the assessment result or the score, the greater the fire risk classification. Summary of all scores, then classified into 5 levels:

a. 1st level fire risk is very light (<20%).
b. 2nd level fire risk is light (21-40%).
c. 3rd level fire risk is medium (41-60%).
d. 4th level fire risk is high (61-80%).
e. 5th level fire risk is very high (>80%).

The data obtained were analyzed and classified the level of fire risk based on the elements of hazard, vulnerability, and fire protection in Cilincing, Tanjung Priok, and Penjaringan sub-districts, North Jakarta.

This study has processed the ethical assessment procedure and been approved by the Research and Community Engagement Ethical Committee Faculty of Public Health Universitas Indonesia, with ethical approval number 256/UN2.F10.D11/PPM.00.02/2021.

RESULTS

Fire Risk Clasification Result

Assessment in the district of Cilincing, Tanjung Priok, and Penjaringan showed the results of nine areas at medium fire risk and six areas at high risk, with average percentage of 58.9% or at medium fire risk. The details of the fire risk classification are described as follows.

a. Cilincing sub-districts, with areas of Marunda (RW01), Semper Barat (RW05), Rorotan (RW06), Kalibaru (RW09), and Semper Timur (RW11) overall showing medium level of fire risk, with an average score of 51.3% .
b. Tanjung Priok sub-district, with areas of Papanggo (RW01), Sunter Agung (RW01), Sungai Bambu (RW06), Sunter Jaya (RW06) showing medium level of fire risk, while the Tanjung Priok sub-district area (RW12) is at a high level of fire risk. The average score in Tanjung Priok sub-district is 57.3% or medium fire risk.
c. Penjaringan sub-district, with areas of Kamal Muara (RW01), Kapuk Muara (RW01), Pejagalan (RW15), Penjaringan (RW17), and Pluit (RW22), the overall risk of fire is high, with an average score of 68.2 %.

The classification of fire risk in Cilincing, Tanjung Priok, and Penjaringan sub-districts is described in detail in the following figure:
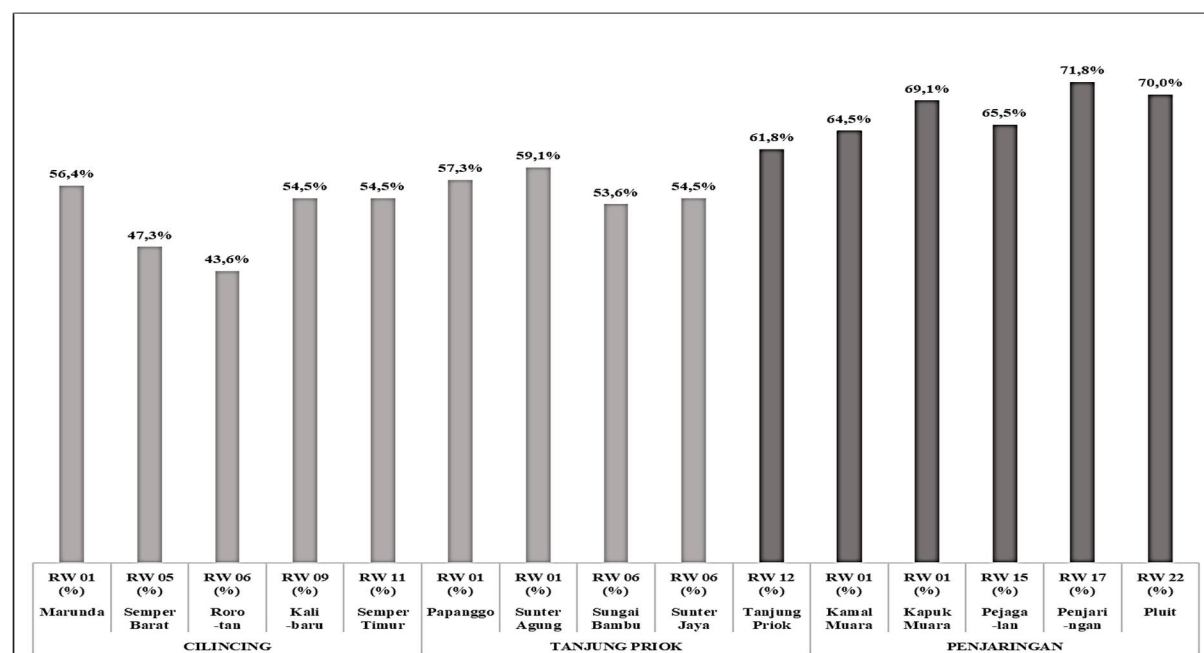

Figure 2. Fire risk classification

Fire Hazard, Vulnerability, and Fire Protection Assessment Result

Details of the percentage of fire risk mapping based on the elements of danger, vulnerability, and fire protection in Cilincing, Tanjung Priok, and Penjaringan sub-districts are shown in the following figure:
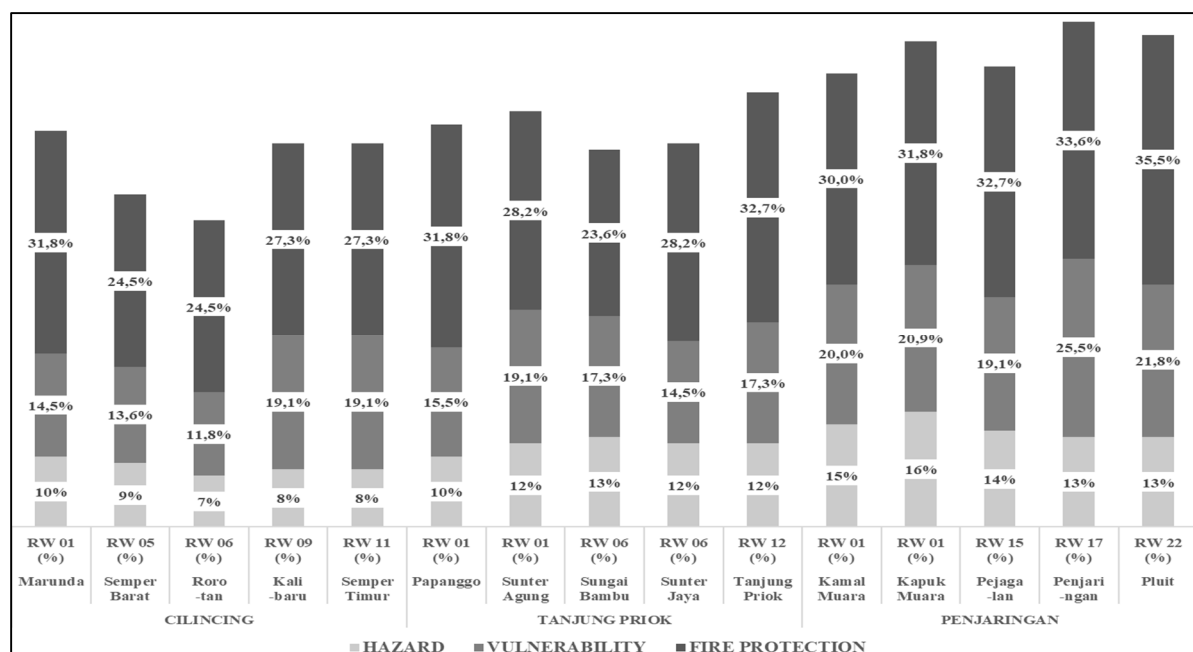

Figure 3. Percentage of fire hazard, vulnerability, and fire protection

The highest score (16%) on the fire hazard aspect, was in the Kapuk Muara area, Penjaringan sub-district. Meanwhile, the aspect of vulnerability to fire risk is found in the Penjaringan sub-district, with a score of 25.5%. Fire protection aspect has the highest score (35.5%) in the Pluit area, Penjaringan sub-district, North Jakarta.

Results of the average score analysis of aspects of fire hazard, vulnerability, and fire protection on 22 elements are described in the following table:

Table 1. Average score of fire hazard, vulnerability, and fire protection

Aspect	Category	Average Score
Fire hazard	Community activities that can cause fire	3.5
	Electricity usage	2.9
	Open fire usage	3.3
	Hazardous and toxic materials	2.8
Vulnerability	Population density	4.3
	Building density	3.1
	Building quality and slum rate	3.6
	Frequency of fires	1.3
	Area size and loss	1.6
	Fire propagation and building quality	3.3
	Obstacles faced by fire station	2.5
Fire protection	Distances between buildings	4.2
	Environmental fire resistance system /building fire safety management	3.4
	Emergency communication	2.1
	Early fire extinguishing	2.4
	Preparedness of fire station	2.2
	Fire station operational access	3.1
	Fire station response time	2.6
	Fire stations' service	2.3
	Operational for further extinguishing and availability of fire-extinguishing water resources	2.3
	Ease of access to extinguishing tools	3.3
	City hydrants	4.7

The results of the average score on all 22 elements of the hazard, vulnerability, and fire protection aspects are described in the following Spider Map to show the level of fire risk.
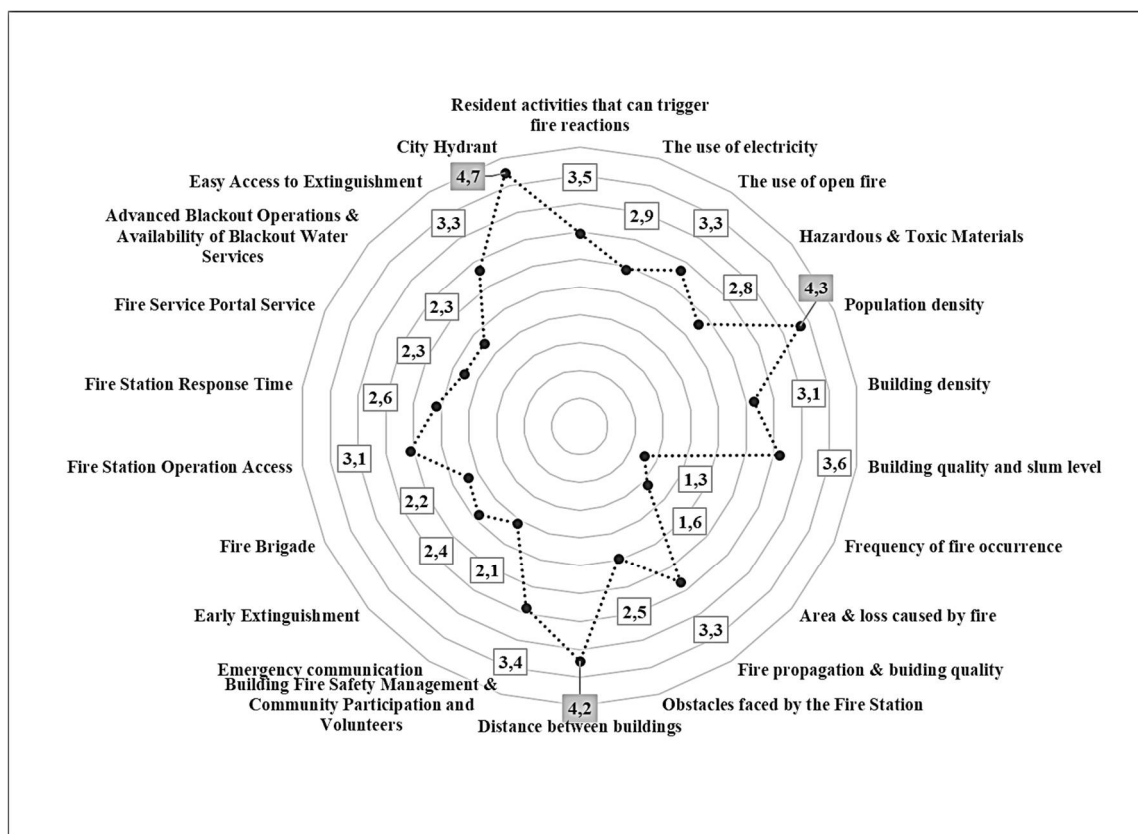

Figure 4. Fire risk spider map of North Jakarta

Based on Table 1 and Spider Map in Cilincing, Tanjung Priok, and Penjaringan sub-districts, the highest average score on the 22 elements of hazard, vulnerability, and fire protection aspects is found in city hydrants (4.7), population density (4.3), and the distance between buildings (4,2).

DISCUSSION

Cilincing (39.70 Km^2), Tanjung Priok (22.52 Km^2), and Penjaringan (45.41 Km^2) are the third largest sub-districts in North Jakarta[3]. Fire risk assessment will elaborate aspects of fire hazard, vulnerability, and fire protection, refer to law, government regulation and applicable standard, consist of Law No. 28 of 2002, Regulation of the Minister of Public Works No. 20 of 2009, Regulation of the Governor of DKI Jakarta Province No. 93 of 2014, and SNI 03-1733-2004. Fire risk assessment focusing on the RW unit level, where most of the area is dominated by dense residential. In addition to residential areas, there are also office buildings, home industries (convection, printing, food), warehouse, workshop, grocery stores, and food stalls. Gas stations, gasoline retail, and LPG (liquefied petroleum gas) retail are also found in several areas within this sub-district. Fire risk assessment result categorized at 9 medium risk and 6 high risk area, with average percentage of 58.9% or at medium fire risk.

Fire Hazard Aspect

Fire hazard constitute of all factors present in a building that can cause ignition (start fire), aggravate fire severity, incapacitate building fire safety provisions, and hinder escape or firefighting operations [11]. Fire hazard assessment in this study was analyzed based on three factors, specifically community activities that can cause fire, hazardous and toxic materials, electricity and open fire usage. The analysis on the potential fire hazard aspect shows the highest average score with a result of 3.5. related to community activities that can cause fires. Household activities including cooking, substandard electrical use, burning garbage can trigger fires. Major fire accident was recorded in the last five years in Cilincing, Tanjung Priok, and Penjaringan was caused by gas stove and short circuit event from electrical usage. Fire and Electrical Department have to maintain inspection program ensuring proper electrical installation. Fire Department can have collaboration with Fire Volunteer Community to have fire

safety session to improve awareness of potential electrical hazard and how to minimize risk short circuit incident. It is also important to know the standards for using LPG and maintain proper condition gas and stove. Avoid flammable equipment out of reach of children, such as chemical liquids that use sprays, candles, matches, etc. Based on NFPA statistic (2015-2019), cooking is the leading cause of fire in residential buildings. Other sources of ignition in buildings include all heating equipment, electrical distribution and lighting equipment, and smoking materials. After ignition, fire severity can be aggravated by several factors such as large quantity of combustible household materials; improper storage of tools, rubbish, equipment, and volatile flammable materials (liquid petroleum gas, paints, ammunition etc.); materials producing toxic smoke on combustion; and combustible building components such as composite panels and timber [12].

In addition to the use of gas stoves, open sources of fire can come from burning garbage and grass. Waste burning activities that are not monitored are human carelessness behavior that can cause fires. Enlarging grass fires have been reported in Semper Timur and Pluit. Therefore, burning garbage and grass should be prohibited by the Head of RW and Fire Department to be carried out by the community. LPG retails, gasoline retail sales, and gas station also make the subdistrict vulnerable to have fire accident. Flammable / combustible liquid or gas was the leading items first ignited in home structure fires during 2015-2019 resulted in death and injuries refer to NPFA report. Nilson and Bonander describe several efforts to prevent fire deaths, by reducing heat, stopping the ignition process, inhibiting the growth of fire, and the evacuation process. The first two prevent the fire while the last three come into play after the fire starts [12]. Efforts to increase preparedness can minimize losses that arise if a fire disaster occurs. Community preparedness in fire disaster management needs to be supported by public understanding of disasters that threaten in their area, availability of supporting public facilities for disaster management, and the existence of disaster response organizations[13]. Community preparedness is part of the parameters of community capacity in dealing with fire hazards according to the reference to Head Regulation of National Board for Disaster Management (BNPB) No.2/2012 related to General Guidelines for Disaster Risk Assessment, as early warning parameters and disaster risk studies, disaster education, and reduction of basic risk factors [10].

Vulnerability Aspect

Vulnerability is defined as the potential effect of a threat and takes into account the adaptive capacity and resilience of the affected units over time[14]. Vulnerability aspects in this study include population density, building density, building quality and slum rate, frequency of fires, area size and loss, fire propagation and building quality, and obstacles faced by fire station in handling fires. Based on the aspect of fire risk vulnerability, population density with the highest average score (4.3) is an existing element that remains a concern for fire prevention. Cilincing, Tanjung Priok, and Penjaringan subdistrict based on the Regional Statistics of North Jakarta City in 2021, have the highest population and have a relatively high population density in North Jakarta[4], with settlements occupied more than 200 people/hectar[15]. Several RW sampling area in Cilincing, Tanjung Priok, and Penjaringan is categorized high building density, that 80% congested area or city center, based on Law No. 28 of 2002 and Government Regulation of Indonesia No. 36 of 2005. High building density is related to the basic building coefficient and building floor coefficient, namely the ratio of the total building area to the function of the area and the carrying capacity of the environment[16,17]. Population density related to the building density and the distance between buildings, which need to be considered in fire prevention action. Standard of the fire compartment is the empty space between the exterior of the building which is adjacent to each other so that the use of combustible materials in high-density buildings will increase the speed of fire propagation[18]. Therefore, it is necessary to disseminate information regarding the use of residential building compartments with non-combustible materials for settlements in RWs with high building density.

The quality of the building and the level of slums is related to the structure and construction of flammable buildings such as wood, plywood, etc. Overall RW indicated average score of 3.6 where the quality of the building is quite flammable and the slum level is moderate. In most low- and middle-income countries, settlements built in unsuited land for residential or commercial development and these are often chosen because good locations for income-earning opportunities. Housing within these areas is often very dense which increases the risk of fire and makes access to emergency services poor[19]. Fire frequency indicates fire occurrences with an average score of 1.3 or low fire rate frequency in all sub-district between 1-2 times per year and a low loss value of between 200 - 500 million with a fire area of less than 100m2. However, we have to keep vigilant that major fire incidents have ever happened in the last five years in Cilincing (RW9 Kalibaru), Tanjung Priok (RW1 Sunter Agung), and Penjaringan (RW15 Pejagalan, RW17 Penjaringan, RW22 Pluit). This major fire incident have an impact on property damage costs above IDR200Mio. Fire vulnerability is also influenced by road access to the fire location. Congested road conditions and many narrow access roads can only be passed by two-wheeled vehicles or units of 2500 L. In case fire trucks cannot reach the fire location, require a long fire hose to pass through several narrow alleys, in densely populated residential areas. It is recommended in sub-districts to regulate vehicle parking in

public road as obstacles for fire trucks to the fire incident. Additional and accessible hydrant pillars on narrow roads or alleys in densely populated areas are also needed to speed up the fire fighting process.

Fire Protection Aspect

Fire protection management in urban areas is all efforts related to organizational systems, personnel, facilities and infrastructure, as well as management to prevent, eliminate and minimize the impact of fires in buildings, the environment and the city[20]. Community participation in is relatively active in environmental fire prevention & control programs, with an average achievement rate of 3.4 or around 60-70% community components have been actively involved in fire prevention programs. The Environmental Fire Safety System Program (SKKL) is a system for managing human and environmental resources to achieve environmental safety and security from fire hazards[21]. This program has been implemented in every RW as compliance with Regulation of the Governor of DKI Jakarta Province No. 93 of 2014. Community Participation in Fire Prevention and Control. Corporate Social Responsibility programs from private companies are also conducted in several RWs to help increase fire safety awareness to the community. Fire Department can continue collaborate with the RW women's organization (Dasawisma PKK) to perform fire safety socialization. Fire Department also have to maintain fire safety program with Fire Volunteer Community (Balakar), as a community responsibility organizational for fire incident prevention in RW level. This volunteer fire organization has primary role for preventing and responding to early fires, assisting in supervising, maintaining fire fighting infrastructure and facilities, reporting fire occurrences, and reporting activities that pose a fire threat. To support the implementation of volunteer fire duties, Fire Department ensures that volunteers can utilize infrastructure and equipment such as guard posts, portable fire extinguishers, and water pumps. Portable fire extinguishers are available in every RW, but not every RT (sub-RW) has a fire extinguisher. Government must ensure the availability of fire extinguishers in sufficient quantities in every RT. Fire volunteer also supported with emergency communication system e.g. emergency number, handy talkies, and procedures to ensure proper emergency reporting to Fire Department.

Fire Department indicated that they have fulfilled standard response time, with average score of 2.6. Refer to Regulation of the Minister of Public Works No. 20 of 2009 regarding Technical Guidelines for Urban Fire Protection Management, Fire Department have 15 minutes maximum response time after fire notification. It is consists of time starts from the receipt of notification of a fire in a place, determination of the location of the fire, information on burning objects and preparation of troops and extinguishing facilities, travel time from the fire station to the location, time of equipment deployment at the site until the spraying operation is ready. Several factors determining response time are: (a) types of services provided by the Fire Department, especially the types of life-saving, medical emergency, and fire fighting services (b) served area size, including the potential hazards at the location and existing capacity (c) community capacity including local government in providing fire protection infrastructure and facilities[21]. For further extinguishing and availability of fire-extinguishing water resources, Fire Department quite ready with fire truck unit 4000L for main road and 2500L for alley way. Fire Department also have support systems, sufficient water sources to support extinguishing operations from various main sources including river water flow / river / sewer and drainage catchment systems such as lakes / ponds. Fire Department use water from rivers such as Cakung, Blencong, Malaka, Java Sea (Cilincing), Ciliwung, Warakas Martadinata, Pademangan, Sunter Lake (Tanjung Priok), Semongol, Cagak, Angke, Gendong (Penjaringan).

City hydrant become main problems due to the highest average score (4.7) in fire protection aspect and also overall aspect in vulnerability and fire hazard. Questionnaire and FGD session indicated there was insufficient hydrant function, difficult to access & doesn't reach the area in Cilincing, Tanjung Priok, and Penjaringan sub-districts. No city hydrant installed in Kamal Muara (RW01), Kapuk Muara (RW01), Pejagalan (RW15), Pluit (RW22), Tanjung Priok (RW12), Papanggo (RW01), Marunda (RW01), Sunter Jaya (RW06). Hydrant condition in Rorotan (RW06) the water is intermittent, only at night the water can flow and can be used. In Sunter Agung (RW01) and Penjaringan (RW17), city hydrants did not function, Fire Department rely on rivers, reservoirs and lakes. Hydrants are usually equipped with two couplings as a connection with the hose. In 2019, hydrants in North Jakarta were reported lost 72 couplings, from total 270 hydrants[22]. This requires attention the Fire Department to cooperate with community to maintain and improve hydrant monitoring and supervision to ensure hydrant in proper condition[21]. The primary purpose of the fire hydrants, installed throughout water distribution systems, is to enable fire fighters to connect fire engine hoses with the hydrants to help with extinguishing the fire whenever it occurs[23]. Office building have to comply with Regulation of the Governor of DKI Jakarta Province No 92 of 2014, Technical Requirements and Procedures for Installing Upright Pipe and Fire Hose Systems and Fire Hydrants. Beside residential area, office building need to provide hydrant, positioned close to the entrance or a position that can be entered by fire trucks, at a maximum distance of 150 meters, and not obstructed by parking, loading and unloading, and office park. Fire Department also need to have regular inspection to office building to verify proper installation of siamese connection and accessible by fire truck when fire incident occur[24].

There may be some possible limitations in this study. The primary limitation of these result is focussing in RW area / neighbourhood group due to availability resources of RT level (sub-RW area) and limited-time for

research allowed this study to be performed at the RW unit level. Data collection is conducted in online basis. No field observation had been taken in study area, due to COVID-19 pandemic condition.

CONCLUSION

Hazard mapping, vulnerability, and fire protection assessment result in Cilincing, Tanjung Priok, and Penjaringan sub-districts, North Jakarta, categorized in 9 medium risk and 6 high risk area, with average percentage of 58.9% or medium fire risk. The highest fire risk and priority needed for improvement were improper function of city hydrants, population density, the distance between buildings which further increases the potential for rapid fire spread and community activities that can cause fires. There area several recommendation for Fire Department of North Jakarta to prevent the fire disaster. Provide proper and sufficient city hydrants and ensure accessible of city hydrants, as well as ensure the implementation of periodic hydrant testing programs. Fire Department also need to ensure proper fire protection for high-risk community activities (e.g. workshops, home industries, and retail sale of LPG cylinders). It is recommended to disseminate information regarding the use of building compartments with non-combustible materials, educate residents about fire prevention and suppression, and empower the community to be involved in fire emergency response drill.

Acknowledgement

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