Evaluation of Public Shelter Plan for Tsunami Evacuation in Padang City after 2009 West Sumatera Earthquake

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1. Introduction

Padang city, a capital of West Sumatera Province is one of the most vulnerable cities against tsunami disaster in the world because almost 60% people of Padang live in the coastal area, and the strong of tsunami disaster history. Padang city had experienced great tsunami events in 1797 and 1833 with their run up height at least 5 m and 4 m respectively[1]. The recent powerful earthquake occurred with magnitude 7.6 on September 30, 2009. It was reported that total of affected people in West Sumatera province are 1.195 dead, 1.798 injured, and 2 missing[2]. Evacuation places for tsunami disaster in this city have been proposed by KOGAMI, one of NGO in West Sumatera Province and by MMAF, the Ministry of Marine Affairs and Fisheries. Through our field survey right after 2009 earthquake, we found that many of those shelters were damaged. This study evaluates those public shelters plan that were allocated by KOGAMI and MMAF under the damages on 2009 West Sumatera earthquake. Furthermore, this study proposes a new allocation of tsunami shelters, and investigates the effect of those allocated shelters on increasing the number of evacuee to be accommodated.

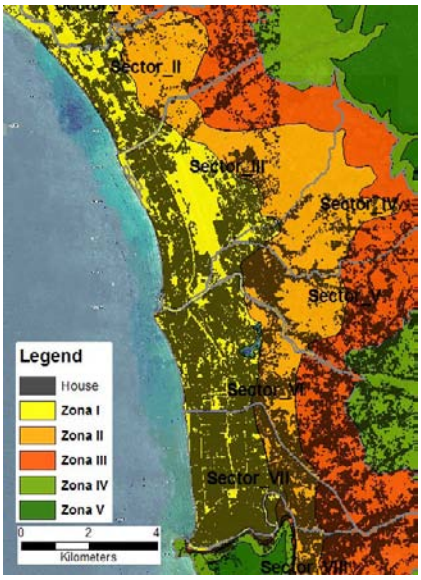

Fig-1. Tsunami hazard map of Padang city

2. Hazard Map and Public Shelter Plan in Padang City

Currently, Padang uses an existing tsunami hazard map which is provided by KOGAMI as shown in Fig.1. The map is based on the worst-case scenario set by Borrero et al's model [3]. The MOST model was used to simulate the tsunami generated by the source parameters of historical tsunami of 1797 and 1833. This hazard map divided the Padang city into four categories, such as danger zone (Zona I), alert zone (Zona II), safe zone (Zona III), and relocation zone (Zona IV and V). In 2006, the total population of Padang city is around 819.740[4], and around 268.704 people live in danger zone. Those are the number of people that have to evacuate firstly when tsunami occurs.

For evacuation planning, KOGAMI divided Padang city into eight sectors that are bordered by main rivers as seen in Fig. 2. KOGAMI and MMAF arranged 93 and 152 shelters respectively. All of those existing shelters are used for government office, schools, hotels, mosques, shop-houses and hospitals in common use. Through our field survey after 2009 earthquake, we found that 27% of shelters allocated by KOGAMI and 37% of shelters allocated by MMAF were damaged by the earthquake, and were unavailable to be used as temporal shelter. As shown in Fig. 2 and Fig. 3, it found many damaged shelter occurred in Sector VII. That sector had the severest damage under the 2009 West Sumatera earthquake.

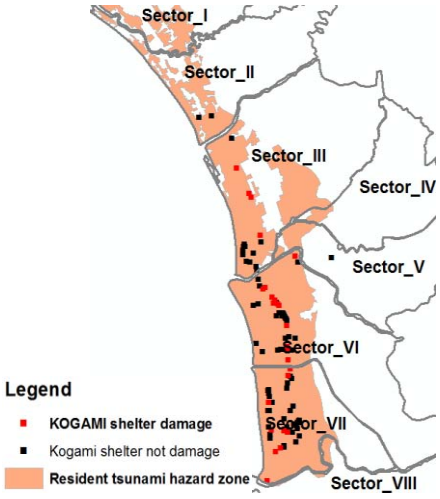

Fig-2. Public shelter plan arranged by KOGAMI

3. Evaluation of Public Shelter Plan

It was estimated that the tsunami attacks Padang city approximately 33 minutes after the earthquake occurs on Sunda megathrust[5]. Judging from the current tsunami warning transmission system, approximately 20 minutes will be consumed after the earthquake; time for evacuation remains 13 minutes. By assuming the evacuation speed for walking people is 3.6 km per hour, the service area in which evacuees have sufficient time to evacuate to their shelter is generated base on both spatial and network analysis on ArcGIS tools.

(a) Shelter arranged by KOGAMI and arranged by MMAF

Fig. 4 shows the number of evacuees that have sufficient time and do not have sufficient time to evacuate to the shelter before tsunami attack on shelter planning by KOGAMI and MMAF before and after 2009 West Sumatera earthquake. Fig.4(a) and Fig.4(b) show the influence of damaged shelter after

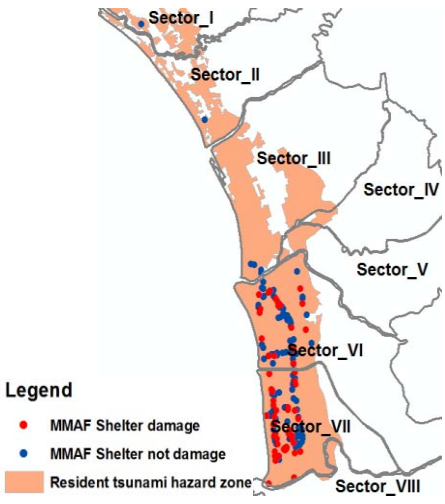

Fig-3. Public shelter plan arranged by MMAF

2009 earthquake arranged by KOGAMI and MMAF respectively. It shows that the number of evacuees that do not have sufficient time to evacuate to shelter increases significantly in Sector-III on shelter planning by KOGAMI and in Sector-VII on shelter planning by MMAF. It is because those sectors had the severest damage under the 2009 West Sumatera earthquake.

Sector I, II, IV, and VIII on shelter planning by KOGAMI and Sector II, III, IV, and V on shelter planning by MMAF were not affected by 2009 earthquake, because there was no damaged shelter or no shelter allocated in those sectors. Totally, after 2009 earthquake, the number of evacuees that do not have sufficient time to evacuate to the shelters increase 19% because of the 27% damage shelters allocated by KOGAMI, and increase 14% because of the 37% damage shelters allocated by MMAF. About 53% and 51% of evacuees do not have sufficient time to evacuate to the shelters on planning by KOGAMI and MMAF respectively. This means that the current allocation of evacuation shelters in tsunami hazard maps provided by KOGAMI and MMAF are insufficient for mitigating tsunami risk on residential area, and new shelter allocation is strongly desired.

(b) Proposed Potential Public Shelter

Based on field survey, this study proposes a new shelter allocation to revise the shelter arrangement by KOGAMI and MMAF. In addition to the non-damaged shelters arranged by KOGAMI and MMAF, we utilize the public buildings which were not damaged under 2009 earthquake. The new shelter allocation in this study decreases the number of evacuees that do not have sufficient time to evacuate to the shelter significantly as shown in Fig.4(c). The most significant reduction can be seen in Sector-III. It is because we found many shelters that can be supposed as tsunami public shelters in this sector. However, the proposed shelters allocation could not cover all of evacuees. As shown in Table-1, there are about 52.737 evacuees that do not have suficient time to reach shelter before tsunami attack. The capacity of proposed shelters also does not enough space to accommodated all of evacuees that have suficient time to reach shelters. Providing new building for evacuation shelter is strongly required in the disaster mitigation planning of Padang city.

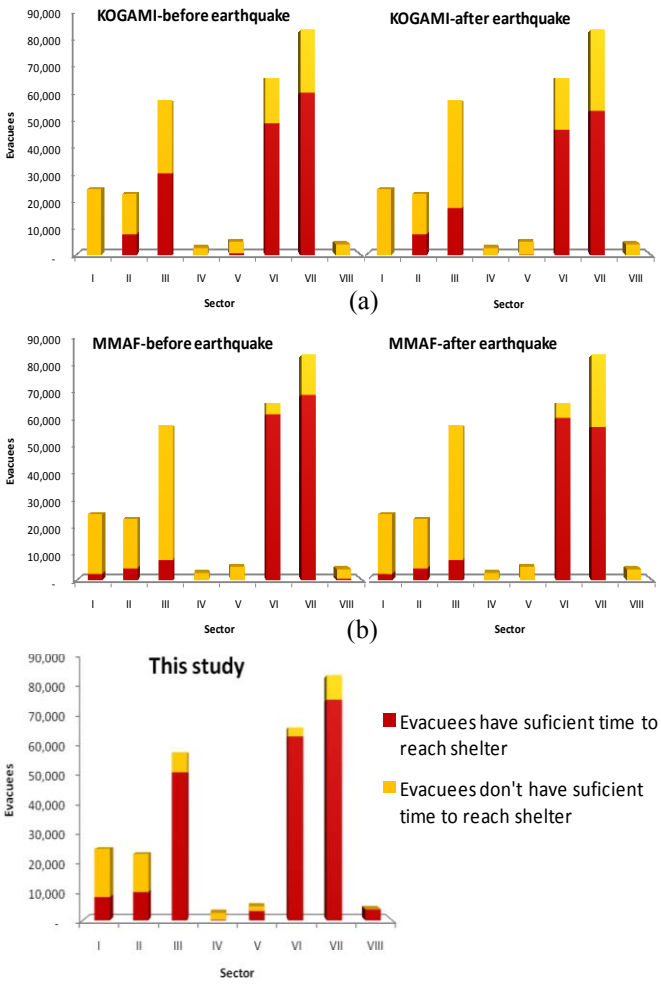

Fig-4. The number of evacuee and time sufficiency to evacuate to shelter arranged by KOGAMI (a), MMAF (b) and this study (c)

Table-1. The capacity of shelter proposed from this study and the number of evacuee that can be accommodated in shelter

Sector	Number of Evacuee	Evacuees don't have suficient time to reach shelter	Evacuees have suficient time to reach shelter	Shelter Capacity	Evacuee can be accommodated
I	24,749	16,693	8,055	3,919	3,919
II	22,963	13,198	9,765	2,068	2,068
III	58,153	6,978	51,175	19,614	19,614
IV	2,589	2,378	211	-	-
V	4,909	1,720	3,190	330	330
VI	66,668	3,113	63,554	82,724	63,554
VII	84,743	8,525	76,219	39,288	39,288
VIII	3,930	132	3,797	1,981	1,981
Total	268,704	52,737	215,966	149,925	130,755

4. Conclusions

This study evaluates public shelters plan that were allocated by KOGAMI and MMAF under the damages on 2009 West Sumatera earthquake. The current shelters arrangement by KOGAMI and MMAF are insufficient for mitigating tsunami risk in residential area. This study proposes a new shelter allocation for tsunami evacuation with considering the damages by 2009 West Sumatera earthquake. It was cleared that the new allocation of shelters reduces the number of evacuees that do not have sufficient time to evacuate remarkably.

5. References

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[2] BNPB, 2009, Damage, Loss and Preliminary Needs Assessment, A Joint Report by the BNPB, Bappenas, and the Provincial Government of West Sumatera, Jambi and International Partners, Jakarta, Indonesia.

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