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Fire risk analysis and mapping in Kepulauan Seribu, North Jakarta, Indonesia

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Abstract

Purpose: Kepulauan Seribu is an inseparable part of DKI Jakarta Province. Kepulauan Seribu has more than 110 islands and 11 inhabited islands, where this island area has its own challenges to fire response time. The objective of this study is to measure the fire risk in Kepulauan Seribu, North Jakarta. **Method:** The data collection was carried out by means of stratified sampling and cross sectional using a list of questionnaires and focus group discussion (FGD). The instrument used for the FGD with the Local Government Fire Service of Jakarta was a selected document with three parts; hazard, vulnerability, and risk management or fire protection and has twenty-two questions on a scale of one to five. The questionnaire on community leaders used the customized questions on a scale of one to three. The results of both instruments were analyzed univariate and overlaid with the map of Kepulauan Seribu. **Results:** The results from both areas consisting of six urban villages and twenty four community units showed that the locations with the highest risk of fire were located at Kelapa Island Urban Village at the high level, while the other five urban villages had moderate risk. The most influential aspect at the high level of fire risk in Kepulauan Seribu was the dimensions of risk management and fire protection. **Conclusion:** The lack of infrastructure and fire fighting equipment were two important factors in the high risk of fire. The condition of the islands provides a significant difference in the source of the danger to fire, which one of the fire causes was autoignition. Suggestions that could be given are increasing the awareness and active roles of the community in fire control and prevention, managing on training and socialization undertaken by the local communities, and conceiving provision of infrastructure that supports fire prevention and control, transportation, and fire station.

Keywords: fire risk; hazard; vulnerability; fire protection

INTRODUCTION

Fire hazards are classified into 1) Primary Fire Hazards: Any actions, materials, or conditions that have a damaging effect related to fire initiation and aggravation of fires; such as the presence of oxygen, fuel, and ignition; and 2) Secondary Fire Hazard: Any actions, materials, or conditions that have the potential to cause fire severity due to delays in response such as ineffective emergency planning, inappropriate size of evacuation routes [1]. The distance traveled by firefighters is a critical factor that needs to be considered in the fire prevention process [2]. In addition to housing overcrowding, it also limits firefighters' access to settlements and increases the risk of catastrophic fires. The fire risks also arise from poor structural characteristics and

Table 1. Calculation scale of each component

Categories	Variables	Semantic Differential Scale
Hazard	Fire-triggering activity	1= very low risk; 5= very high risk
	Electricity usage	1= very safe; 5=unsafe
	Use of open flames	1= very safe; 5= unsafe
	Hazardous & toxic material	1= very safe; 5= unsafe
Vulnerability	Population density	1= very low density; 5= high density
	Building density	1= very low density; 5= high density
	Building quality & slum level	1= very hard to burn; 5= very flammable
	Frequency of fire occurrence	1= very low; 5= very high
	Area of fire & loss	1= very low; 5= very high
	Fire propagation	1= more than standard; 5= not up to standard
	Fire post obstacles	1= no problem; 5= the obstacles are very heavy
Risk Management and Fire Protection	Distance between buildings	1= more than standard; 5= not up to standard
	Participation of fire volunteers	1= more than standard; 5= not up to standard
	Emergency communication	1= very ready; 5= not ready
	Early fire fighting	1= very ready; 5= not ready
	Fire post eligibility	1= more than standard; 5= not up to standard
	Fire station operational access	1= more than standard; 5= not up to standard
	Fire post response time	1= very fast; 5= not up to standard
	Fire post service	1= more than standard; 5= not up to standard
	Fire fighting operations & availability of water sources	1= very ready; 5= not ready
	Ease of fire extinguishing access	1= more than standard; 5= not up to standard
	City hydrant	1= very good; 5= not working/not available

unsafe behavioral practices, including unsafe electricity [3].

Fires account for 15% of all disasters in Indonesia, especially in urban areas with high population density. Urban areas are identical to residential areas, which have activities that trigger fires [4]. Urban fires often vary by space and time and are closely related to human activities, the physical environment, and demographic and socioeconomic factors [5]. Fires in urban and residential areas also take a toll on people's lives, loss of property, and threaten the community's security to the possibility of disruption of economic activities and environmental damage [6]. Fires that occur every year can cause damage with a total loss of billions of rupiahs. Based on data from JakartaFire.net, the fire incidents that occur in DKI Jakarta every year are highly caused by electricity, cigarettes, stoves, and others. In 2018 there were 1,528 incidents, 1,355 incidents in 2019, and 1,088 incidents in 2020 [7].

Kepulauan Seribu Regency is listed on DKI Jakarta Fire Management Area (FMA), managed under the North Jakarta sub-department. Having an area of 4,745 km2 with a land area of 8.76 km2, Kepulauan Seribu is formed by more than 110 islands. Its archipelago setting caused the Emergency and Fire Management Services to face many challenges, ranging from inter-island access, transportation, spontaneous combustion, to response time. For this reason, it is necessary to map the risk of fire in the Kepulauan Seribu Regency to provide recommendations to optimize the prevention and control of fires in the area in the future.[4] Fire in areas and ecosystems is one of the emissions sources that impact the atmosphere and public health, particularly from the emitted smoke. A previous study provides a scientific model to explain the quality of low-level complexity air and the epidemiological relationship to identify and assess the fire impact on public health. [8]

Fires also emit PM2.5 fine particulates associated with health impacts on human beings, including respiratory disease and increased mortality rates. This concern has become one of the distinctive challenges for public health institutions and authorities to assess and evaluate the potential and duration of fire occurrence. [9]. A study conducted [10] revealed that one of the consequences of fires is a respiratory syndrome associated with air pollution.

Previous research was carried out mapping areas prone to forest and land fires by taking into account the components of vulnerability and land

fires considering several aspects such as soil type and rainfall [11]. Similar research defines the parameters that determine the level of fire vulnerability are vegetation cover, slope, accept, distance from road, and distance from settlements [12]. Previously, an analysis of the vulnerability of residential fires was carried out in the Cengkareng sub-district, West Jakarta, where the results of the high zone included Kapuk District, the medium zone included Duri Kosambi, East Cengkareng, Kedaung, Kaliangke, and the low zone included West Cengkareng, Rawa Buaya [13].

From several previous studies, fire analysis only focuses on the vulnerability component and does not consider the components of fire protection, risk management and estimating emergency needs. Meanwhile, the risk of fire is only analyzed in densely populated residential areas, even though Kepulauan Seribu is part of DKI Jakarta. Efforts to map, forecast potential, and mitigation are a global imperative [4], especially if the fire affects vulnerable populations and densely populated areas, it is important to involve the community [5,8].

This indicates the need for a more comprehensive fire analysis including the components of fire protection and risk management. This study analyzes components that were not previously analyzed, fire protection and risk management at the Community Units (CU) level. This research also helps in mapping fire risk based on the smallest units. Making a fire susceptibility map is one of the non-structural mitigation efforts, so that the research area identified by the fire hazard zoning level is used as a reference for risk reduction policies. Besides discovering the risk of fires and mapping the area of Kepulauan Seribu to prevent fires, this research is also expected to integrate a measurable monitoring procedure into public health preparedness plans.

METHODS

Study design and data collection

This study adopted a cross-sectional design approach. Data is collected through two methods. The first method is the Focus Group Discussion (FGD) with the representatives of Jakarta Fire and Rescue Agency (Dinas Penanggulangan Kebakaran dan Penyelamatan Provinsi DKI Jakarta), particularly the Kepulauan Seribu Sector (North Kepulauan Seribu District and South Kepulauan Seribu District). Representing each respective sector, the Sector Heads and Platoon Commanders were interviewed with a list of selected questions consisting of 3 parts, with a total of 22 questions. The other method is collecting the necessary data through the questionnaire to be filled by the Chief of Community Units (*Ketua RW*) representing the research participants: 20 Community Units spread in six sub-districts and two districts. FGDs were also conducted to collect data for all Community Units in the North and South Kepulauan Seribu Districts. The data is collected from 20 CU as the sample. The amount of sample represents the population of 24 CU.

Data analysis

The instrument used in this study uses 3 approaches, namely: hazard, vulnerability, and fire protection risk management with each part having the variables described in Figure 1.

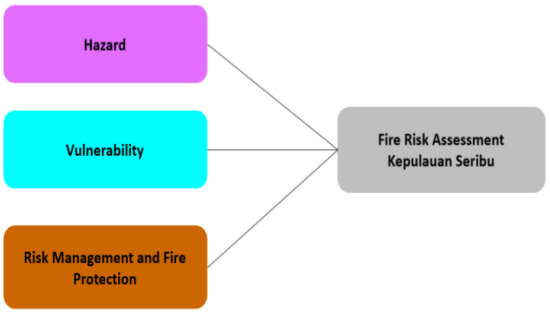

Figure 1. Analysis framework

The overall score of each component obtained according to table 1 will be compared with the maximum number of scores which will result in a percentage of the risk value which is divided into 5 categories, namely <20% with a very light fire classification, 21-40% with a light fire risk classification, 41-60 % with moderate fire classification, 61-80% with severe classification, and >80% with very severe risk classification. This study has been reviewed by the Ethics Committee of The Research and Community Engagement of Faculty of Public Health Universitas Indonesia under ethical approval No. Ket-256/UN2.F10.D11/PPM.00.02/2021.

RESULTS

Figure 2 explains the average score for the category of hazard, vulnerability, and fire protection for each Sub-District based on 20 Community Units (CU). From each CU, CU F got a score of 64%, and CU G got 62.7%, which was categorized as severe fire risk, where the highest category was fire protection. The villages in Untung Jawa Island, Pari Island, and Tidung Island have a moderate fire risk with 56.4%. Harapan Island and Panggang Island have a moderate fire risk with a score of 52.7%.

The CU F, located on Kelapa Island, has a severe fire risk classification. It is caused by a high population density of 418 people per hectare, according to SNI03-1733, 2004 concerning Procedures for Planning for Residential Environments in Urban Areas, whereas population density is correlated to environmental facilities and public utilities. In CU F, the majority of areas are residential zones with a moderate slum category. The wood structure in slum housings is categorized as flammable type IV, with the separation distance between buildings not following the minimum standard, which is less than 3 meters. [14] In addition to population density, CU F has a history of fires in 2020 in residential areas caused by the use of gas stoves, the presence of 3-4 cottage businesses, restaurants, small shops, stalls, and the absence of hydrants. The CU G, located on Kelapa Island, has similar characteristics to CU F. The identification of residents' activities associated with triggering fires are dense settlements with semi-permanent houses, welding workshops, retail gasoline sellers, and water distillation industries. In 2019, two historical fire incidents in CU G were caused by gas stove activities in residential areas and street vendors.

Figure 3 describes the elements that contributed to the fire risk score based on the average of all CU samples in the North and South Kepulauan Seribu Districts. The average value of each variable is between one and five.

Figure 4 and Figure 5 explain mapping fire risk in Kepulauan Seribu Regency. The highest elements that contribute to the increased risk of fire incidents in Kepulauan Seribu Regency are the presence/ absence of the hydrant(s) with a score of 5.0, the feasibility of the Fire Station with a score of 4.5, the response time of the Fire Station with a score of 4.2, and the fire service post with a score of 4 0.0 out of a maximum score of 5.0, followed by distance between buildings, fire fighting operations & availability of water sources, fire post obstacles, and building quality & slum level.

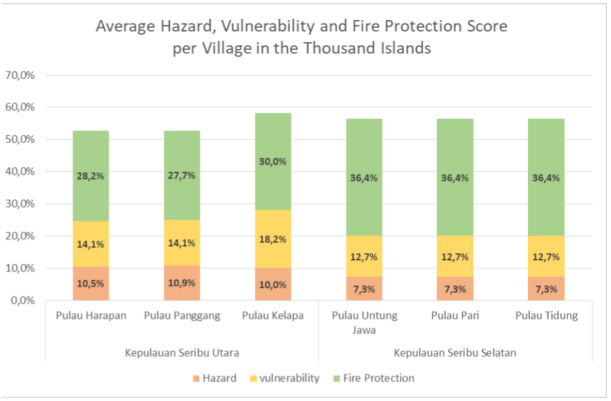

Figure 2. Average hazard, vulnerability, and fire protection score per village in Kepulauan Seribu

DISCUSSION

Fire post response time

The fire department's response time is greatly influenced by the distance between the fire station and the fire area or area. Kepulauan Seribu Regency has its uniqueness due to its archipelago setting, so the distance between the islands and the fire stations might cause a delayed response. Currently, not all inhabited islands in Kepulauan Seribu Regency already have a proper Fire Post. Some residents were participating in Karang Taruna (Community Group).

Figure 6 shows that the distance between Panggang Island, Harapan Island, and Kelapa Island is considerably far, which is about 9.5 kilometers. Untung Jawa Island and Pari Island are about 13-15 kilometers apart. In Pari Island itself, there are two islands separated by a distance of about 7 kilometers. The distance between Tidung Island to Pari Island is about 5-7 kilometers, and to Untung Jawa Island is about 26 kilometers.

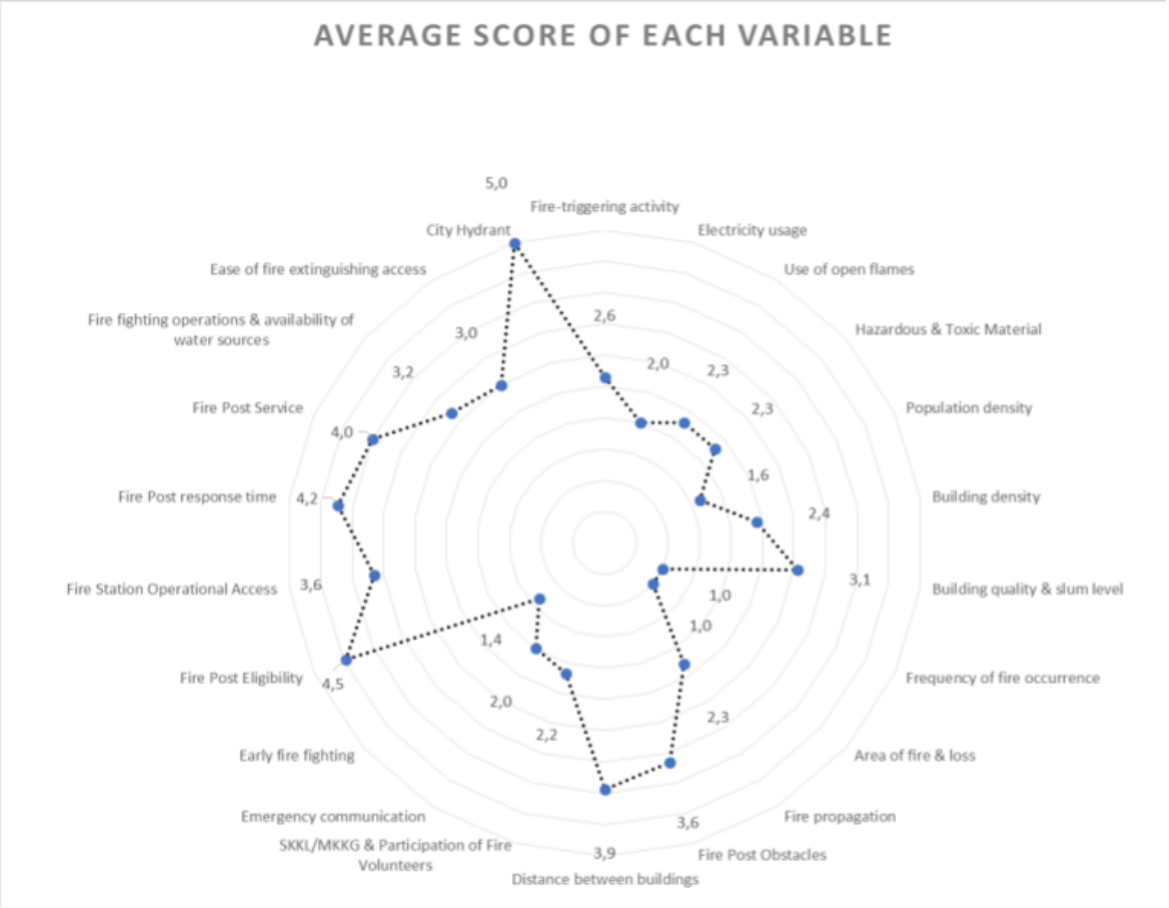

Figure 3. Average score of each variable

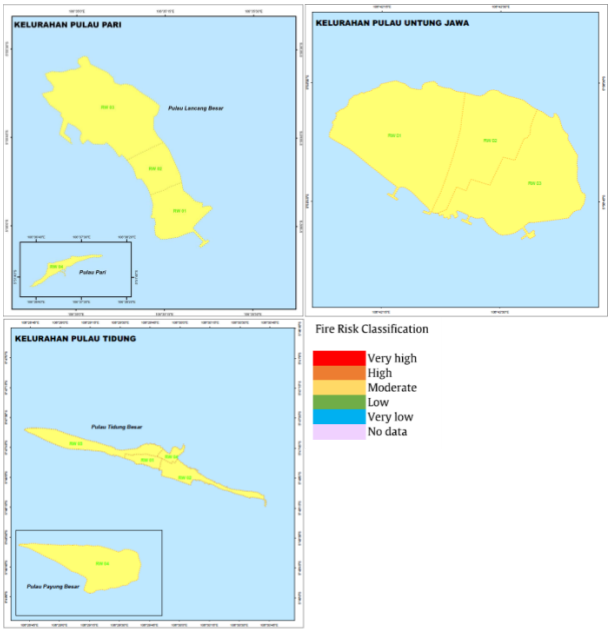

Figure 4. Fire risk mapping in South Kepulauan Seribu District

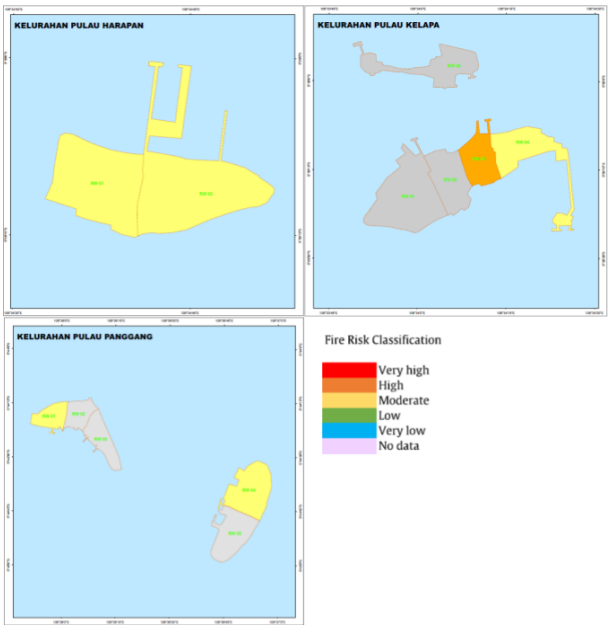

Figure 5. Fire risk mapping in North Kepulauan Seribu District

Response time is the total time starting from the first time the fire warning is received, planning troops and sending infrastructure facilities to the location of the fire until they are ready to extinguish the fire.

Several things that affect the response time are the area that is the responsibility of FMA. It is also

affected by the capacity, awareness, and perception of response time, including the time when fire notification is received, interpretation and details of the fire location for 5 minutes, travel time from the fire station to the fire location for 5 minutes, time to prepare extinguishing equipment and ready to extinguish for 5 minutes [7]. All of these variables are equally important and are not listed in order of priority.

Eligibility of fire stations and infrastructure

Based on the Ministry of Public Works Regulation No. 20 of 2009 concerning Technical Guidelines for Fire Protection Management in Urban, Fire Stations in a Fire Management Area (FMA) is required to adjust the response time to accommodate all areas in the area of responsibility [15]. Based on the FGD of UC I results in South Kepulauan Seribu District, the Fire Brigade Post is inadequate in terms of capacity, so they cannot rest. The post did not have any public toilet available, so firefighters needed to go to other facilities (Karang Taruna). The guard time at the Fire Station is 3x24 hours with shifts of 3 working days and five days off with 7-8 personnel per post. Meanwhile, the operational team has developed a Fire Management Area (FMA) where the aim is to be faster in providing services to the community. Each FMA is headed by a sector section head responsible for one sub-district, and the sector office has four fire fighting units. FMA also oversees four fire stations that have 1-2 units of fire engines [16].

Compared to the fire department report in England in 2018-2019, the average response time by firefighters was 8 minutes 49 seconds, an increase of 11 seconds from 2017-2018 for primary fires. While secondary fires are about 9 minutes 42 seconds {17].

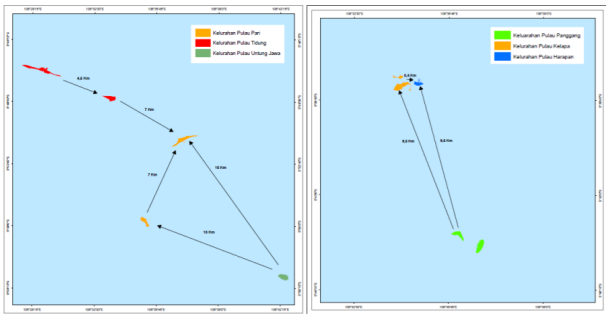

Figure 6. The distance between island (left) in the South Kepulauan Seribu District; (right) North Kepulauan Seribu District

The response time of the Fire Service impacts the amount of damage. Research that has been conducted in New Zealand, the percentage of building fires rose by about 10% when emergency calls were also declined, delayed, or late [18]. Response time to fires is often delayed, and the existing emergency system cannot meet the needs of immediate extinguishing [19].

CONCLUSION

This study concludes that both areas consisting of six urban villages and twenty CU showed that the locations with the highest risk of fire incident were located at Kelapa Island at the high level. In comparison, the other five villages had moderate risk. The most influential aspect at the high level of fire risk in the Kepulauan Seribu Regency was the dimensions of risk management and fire protection. It is recommended that Fire Station(s) in every inhabited island in the North and South Kepulauan Seribu Districts, such as Pari Island, Lancang Island, Untung Jawa Island, Payung Island, and other inhabited islands. It is also recommended to equip firefighting infrastructures such as rescue boats, portable pumps, independent hydrants and dry hydrants, fireboats for rescue purposes, and vehicles for fire patrols.

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