Fire Disaster Mitigation in Dense Settlements in Batu Merah Country

Hertine Megiestri Kesaulya[1]*, Resky Prafitri[2]
[1,2] Urban and Regional Planning Study Program, Universitas Pattimura Ambon

Email: hertkesaulya@gmail.com

Abstract

Fire is a disaster that cannot be predicted when and where it will occur. Many fire disasters occur in dense settlements, so dense settlements become vulnerable to the danger of fire disasters. Negeri Batu Merah is one of the densely populated settlements located near the central area of Ambon City. This dense residential condition has resulted in settlements in Batu Merah Country becoming areas that are potentially vulnerable to fire disasters. This research aims to determine the distribution of fire disaster vulnerability levels in dense settlements in Batu Merah State. Apart from that, this research also aims to provide recommendations for reducing the level of fire vulnerability in the study area. The analytical methods used in this research are spatial analysis, appreciation analysis and descriptive analysis. Based on the results of the vulnerability analysis in the study area, the level of fire vulnerability is divided into three, namely low, high and very high levels of vulnerability. Interventions to reduce the level of fire vulnerability can be carried out by mitigating efforts both structurally and non-structurally by adding fire extinguishing facilities, widening residential roads, and widening roads in the Batu Merah settlements.

Keywords: *Vulnerability, Fire, Dense Settlements*

– – – – – – – – – – ◆ – – – – – – – – – –

INTRODUCTION

Fire is the process of burning something that can cause danger or cause a disaster (Rohmadiani, 2019). Based on the cause, fire disasters are not only caused by natural factors, but are influenced by human activity factors. Residential fires have special characteristics compared to other disasters. Huang (2009), believes that one of the most detrimental fire incidents is fires in residential areas in urban areas. Residential fires do not cause more casualties than earthquakes, tsunamis and other disasters, but the material losses caused by residential fires are quite large.

The danger of fire is a danger with a high potential for occurrence which is always related to the conditions, behavior and culture of the community. Fires in urban areas are more often caused by human factors (*human error), either from direct* fire sources or human activities that can indirectly cause fire . This is supported by research by Kai Huang (2009) which states that human behavior is the highest cause of fires in residential areas . Another cause of the high risk of fire in dense residential areas is the density of residential buildings and the lack of distance from each building. Residential conditions that are densely built can cause the fire to spread more quickly when a fire disaster occurs.

The emergence of dense settlements is caused by a large increase in urban growth, so that population growth increases and the number of settlements also increases. The increasing demand for land for residence can increase the sense of competition so that settlement patterns are formed that have a high level of density both in terms of population and building density. This condition also occurs in Batu Merah Country , due to limited land, which is further exacerbated by uncontrolled urbanization, resulting in pockets of new slum and illegal settlements emerging in the Batu Merah Area which is one of the main buffer areas for the economic center in Ambon City. The need for land to live on causes people to be forced to occupy areas that are prone to fire disasters as residential areas , so that the chance of fire disasters occurring in residential areas in Batu Merah Country becomes greater.

One of the efforts made to overcome disasters is mitigation measures for fire disasters. Mitigation efforts can be carried out to reduce the risks and impacts caused by disasters on communities in disaster-prone areas. Fire prevention needs to be done to reduce losses, especially material losses caused. One of the fire prevention efforts is to carry out a fire vulnerability analysis. Analysis of residential fire vulnerability can produce information that is useful for fire prevention purposes. Settlements that are prone to fire are characterized by the condition of their settlements, including dense areas, with irregular residential building patterns, narrow entrances, and the building materials are in the non-permanent category so they are somewhat flammable, locations with water sources and unavailability of fire extinguishing facilities (Somantri, 2011).

This research is important to carry out, because fire disasters that can occur at any time can be prevented by knowing the vulnerability of fire disasters in the area. By knowing the distribution and level of vulnerability to residential fires in the study area, we can find out what mitigation efforts can be taken to overcome the occurrence of fires and losses arising from fire disasters in residential areas. Mitigation planning according to Moga (2002), is seen as a strategy development to reduce the impact of disasters on communities, facilities, regions, cities or countries. Mitigation planning can be grouped into many categories but is generally grouped into physical and non-physical mitigation (Moga, 2002). Protection against disaster threats can be achieved by eliminating the causes of the threat to reduce the danger or by reducing the effects of the threat if the threat occurs (Coburn et al., 1994) .
The aim of this research is to determine the distribution of fire disaster vulnerability levels in dense settlements in Batu Merah State. Apart from that, this research also aims to provide recommendations for reducing the level of fire vulnerability in the study area. The scope of the research area is Batu Merah Country, so that the research results obtained are more detailed, the research will focus on RW 03 (RT 01, RT 02 and RT 03) and RW 04 (RT 01, RT 02 and RT 03).

METHOD

To achieve research objectives, analytical methods are needed to manage and organize data into information formulations that can answer the problems encountered. In this research, there are three analyzes that will be carried out using different analytical methods , namely spatial analysis, appreciation analysis, and descriptive analysis. Sapatial analysis was carried out to map residential fire vulnerability. The residential fire vulnerability map is obtained from the overlay process of each variable determining the level of vulnerability. Before overlaying, a score is first assigned to each variable determining vulnerability. At this stage, an assessment analysis is carried out. After obtaining the distribution of vulnerabilities, descriptive analysis is then used to determine efforts to reduce vulnerabilities. The following are the determining parameters for residential fire vulnerability which are presented in table 1.

Table 1. Residential Fire Vulnerability Parameters

Parameter	Information	Score
Building Density	Housing density in the unit settlement <40% (seldom)	1
	Density House on units settlements 40%-60% (currently)	2
	Density House on units settlement >60% (congested)	3
Mukim House Building Pattern	>60% of buildings parallel settlements with roads and form House relatively uniform	1
	40% - 60% building parallel to the road and the shape of the house rather uniform	2
	<40 % of buildings parallel to the road and the shape of the house No uniform	3
Types of Building Materials	>75% building made from materials that are not easy burnt (permanent)	1
	50-75% building made from materials that are not easy burn (semi permanent)	2
	<50% building made from materials that are not easy burn (non-permanent)	3
Entryway Width	Road width >6 meters, or with assumption can passed fire trucks big with freely	1

Parameter	Information	Score
	The road width is 3-6 meters, or with assumption can passed fire trucks small	2
	Road width <3 meters, or with assumptions cannot be made passed fire trucks small	3
Distance of Settlement Location from Water Source	<500 m, assuming time Which needed from water source to the location fire (fast)	1
	500-2000 m, assumed time Which needed from sourcewater to the location of the assumed time of fire (currently)	2
	>2000 m, that isneeded from the water source to location fire (Far)	3
Fire Extinguishing Facilities (Hydrant, APAR and APAB)	There are fire extinguishing facilities, > 75% within < 500m	1
	There are fire extinguishing facilities, 50%-75% are < 500m and between 500m-1,000m	2
	There are no or no fire extinguishing facilities, <40% are < 500m and between 500m-1,000m	3
Distance of Settlement from Fire Department	Distance < 1,500 meters	1
	Distance between 1,500 – 3000 meters	2
	Distance > 3,000 meters	3

Source: Somantri (2011), (Anwar & , 2019) with changes

Scoring is carried out on each parameter, a score of 1 is given for parameters that are considered to have a lower influence on vulnerability and a score of 3 is given for parameters that are considered to have a higher influence on vulnerability, in accordance with the vulnerability classification in table 1. The classification of vulnerability levels is divided into 5 categories, namely very lace, lace, medium, high, and very high, as shown in table 2.

Table 2. Fire Vulnerability Categories

No	Vulnerability Level	Score
1	Very low	9-7
2	Low	12-10
3	Currently	15-13

4	Tall	18-16
5	Very high	21-19

RESULTS AND DISCUSSION

Residential fire vulnerability is influenced by factors such as building density, residential building patterns, types of building materials, width of driveways, fire extinguishing facilities and other determining factors.

1. Conditions of Dense Settlements in Batu Merah State

Dense settlements in Batu Merah Country will reduce the quality of the residential environment and are also vulnerable to fire disasters. Settlement conditions in Batu Merah Country are very diverse, but in general the building density in Batu Merah Country has a high building density with distances between houses ≤ 1 m – 2m, and is dominated by semi-permanent buildings.

Figure 1. Condition of residential buildings
Source: Observation Results, 2023

In general, settlements in Batu Merah Country have driveways and neighborhood roads 1-2 meters wide, which can only be passed by motorized vehicles and pedestrians. Apart from that, the hilly topography of Batu Merah Country means that some settlements are located in hilly areas, making it difficult for fire trucks to reach them. However, there are several houses located in front of the main road that can be served by fire engines.

Figure 2. Condition of residential entrance roads
Source: Observation Results, 2023

In assessing the level of fire vulnerability in residential areas, the aspect of water availability is also important for extinguishing fires. Water for fire fighting can be obtained from various water sources. In Batu Merah Country, especially in RT 03 and RW 04, the most widely used source of clean water is PDAM. Other water sources in the study area are wells and water storage tanks which are supplied to several houses. However, it is not yet known for certain what the average volume of water is.

Figure 3. Clean Water Sources
Source: Observation Results, 2023

The existence of dense settlements in this study area will be a problem so that the vulnerability of settlements to fires will increase. Apart from that, the unavailability of fire extinguishing facilities such as hydrants, APAR and APAB makes them more vulnerable to the threat of fire.

2. Vulnerability of residential fire disasters in Batu Merah Country

Research in the study area focused on RW 03 (RT 01, RT 02 and RT 03) and RW004 (RT 01, RT 02 and RT 03). Each study area has a different level of vulnerability

according to the results of the scores obtained for its classification. Table 3 shows the scores obtained for the parameters used in each RT in RW 03.

Table 3. RW 03 Score Calculation Results

No.	Parameter	Score		
		RT 01	RT 02	RT 03
1	Building Density	2	2	2
2	Mukim House Building Pattern	3	3	3
3	Types of Building Materials	2	2	2
4	Entryway Width	3	3	3
5	Distance of Settlement Location from Water Source	1	1	1
6	Fire Extinguishing Facilities (Hydrant, APAR and APAB)	3	3	3
7	Distance of Settlement from Fire Department	2	2	2
Total Score		16	16	16

Based on observations in the study area and analysis results, RW 03 is included in the high vulnerability classification with a final score of 16. The parameters that most influence the high level of vulnerability for each RT are the residential building pattern parameters and the unavailability of fire extinguishing facilities in the study area, such as hydrants. , APAR and APAR. Apart from that, it is also related to the width of the driveway, in general the width of the driveway to the settlement and the road in the settlement is <1m – 2m which makes it impossible for cars to enter the settlement. Areas that are prone to fire disasters are areas that have a very high to moderate level of vulnerability. The same observations and analyzes were also carried out at RW 04 RT 01, RT 02 and RT 03) and RW004 (RT 01, RT 02 and RT 03). Table 4 shows the scores obtained for the parameters used.

Table 4. RW 04 Score Calculation Results

No.	Parameter	Score		
		RT 01	RT 02	RT 03
1	Building Density	3	3	2
2	Mukim House Building Pattern	3	3	3
3	Types of Building Materials	2	2	1
4	Entryway Width	3	3	3
5	Distance of Settlement Location from Water Source	1	1	1
6	Fire Extinguishing Facilities (Hydrant, APAR and APAB)	3	3	3
7	Distance of Settlement from Fire Department	2	2	2

Total Score	17	17	15

Based on the results of the analysis carried out in the RW 04 study area, it shows that RT 01 and RT 02 both have a vulnerability score of 17, while the Vulnerability Score for RT 03 is 15. The results of observations and analysis carried out at this study location show that the score is high. obtained in RT 01 and RT 03 obtained from an assessment of the parameters of building density, residential building patterns, road width and also the unavailability of fire extinguishing facilities. dense residential conditions and narrow road access have an impact on the high vulnerability of fires in these settlements. Fire fighting facilities such as hydrants and APARs are also not available in the two RWs.

Table 5. Classification of Residential Fire Vulnerability Levels

Location		Score	Classification	Area (Ha)
RW 03	RT 01	16	Tall	0.779
	RT 02	16	Tall	0.502
	RT 03	16	Tall	0.644
RW 04	RT 01	17	Tall	0.417
	RT 02	17	Tall	0.654
	RT 03	15	Currently	1,149

Table 3 and table 4 show the calculations and results for all blocks in the research location. The resulting scores are then classified based on the scores obtained when calculating each parameter. The classification of vulnerability levels in this study is categorized into 5, namely very low, low, medium, high and very high.

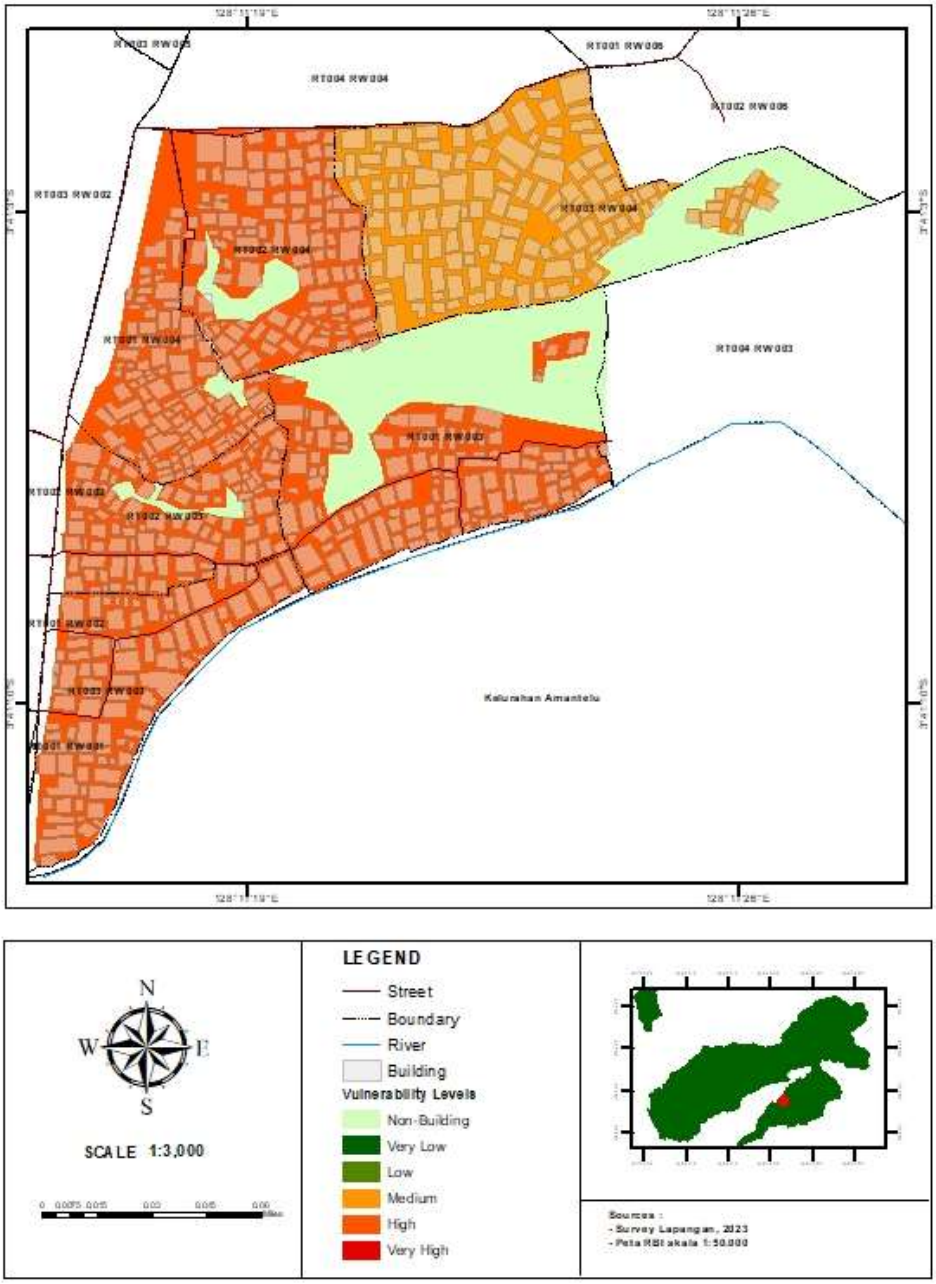

Figure 4. Residential Fire Disaster Vulnerability Map

The area with a high level of vulnerability classification is 2.99 Ha, while for moderate vulnerability in RW04 RT03 the area is 1.149, which can be seen in table 5. Based on this analysis, it is known that the average level of vulnerability at the study location is high vulnerability.

3. Fire Disaster Mitigation Efforts

Mitigation efforts that can be made to reduce the level of vulnerability are by increasing the capacity aspect. The fire prevention scenario as a mitigation effort can be carried out by intervention by including capacity variables. Action is needed on the

potential capacity variable so that it can be used in fire fighting efforts (Sagala, 2013). Based on the results of the analysis in the previous discussion, there are several parameters that have high scores. For this reason, parameters that have high scores require intervention to reduce the level of vulnerability in the study area. Mitigation carried out to reduce the level of vulnerability is structural and non-structural mitigation. So it can be concluded that mitigation efforts by optimizing potential capacity can be the main alternative for overcoming fire dangers in high density areas.

Regarding the parameters of building density and irregular settlement patterns, it really influences the level of vulnerability, because the assumption is that increasingly dense and irregular settlements result in no distance between buildings. This condition further accelerates the spread of fire if a fire occurs. Intervention by reducing the level of building density is difficult to implement because it has the potential to create conflicts of interest regarding the area where the reduction will be carried out. Based on the results of the analysis in table 3 and table 4, the most feasible intervention is on the parameters of the type of building material by changing the building material to fire-resistant material. Apart from that, it is also related to road width parameters, road widening can be carried out on environmental roads in several locations where it is possible to widen roads up to 3-4 meters.

Fire fighting facilities, based on observations at the study location, there are no fire fighting facilities such as APAR and APAB hydrants. It is necessary to provide hydrants, APAR, APAB and fire alarms, especially for fire triggers. Installing a smoke detector alarm is an easy and effective way to provide early warning against fire (Duncanson et al, 2012). Apart from fire alarms, designing the location of fire hydrants requires further identification of the distribution pipe network, apart from that, further analysis is also needed for water availability, as well as the availability of water sources and water discharge requirements to support the use of hydrants so as not to disrupt commercial water needs in residential areas. Regarding the location of the water source, it is necessary to provide a reservoir to accommodate water.

The intervention carried out can reduce the level of vulnerability as can be seen in Figure 5. At the study location in RW 04, after the intervention was carried out, the level of vulnerability in RT 01 and RT 02 fell to medium, while the level of vulnerability in RT 03 became low. Furthermore, in RW 03 all RTs from high vulnerability level dropped to low. Based on the results of the analysis, mitigation actions provide a significant impact on the study area. This impact can be seen from the reduction in the level of vulnerability in each RT in the study area.

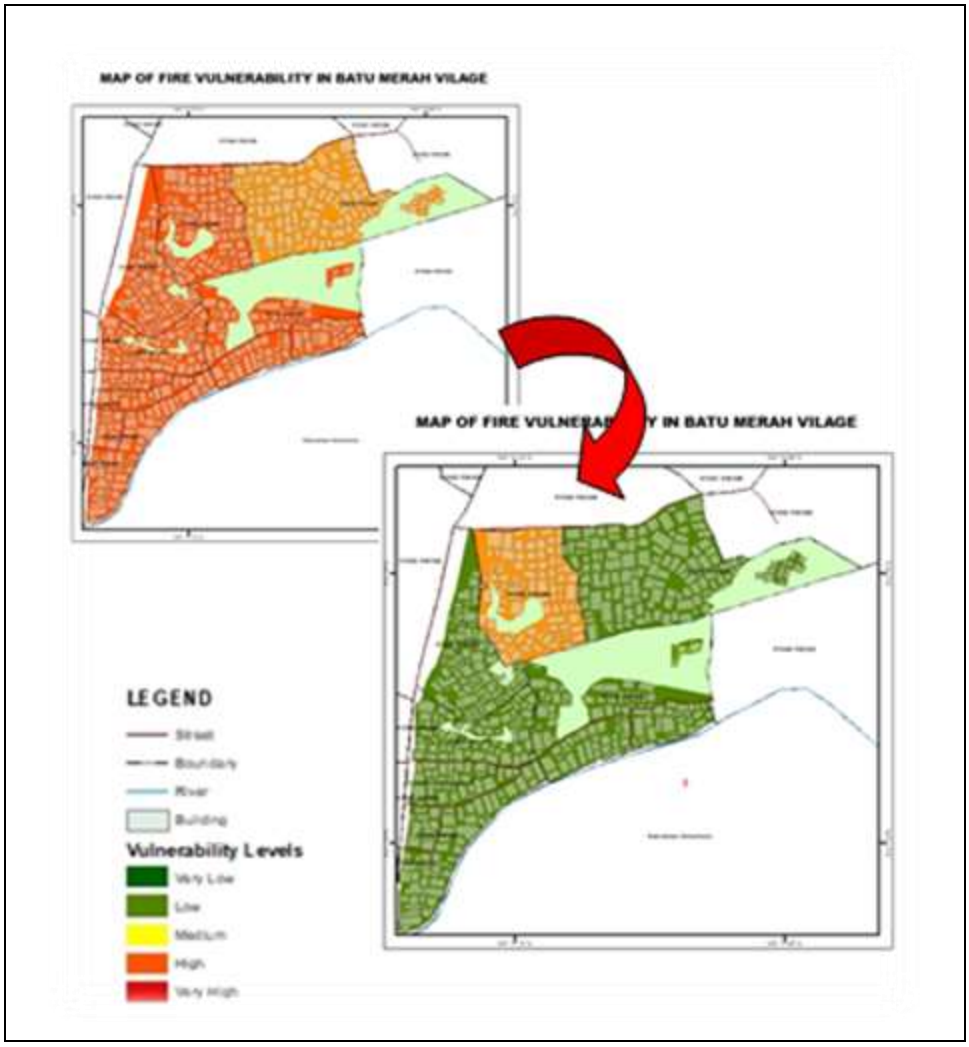

Figure 5. Comparison of vulnerability levels after intervention

Structural or physical mitigation measures are a form of mitigation planning that can be implemented in areas that have moderate to high potential and vulnerability. Apart from water sources and road width, the provision of evacuation routes that can be used when a disaster occurs needs to be planned. Apart from structural mitigation, other non-structural mitigation efforts that can be carried out relate to providing evacuation routes, widening roads, water sources and fire fighting facilities, namely as follows.

- Providing evacuation route maps that can be accessed by the community and carrying out outreach activities for the community about evacuation routes that have been installed in areas prone to fire disasters.
- Provide training for the community on how to extinguish fires and use fire extinguishing facilities such as hydrants and other facilities that are available in settlements.
- Preparation of community members in the evacuation process and first aid in case of accidents.

- Optimizing potential capacities such as water sources and road widths will be input into content in future RDTR and RTBL because these documents are physical planning documents that serve as a reference for physical development.

CONCLUSION

The research carried out produced the level of fire vulnerability of residential areas in Batu Merah State, namely in RW03 (RT 01, RT 02, RT 03) and RW 04 (RT 01, RT 02, RT 03). Based on the results of the analysis, the level of vulnerability to residential fire disasters in the study area is high vulnerability and medium vulnerability. Furthermore, this research also carried out an analysis of mitigation efforts that could be carried out to reduce the level of fire vulnerability in residential areas. The mitigation efforts carried out are increasing the capacity of existing vulnerabilities. For this reason, parameters that have a high score need to take intervention measures to reduce the level of vulnerability in the parameters of type of building materials, road width and fire fighting facilities. Non-structural mitigation that can be carried out is in the form of outreach and training for the community in using fire extinguishing facilities and rescue measures when a disaster occurs by utilizing existing evacuation routes. Apart from that, optimizing potential capacity such as water sources and road width to become content input in RDTR and RTBL.

REFERENCES

Anwar, Y., & -, L. (2019). Kerentanan Kebakaran Permukiman Padat Di Kelurahan Sidodamai Kecamatan Samarinda Ilir Kota Samarinda. *Jurnal Azimut*, *2*(2), 121. https://doi.org/10.31317/jaz.v2i2.483

Coburn, A. ., Spence, R. J. ., & Pomonis, A. (1994). Mitigasi bencana II. Program Pelatihan Manajemen Bencana. *Program Pelatihan Manajemen Bencana. UNDP.," Cambrid Architectural Research Limited.United Kingdom*.

Duncanson, M., Woodward, M. and Reid, P., 2002. Socioeconomic deprivation and fatal unintentional domestic fire incidents in New Zealand 1993–1998. Fire Safety Journal, 37: 165–179.

Huang, K., 2009. Population and Building Factors That Impact Residential Fire Rates in Large U.S Cities, *Texas State University-San Marcos*, Texas.

Moga, J., 2002. Disaster Mitigation Planning: The Growth of Local Partnership For Disaster Reduction. , *Regional Workshop on Best Practise in Disaster Mitigation*.

Rohmadiani, L.D., & Kawara, R.A (2019). Tingkat Risiko Kawasan Rawan Kebakaran Sebagai Upaya Pencegahan dan Penanggulangan Kebakaran. Waktu: Jurnal Teknik Unipa, 17(1), 32-44

Sagala, S., Adhitama, P., & Sianturi, D. G. (2013). Analisis Upaya Pencegahan Bencana Kebakaran di Permukiman Padat Perkotaan Kota Bandung, Studi Kasus Kelurahan Sukahaji. *Resilience Development Initiative (RDI)*, *3*(3), 5–18.

Somantri, Lili (2011), Pemanfaatan Citra Quick Bird dan Sistem Informasi Geografis untuk Zonasi Kerentanan Bahaya Kebakaran Permukiman Kasus Di Kota Bandung Bagian Barat, Gea, Vol. 11, No.1