JAMBA-1123-R2 Transportation Infrastructure Planning In Supporting Disaster Mitigation: Case Study in Mount Gamalama

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TRANSPORTATION INFRASTRUCTURE PLANNING IN SUPPORTING DISASTER MITIGATION: CASE STUDY IN MOUNT GAMALAMA

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Abstrak

Effective mitigation planning is needed for communities living in areas prone to disasters, including disasters caused by volcanic eruptions. Ternate city is disaster-prone area because there is an active mountain and is passed by the pacific ring of fire. This area includes vulnerable zone so it is important to make mitigation plan to assist the community in evacuating and reducing impacts that occur. Survey method was carried out in Ternate city, which is located close to mount gamalama to obtain data in the form of facilities and infrastructure for land transportation, sea transportation and road network observations. The research aims to formulate disaster mitigation measures for the eruption of Mount Gamalama to reduce disaster victims and identify plans for evacuation routes in disaster-prone areas. The analysis technique uses vissim program to obtain transportation modeling program in analyzing existing and forecasting traffic conditions. Results showed that the road network performance of Ternate city which has roads that can be used for evacuation routes for victims because it has good road performance. In the event of volcanic eruption, to reduce the number of victims, socialization of disaster mitigation to community and installation of disaster information signs is complemented by preparing evacuation routes in the form of evacuation gathering points and final evacuation points. Novelty produced in this study is recommended to the local government to be implemented so as to be able to assist the community in dealing with potential disasters and to reduce the impact.

Keywords: mitigation, disaster prone, mount gamalama, pacific ring of fire, transportation infrastructure

Introduction

Indonesia is one of the most disaster-prone countries in the world (Fernalia et al., 2020). Ternate city is one of the regions in Indonesia which is prone to disasters because it is in the interaction of three major plates in the world, namely Eurasia, Australian Indies and Pacific, and is passed by pacific ring of fire. Mount Gamalama with an altitude of 1715 meters above sea level is one of the active volcanoes that often results in eruptions, lava flows and volcanic ash. This mountain experienced an increase in activity in 2011, recorded 67 activities followed by an eruption and the last time in 2016 which caused fatalities and severe damage to residential areas with 35 people dead, 72 seriously injured, 120 lightly injured, 82 units houses were severely damaged and 110 housing units were slightly damaged. The number of fatalities and damage is due to the absence of an integrated evacuation route for disaster victims, delays in evacuation process and providing information to community, and the utilization of transportation function in the evacuation process of disaster victims.

Ternate city is gateway to North Maluku, a center for economic growth and regional development that requires coordinated and integrated planning. Therefore it is necessary to take strategic steps to protect residents from the threat of the natural disaster for the eruption of Mount Gamalama. Based on the Ternate Regional Regulation number 02 of 2012 concerning the spatial plan for Ternate region, which is related to strategies for improving quality and coverage of transportation, telecommunication, electricity and water resources infrastructure services that are integrated and evenly distributed on the islands in Ternate region which contain among others to develop disaster evacuation routes in disaster prone areas. Therefore it is necessary to study the planning of evacuation routes for victims of Mount Gamalama disaster by determining points, integrated rescue route for the evacuation of victims, the utilization of transportation facilities and infrastructure functions. The purpose of this study is to formulate a direction for disaster mitigation measures for the eruption of Mount Gamalama as effort to reduce disaster victims and identify evacuation route planning in disaster-prone areas due to the eruption of Mount Gamalama.

Literature Review

Managing disasters involves ideal dynamic process (Pratama & Nurmandi, 2020). Disasters occur as result of nature's efforts to restore the balance of ecosystems that are disturbed by natural processes themselves or due to human activity in exploiting natural resources (Tondobala, 2011). The mitigation paradigm (Tao & Run-qiu, 2017), was previously responsive or emergency response in dealing with disaster, is now being transformed into preventive activity so that risks can be minimized (Faturahman, 2019). Disasters can be caused by natural disasters or man-made disasters. Volcanoes are cranial holes or cracks in the earth's crust where magma, gas or other liquids come out onto the earth's surface. Determination of the volcanic eruption hazard index is made by referring to guidelines issued by volcanology and geological disaster mitigation center using the method of weighting the volcanic disaster-prone zone (KRB). Each KRB zone (zone I, II, and III) consists of flow zone and a fall zone which is given different weight values based on the level of vulnerability. Another danger caused by increased volcanic activity is the danger of cold lava. Hot cloud is mass flow of gas and ash during volcanic eruptions. Its glide speed is around 90 km/hour with temperature of about 350 degrees Celsius with a sliding distance of 8-12 km, the direction of slide generally follows the flow of valley or river that starts at the center of eruption. Apart from the heat that can burn anything in its path, its mass also has ability to destroy large objects. The mass of clouds places volcanoes in their own type of eruption. Volcano experts classify the types of eruptions in order to anticipate dangers that can be caused. Volcanic hot clouds can result from avalanches or falling lava domes or eruptions. Avalanche hot clouds occur due to landslides part of the incandescent lava dome due to magma pushing on the dome under construction. The eruption of Mount Gamalama itself is an eruption that has volcanic type. This eruption occurs when during the eruption process, lava which is thick enough to cool suddenly. The main characteristic of this type of eruption is high level of fragmentation with a wide spread of tephra in the form of gas, thick ash and pumice. Volcanic ash usually leads to residential areas in Central Ternate District and South Ternate District so residents in these areas must be careful and alert to the eruption of Mount Gamalama that can occur at any time.

Disaster Management

Basically, disaster management is series of activities carried out in the context of prevention, preparedness mitigation, emergency response, and recovery related to disasters with the aim of reducing losses and risks that may occur and accelerating the recovery process after disaster occurs (Tictona et al., 2020). The cycle begins with a prepardness phase or disaster preparation phase as effort to minimize the impact of impending disaster, namely a program to reduce the impact of disaster on society or community. Information has very important role in disaster management. Disaster mitigation is first step in disaster management with the aim of reducing disaster risk and reducing the greater impact of natural disasters (Faturahman, 2019). Speed of information can be collected, analyzed and distributed by parties concerned and will produce an effective response so that more lives can be saved. During a crisis, humanitarian agencies need information relating to the conditions of disaster, people affected by disaster and availability of resources. However, gathering information can be very difficult due to the lack of access to affected areas due to damaged infrastructure and in some cases the remoteness of affected areas. Responses to major disasters generally require the involvement of many parties, both national and international. Preparedness is an urgent effort needed to reduce the impact of natural disasters which is the responsibility of government and society and reaches all levels of society without exception (Fernalia et al., 2020). The high intensity and complexity of disasters require efforts for disaster management systematically (Saputri et al., 2019).

Disaster mitigation

Disaster mitigation includes planning and implementing actions to reduce risks associated with known disaster hazards and planning processes for effective response to real-time disasters. Term mitigation applies to a wide range of protective activities and measures that may range from physical, such as building stronger structures, to procedural ones such as standardized techniques for incorporating hazard assessments into land use plans. Furthermore, urban disaster mitigation is step that really needs to be done as main starting point of disaster management. In accordance with its main objective, reducing, eliminating victims and losses that may arise, it is

necessary to provide it at the stage before disaster occurs, especially taming or suppression activities known as mitigation. Mitigation is carried out to minimize, reduce and soften the impact of disasters. Therefore, the city government has very strategic role and function in carrying out development in all fields, which aims to increase the role of the city as regional growth center, development driver, service center in all fields, information and innovation center, including in matters disaster mitigation technology. However, the large concentration of roles in these cities cannot be separated from the fact that cities in Indonesia are located in locations that are prone to natural disasters. Cities in Indonesia are very heterogeneous, and their pluralistic social and economic systems leave Indonesian cities at the same time prone to social, technological, or other man-made disasters. In general, mitigation can be classified into structural mitigation and non-structural mitigation. The weaknesses faced in managing temporary shelters for disaster victims are limited human resources and limited budget (Lakosa & Alhadi, 2019). Structural mitigation is related to physical construction development efforts, while non-structural mitigation includes, among others, land use planning that is adjusted to the vulnerability of area and enforcing development law enforcement.

Term evacuation is the movement of people from their place of residence due to security disturbances or population displacement due to natural disasters or security disturbances. Choosing the right evacuation route, choosing an evacuation location that meets the requirements will greatly help reduce losses and save human lives (Atmodjo et al., 2015). Evacuation of people on large scale is very complex task and depends on efficient use of transport system, and effective evacuation schemes (Sahroli & Hardiansyah, 2019). Temporary evacuation sites are generally in building condition that does not get enough attention by local government which makes them look dirty and unkempt (Lakosa & Alhadi, 2019). The cause of evacuation is due to natural disasters such as floods or volcanic eruptions, or man-made consequences, such as a bomb in building, fire on train in a tunnel or industrial accident and also war. During the evacuation people or victims usually wait for help.

Methodology

This research was conducted in Ternate city, which is one of the disaster-prone areas in Indonesia. Ternate is in the interaction of three world plates, namely Eurasia, Indies Australia, and the Pacific as well as the area through which pacific ring of fire passes. Mount Gamalama is one that is still active and can produce eruptions, lava flows and volcanic ash on regular basis. To reduce the number of disaster victims and increase public knowledge to be more alert in dealing with disasters, it is necessary to plan for evacuation route of Mount Gamalama Victims. Data collection is divided into two, primary data collection and secondary data. Primary data is data obtained from field survey process, land transportation infrastructure and facilities inventory surveys, marine transportation facilities and infrastructure inventory surveys, and road network observations. Meanwhile, secondary data is data obtained from related agencies such as KRB maps, road network maps and maps of the study area, which are obtained from the public works department and regional disaster management agencies in Ternate city.

Data processing used includes O/D matrix, road network maps, as well as transportation facilities and infrastructure. Processing data is using vissim software. Vissim is transportation modeling program to analyze existing traffic conditions, and forecasting. Data that has been collected is then codified, structured, and shaped according to predetermined format. Vissim is software for microscopic traffic simulation (Yulianto & Munawar, 2017). Vissim is able to present simulation with various types and characteristics of daily used vehicles, including vehicles, public transport, cycles, and pedestrians. Processing of final result by determining the points using several alternative points, the use of transportation modes, determining evacuation route, selecting the most effective evacuation route, installing information signs, and providing outreach to the community requires some analysis of the methods used.

Object of this research is Ternate city, consists of North Ternate which includes 14 subdistricts, Central Ternate includes 15 sub-districts, South Ternate cover 17 sub-districts, Ternate island cover 13 sub-districts. In general, data are needed based on the objectives of problem topic so that data can be used effectively, efficiently and appropriately. Secondary data is summary of data to support analysis process, for example a map of the road network, population, type of crater, and wind direction. Primary data in this research is data from

questionnaires that originate from respondents. Primary data collection was carried out by direct field observation through several types of surveys. The surveys carried out included inventory survey of land and sea transportation infrastructure facilities to determine the availability of facilities and conditions of land and sea transportation facilities and infrastructure in the evacuation process of Mount Gamalama disaster victims, and observations of evacuation sites themselves in order to identify areas that could be used for shelter and to determine the point of gathering by considering land conditions.

Result and discussions

Ternate city is characterized as archipelagic city with an overall road length of 363.9 km, consisting of 44.13 provincial roads and 319.77 km city roads. The characteristics of roads in Ternate area are dominated by roads with type 2/2 that are not divided, with intersection types without signals and priority. Judging from its characteristics, Ternate city has combination of grid and radial road network patterns, where as whole Ternate city has radial or circular road network pattern following the contours of land because it surrounds the island and at the city center has grid road network pattern with many intersections. The road grouping according to their status is divided into three, primary collector roads with road lengths of 44.13 km, secondary collector roads with road lengths of 20.47 km, and local roads with road lengths of 11.49 km.

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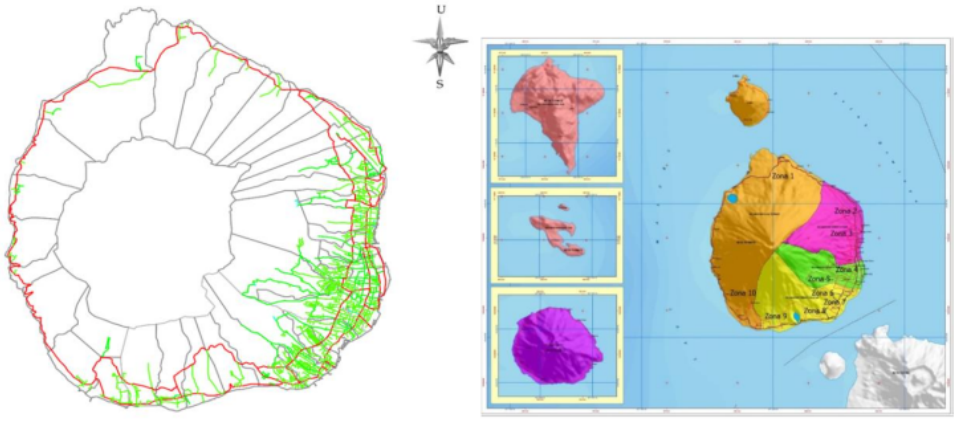

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205 **Figure 1.** Map of road network and zone of Ternate city

The condition of disaster-prone zone consists of 3 KRB zones. KRB-I is area that is potentially affected by lava flows and may be exposed to expansion of hot clouds and lava flows. This area is also potentially exposed to heavy ash rain with radius of 3.5 km from the center of eruption. In KRB I, community needs to be vigilant in the event of eruption Mount Gamalama or heavy rain, by paying attention to the development of Mount Gamalama activities as stated by volcanology and geological disaster mitigation center. KRB-II is area that has potential to be affected by hot clouds, ejection and avalanches of incandescent rock and lava flows, especially around the upper slopes of the north, northwest and southwest sides. This area is also potentially threatened by throwing incandescent rocks with a size of 2-6 cm, as well as heavy ash rain with a radius of 2.5 km from the center of eruption. KRB-III is area that has potential to be affected by hot clouds, ejection and avalanches of incandescent rock and lava flows and toxic gases, especially around peaks and northern slopes. This area is also very potentially threatened by throwing incandescent rocks with size of more than 6 cm, as well as heavy ash rain with radius of 1.5 km from the center of eruption. This area is not for permanent residence or is cultivated for commercial purposes on permanent basis.

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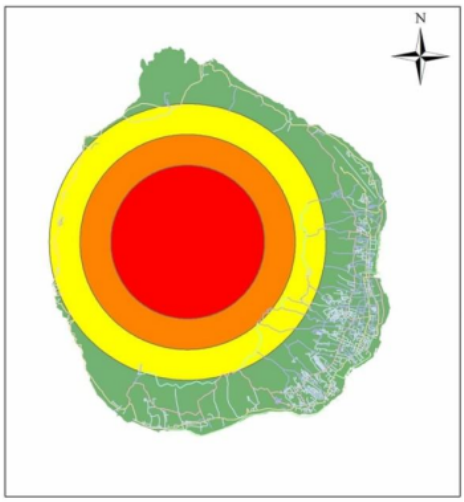

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225 **Figure 2.** Gamalama mountain danger zone

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227 Based on analysis, road network performance is using the vissum application to obtain
228 road speed. According to Ministerial Decree No. 96 of 2015 concerning traffic flow, it is
229 included in category C service level, stable traffic flow service. Results of analysis show that
230 roads carried out can be used for the selection of evacuation routes.
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235 **Figure 3.** Analysis results on existing traffic loading using the Vissum application

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Model validation is done to prove that the model used to forecast trips in planning year can be used. Validation step used the chi-square test. Steps for calculating the chi-square statistical test include formulating hypotheses and determining 95% significance level. Chi-square distribution with the number of road samples tested is 48, so that the chi square obtained from table is 48.60237.

243

244 **Table 1**. Validation of Ternate city road network model in 2020

No	Road Name	Capacity	Volume		Test		V/C		
			Model	Survey	% Validation	Chi-Square	Model	Survey	Differences
1	Jl. Batu Angus	1414	147	149	1%	0.03	0.10	0.11	2
2	Jl. Batu Angus	1414	161	164	2%	0.06	0.11	0.12	3
3	Jl. Pemuda	1241	460	463	1%	0.02	0.37	0.37	3
4	Jl. Pemuda	1241	414	417	1%	0.02	0.33	0.34	3
5	Jl. Merdeka	1608	415	419	1%	0.04	0.26	0.26	4
6	Jl. Merdeka	1608	388	391	1%	0.02	0.24	0.24	3
7	Jl. Pahlawan Revolusi	1548	201	207	3%	0.18	0.13	0.13	6
8	Jl. Pahlawan Revolusi	1548	242	248	2%	0.15	0.16	0.16	6
9	Jl. Mononutu	1500	278	281	1%	0.03	0.19	0.19	3
10	Jl. Mononutu	1500	227	232	2%	0.11	0.15	0.15	5
11	Jl. Jend. Ahmad Yani	856	50	59	15%	1.62	0.06	0.07	9
12	Jl. Jend. Ahmad Yani	856	56	60	7%	0.29	0.07	0.07	4
13	Jl. Hasan Esa	1382	182	190	4%	0.35	0.13	0.14	8
14	Jl. Hasan Esa	1382	166	170	2%	0.10	0.12	0.12	4
15	Jl. Raya Mangga Dua	1261	124	129	4%	0.20	0.10	0.10	5
16	Jl. Raya Mangga Dua	1261	124	130	5%	0.29	0.10	0.10	6
17	Jl. Raya	1106	301	308	2%	0.16	0.27	0.28	7

No	Road Name	Capacity	Volume		Test		V/C		
			Model	Survey	% Validation	Chi-Square	Model	Survey	Differences
	Bastiong								
18	Jl. Raya Bastiong	1106	274	280	2%	0.13	0.25	0.25	6
19	Jl. Kalumata I	1079	230	234	2%	0.07	0.21	0.22	4
20	Jl. Kalumata I	1079	237	240	1%	0.04	0.22	0.22	3
21	Jl. Poros Ngade I	1079	91	99	8%	0.70	0.08	0.09	8
22	Jl. Poros Ngade I	1079	85	89	4%	0.19	0.08	0.08	4
23	Jl. Univ. Khairun II	695	133	136	2%	0.07	0.19	0.20	3
24	Jl. Univ. Khairun II	695	126	129	2%	0.07	0.18	0.19	3
25	Jl. Jambula	1079	168	170	1%	0.02	0.16	0.16	2
26	Jl. Jambula	1079	158	160	1%	0.03	0.15	0.15	2
27	Jl. Kapitan Patimura	619	212	215	1%	0.04	0.34	0.35	3
28	Jl. Kapitan Patimura	619	219	232	6%	0.77	0.35	0.37	13
29	Jl. Yos Sudarso I	1482	124	129	4%	0.20	0.08	0.09	5
30	Jl. Yos Sudarso I	1482	124	130	5%	0.29	0.08	0.09	6
31	Jl. Jati Besar I	619	106	109	3%	0.08	0.17	0.18	3
32	Jl. Jati Besar I	619	113	117	3%	0.14	0.18	0.19	4

No	Road Name	Capacity	Volume		Test		V/C		
			Model	Survey	% Validation	Chi-Square	Model	Survey	Differences
33	Jl. Kalumata II	695	108	115	6%	0.45	0.16	0.17	7
34	Jl. Kalumata II	695	119	125	5%	0.30	0.17	0.18	6
35	Jl. Univ. Khairun	695	32	37	14%	0.78	0.05	0.05	5
36	Jl. Univ. Khairun	695	34	39	13%	0.74	0.05	0.06	5
37	Jl. Gambesi - Sasa	695	168	174	3%	0.21	0.24	0.25	6
38	Jl. Gambesi - Sasa	695	158	163	3%	0.16	0.23	0.23	5
39	Jl. Stadion	1032	241	244	1%	0.04	0.23	0.24	3
40	Jl. Stadion	1032	240	245	2%	0.10	0.23	0.24	5
41	Jl. Kampung Pisang	695	157	160	2%	0.06	0.23	0.23	3
42	Jl. Kampung Pisang	695	136	139	2%	0.07	0.20	0.20	3
43	Jl. Facei - Tarau	1079	329	332	1%	0.03	0.30	0.31	3
44	Jl. Facei - Tarau	1079	313	315	1%	0.01	0.29	0.29	2
45	Jl. Pelabuhan Ferry Bastiong	1044	182	188	3%	0.20	0.17	0.18	6
46	Jl. Pelabuhan Ferry Bastiong	1044	166	169	2%	0.05	0.16	0.16	3
47	Jl. Univ.	695	153	158	3%	0.16	0.22	0.23	5

No	Road Name	Capacity	Volume		Test		V/C		
			Model	Survey	% Validation	Chi-Square	Model	Survey	Differences
	Khairun I								
48	Jl. Univ. Khairun I	695	140	143	2%	0.06	0.20	0.21	3

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The statistical test is used to test whether the resulting simulation results have significant difference value. If there is no significant difference then simulation results can be accepted and validation is not necessary because model results are same as survey results. Otherwise, if there is significant difference, then simulation results cannot be accepted. Following shows the table of results from the selection of traffic routes and function suitability test using chi-square test to find out whether the model used is acceptable.

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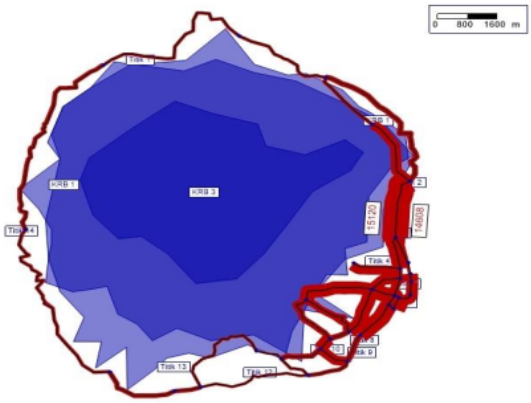

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257 **Figure 4.** The imposition of Vissum for 2024

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Pick-up point from evacuation vehicles is needed in disaster mitigation planning. Meeting point is meeting location for all people in disaster-prone areas. Determination of meeting point must be based on terms and indicators commonly used in handling disaster-prone areas. Terms and indicators for determining meeting point include the availability of adequate open areas, easily accessible to disaster victims and relief teams, sufficient protection from direct or indirect hazards from disasters, availability of temporary places especially for vulnerable groups, easy access to mobilization for moving to locations more quickly, availability of first aid facilities, availability of adequate transportation access that will lead to safer place quickly, availability of evacuation route map that is easy to read and understand quickly. Based on data from regional disaster management agencies, there are several locations for evacuation points for victims of Mount Gamalama disaster, final evacuation site for victims of Mount Gamalama disaster.

Providing evacuation mode and time is very useful as input for residents to find safe, closest and fastest evacuation places. Planning in providing transportation modes must pay attention to the type of mode used for evacuation process of Mount Gamalama victims. It should be noted that the factors that most influence the provision of modes in the event of disaster include carrying capacity modes of transportation and travel time of modes to be used. To provide an evacuation mode, we must pay attention to wind speed so that evacuation speed itself can be faster than wind speed because wind brings volcanic ash which results in bad impacts because it will inhale volcanic ash. Mode of transportation that is determined must also pay attention to the classification of class roads to be traversed. Because when Mount Gamalama eruption occurs, road capacity will be used by all evacuation modes. In addition, provision of evacuation modes prepared by government must be in accordance with needs in evacuation process.

In the analysis of process selecting the mode of disaster evacuation, it is assumed that all people do not have vehicle so that the provision of evacuation fleets for disaster victims uses following formula.

$$\text{Fleet provider} = \frac{\text{Population (demand)}}{\text{Vehicle capacity}}$$

289 **Table 2.** Fleet Requirements

Meeting Point Zone	Total Population	Resident in Coverage Area	Own Vehicle		Private Vehicle Users	Demand	Evacuation Fleet	Health Fleet
			Car	Motorcycle				
1	16892	2567	256	5354	12244	2081	52	5
2	53341	5431	978	20021	45910	2000	50	6
3	61839	7232	1023	22908	51954	2653	66	8
4	9520	2531	272	2112	5856	1133	28	4
5	9538	2521	253	2132	5782	1235	31	5
6	19059	3241	457	5212	13166	2652	66	10
Total						11754	294	38

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Based on various data analysis of test results, evacuation route is obtained according to traffic needs, so that evacuation route can be determined and meeting point for the evacuation of disaster victims. Route 1 is meeting point 14 which is on jikomalamo beach bridges, meeting point 1 at SMP Taduma with final evacuation location at jikomalamo port which can be accessed via Batu Angus 1 streets, and to jikomalamo beach streets. Route 2 is meeting point 13 which is located at Gudang Dolog and meeting point 12 which is in Gambesi Hajj hostel with bastiong ferry port and fast boat speed boat used as final evacuation point, which can be accessed via Jambula highway leading to Poros Ngade street, heading bastiong highway, heading to bastiong ferry port street and heading to bastiong inpress market street. Route 3 is meeting point 10 which is located at SD Ubo-ubo and meeting point 11 which is in Kayu-Merah field with final evacuation point being at bastiong ferry port and speed boat bastiong, can be accessed via Kalumata-2 road to ferry port bastiong street, and to bastiong inpress market streets. Route 4 is meeting point 8 located in Perikanan field and meeting point 9 is at bastiong terminal with final evacuation point being at Mangga-Dua port, can be accessed via inpres bastiong market street to Semut Mangga Dua port. Route 5 is meeting point 6 located at stadium and meeting point 7 is at Ahmad Yani port, with final evacuation point being at Ahmad Yani port, can be accessed via Kampung Pisang street to Kapitan Pattimura street, heading to Pahlawan Revolusi street, heading to Ahmad Yani street. Route 6 is planned as meeting point 4 which is located at Kompi-Senapan and meeting point 3 is located in Ngaralamo field with the location of final evacuation point at Dufa-dufa port, can be accessed via Kapitan Pattimura street section leading to Merdeka street, heading to Pemuda street, and head towards Batu Angus street. Meanwhile, Route 7 is meeting point 2 located at Dufa-dufa port, with the location of final evacuation point at Dufa-dufa port, can be accessed via Facei tarau street leading to Batu Angus street.

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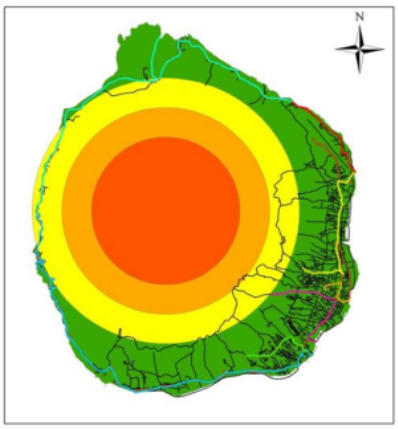

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319 **Figure 5.** Evacuation Route Map

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To make it easier for the community in evacuation process, the provision of information sign equipment, instructions and warnings on each evacuation route is needed because the community will find it easier to understand for information and be able to know information signposts, directions and warnings placed on each evacuation route. Time interval since the eruption of volcano is around 20 minutes, while information from early warning system of climatology and geophysics metrology agency about situation and conditions when volcano erupts followed by other activities such as earthquakes and possible tsunamis takes up to 10-15 minutes to reach the community. So that the community must understand time interval for evacuating themselves when volcano erupts by following evacuation pattern and process that has been prepared to go to safe place with required time span of around 5-10 minutes. This time interval is called golden time, which is time interval for evacuating victims from disaster point to evacuation point or assembly point. If with this indicator, time that is owned by community to save themselves is around 15 minutes. Because time to save oneself is very short, movement of people from place of origin when volcano erupts to destination must be reached in less than 15 minutes. For evacuation time of victims, it should be noted that minimum evacuation time is 30 minutes up to maximum evacuation time of 90 minutes to get to final evacuation place. In evacuation process to final evacuation site, the speed of vehicle and traffic space that is passed needs to be considered and can become an obstacle because there will be many vehicles accessing it. This is because time lag for evacuation from gathering point to final evacuation place must not exceed predetermined time so that casualties and material losses due to disasters can be minimized. People who will be evacuated and who are evacuating independently will be notified which areas are affected by hot and cold lava and volcanic ash. So that in process of evacuation, community has already known the affected and unaffected areas, this area is divided based on map of disaster prone areas.

In an effort to prevent and minimize potential impact due to eruption of Mount Gamalama in the future, it is necessary to plan mitigation programs and disaster preparedness. Mitigation is effort to eliminate, reduce and minimize risk of disasters in vulnerable populations. Scope of mitigation includes risk elimination, risk reduction and responsibility transmission. Focus of mitigation is to eliminate or limit the possibility of disaster and reduce the level

vulnerability of population. Preparedness for potential disasters is form of effort to increase the ability of community to respond effectively to threats and impacts of disasters so that they can recover quickly from impacts that occur. In the aspect of disaster preparedness, active community participation plays an important role. Ternate city government and NGOs are obliged to jointly encourage and strengthen community participation. In addition, it is hoped that collective memory of all time will be revived from dramatic and devastating experiences of disasters that occurred in the past. Disaster prevention efforts in urban areas are prioritized through built environment. Growth and development need to be carried out and managed with principles of harmony, balance and mutual benefit among Ternate people and environment. With due observance of spatial use plan that needs immediate attention in the event of eruption and lava melt, this is residential area along the west coast to south, to east of Ternate Island, because this area has large population concentration.

The impact of traumatic disasters on people and environment due to eruptions and earthquakes can be devastating, as they not only result in huge casualties, material and environmental damage, but also drain economic resources devoted to improving welfare of community. Therefore preventing and minimizing impacts through mitigation and preparedness programs is very important for survival and welfare of people living in disaster-prone areas such as Ternate city. Initial steps taken are developing alternative approaches to mitigation and disaster preparedness that are effective and efficient in Ternate city by conducting policy analysis on disaster mitigation, preparedness and assessment surveys of infrastructure and residential facilities, offices, hospitals, public facilities and environment, related to security systems and early warning of potential disaster hazards due to mount Gamalama activities.

Volcanic eruption disaster management efforts need several steps that must be taken before eruption occurs including monitoring and observing activities on volcanic activity, making and providing maps of disaster-prone areas and volcanic hazard risk zone maps supported by volcanic geological maps, guidance and provision volcano information, geological, geophysical and geochemical investigations and research on volcanoes, improvement of human resources and supporters such as improvement of facilities and infrastructure. Prevention efforts

when eruption occurs that need to be carried out consists of early warning, implementing fixed procedures for volcanic eruption disaster management, carrying out evacuation of population to safe places that have been prepared in advance. After an eruption, activities that must be carried out include taking inventory of data, including the distribution and volume the results of eruption, identifying areas that are at risk of danger, providing advice on hazard management, providing short-term and long-term area arrangements, repairing damaged monitoring facilities, lowering status of activities, and if state of mountain activity has decreased so it is necessary to continue routine monitoring.

Conclusion

Based on data analysis, it can be stated that in loading process using Vissim software, it is known that the road network performance of Ternate city is obtained roads that can be used for evacuation routes for victims of mount Gamalama because they have good road performance. Based on analysis and secondary data for the needs of evacuation route, evacuation meeting point and final evacuation point are obtained. If you look at evacuation meeting point and final evacuation meeting point, then it can be determined that mode to be used in evacuation process is mode that has large capacity and allows disaster victims to be evacuated when disaster occurs. Evacuation is solution to protect human life that cannot always be done in favorable conditions and can have negative consequences if not properly prepared (Memito et al., 2020). To reduce number of victims during disaster, it is important to disseminate disaster mitigation to public and install disaster information signs. By looking at results of future traffic forecasting analysis, as well as seeing the condition of Ternate city area, it is suggested that continuous supervision and maintenance of transportation infrastructure and facilities used in evacuation process of disaster victims must be carried out properly and consistently to anticipate problems in evacuation process. Build transportation infrastructure (Sarjana et al., 2020), and various infrastructure developments in transportation sector can determine change (Hiranrithikorn & Pamornmast, 2019). Transportation systems, network density, and capacity are central to logistics, mitigation and adaptation to disaster risk (Chakwizira, 2019). Referring to general spatial plan, local government is trying to develop disaster evacuation routes in disaster-prone areas. Author

411 recommends that local governments continue to utilize existing evacuation routes and it is very
412 important to create new evacuation routes to increase capacity in the process of evacuating
413 disaster victims. Process of creating new evacuation route can be carried out in stages according
414 to predetermined plan. Evacuation routes must be prepared with good calculations so that people
415 can use them in emergency (Suryani et al., 2020). Main purpose of establishing evacuation route
416 is to promote awareness of disaster prevention and disaster prevention education (Yamamoto &
417 Li, 2017). In process of installing traffic signs it is necessary to pay attention for community to
418 understand signs that are installed which can be done by socializing to public and placing
419 communicative advertisements so that community can easily understand the intent and purpose
420 of signs installed. People who have experienced disaster firsthand try to remember the incident
421 and do not want their offspring to experience and endure it (Sato & Ono, 2021).
422

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All authors contributed equally to this work

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Data sharing is not applicable to this article as no new data were created or analysed in this study.

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