Keeping evacuation places for a massive earthquake in Nankai Trough quake: GIS Approach for the case of Komatsushima city[1]

The University of Tokushima Tohru Naito[2]

1. Introduction

The purpose of this paper is to analyze the relationship between residential property and Hazard map of Komatsushima city in Tokushima. At the great east Japan earthquake, a lot of counties and cities were damaged by earthquake and huge TSUNAMI. Needless to say, the scale of earthquake beyond expectations caused damage to those areas though some of cities provided the infrastructures for disaster prevention. For example Taro town in Iwate prefecture constructed the huge seawall after Showa Sanriku earthquake in 1933. Since Taro town constructed the huge seawall in front of center in the town, that seawall has been called "the robustest seawall in the world". The huge seawall ironically, took the figure of the sea from residents when the great east Japan earthquake happened on 11th in March 2011 and the unexpected huge TSUNAMI with earthquake surged on the coast. As the result, the center of the town in the Taro town has received a crushing damage. The great east Japan earthquake told us not to overcome the threat of nature. It is impossible to say that we are safe by all means even if we perform strong disaster prevention measures so much. Recently many local governments and the Japan government have aimed for diminishing disaster rather than disaster prevention.

According to the expert of the earthquake, it is expected that Tokai or Tonakai earthquake in Nankai Trough will occur with the probability of about 80% within 30 years. Supposed that the damage became the heaviest, it is possible that over 323,000 people will die due to this earthquake. For example, the highest TSUNAMI with 34 meters will attack Kuroshio town in Kochi prefecture if those earthquake occurs in Nankai Trough. In fact, the high TSUNAMI with 34 meters covers up the whole town, the normal disaster prevention facilities will be destroyed at all. Thus, we need consider countermeasures to Nankai Trough quake. The arguments about the past disaster prevention have been mainly performed from a view point of an engineering. However, it is necessary to argue with these problems from a view point of residents there. Thus, the government must take account of residents in the area when he maps out a disaster prevention plan or a diminishing plan for Nankai Trough earthquake. At that time, the governments pay attention to the property of residents, which are age, gender, and so on.

As for the analysis about earthquake in Japan, there are many studies from various viewpoints. Though we refer to studies from only economics or geography in this paper, Naoi et al. (2009) examine whether homeowners and/or renters alter their subjective assessments of earthquake risks after massive earthquakes by using the hedonic pricing approach. Nakagawa et al. (2007) estimate the extent of earthquake risk aversion in housing rents using a 1998 hazard map of the Tokyo Metropolitan Area. Some studies approach the Great east Japan earthquake with Geography Information System to grasp them.

---

[1] This study is supported by Grant-in-Aid for Scientific Research C (25516007) from Japan Society of the Promotion of Science.

[2] Institute of Socio-Arts and Science, The University of Tokushima. 1-1 Minamijosanjima-cho, 7708502 Tokushima JAPAN. Email: naito@tokushima-u.ac.jp

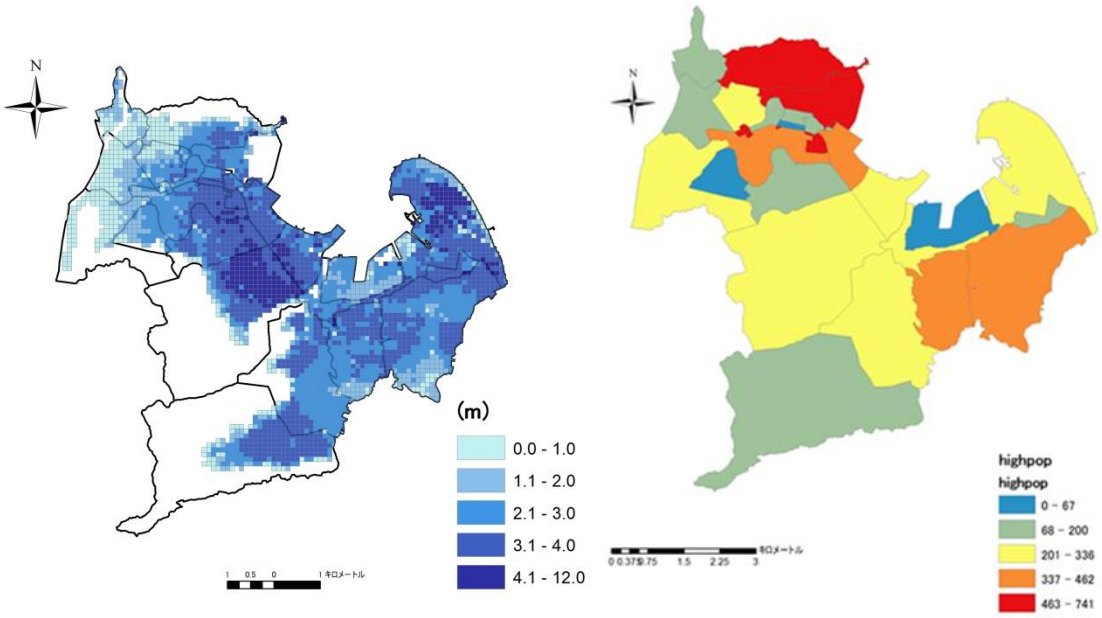

Figure 1(left): the flooded areas map in Komatsushima city at Nankai Trough earthquake

Figure 2(right): High age residents in Komatsushima city

Koarai et al. (2011) or Hashimoto (2012) analyze the damage of the Great east Japan earthquake with Geography Information System. This paper studies the problems and adequate policy of disaster prevention at Komatsushima city in Tokushima prefecture Japan. In our analysis we use Geography Information System (GIS) to grasp them. Moreover, we consider the property of residents on each area and the flooded area in Komatsushima city. This paper is organized as follows. In next section we refer to the geographical situation and the flooded area in Komatsushima city. Section 3 shows the relationship between the residential property and the flooded area in Komatsushima city and the disaster prevention policy or diminishing disaster policy. Finally we will conclude this analysis and refer to the subject of remained analysis in this paper.

2. Geographical property and the flooded area in Komatsushima city

Komatsushima city is located in Tokushima prefecture and is adjacent in the southern area of Tokushima city, the northern area of Anan city, and the western area of Naka town. The population in Komatsushima city has 40,630 people in 2010. Though Komatsushima city had the paper factory and the departure port of ferry bound for Wakayama city once, both the paper factory and the ferry withdrew from the city now. Thus, the population of this city has decreased since 1985. The downtown in Komatsushima city is spreads out around Minamikomatsushima station of JR Mugi line and the Tokushima Red Cross Hospital or Komatsushima city hall are also located around this station. Though the main shopping street was developed in this downtown, recently some large shopping store opened in the suburbs along the National Road No.55. Since 70 percent of city consists of plains, most of area in Komatsushima city is low level relatively.

Since the great east Japan earthquake and Tsunami due to it attacked the coast of Pacific Ocean, most of local governments toward the Pacific Ocean. This is because the arrival of the earthquake of Nankai or

Tonankai is predicted within thirty years. Most of local prefectures in Shikoku, southern Kinki, and Tokai have to reconsider the disaster prevention plan based on the estimation before the great east Japan earthquake. Tokushima prefecture planed the revised disaster prevention plan and announced the flooded area in the coast of Tokushima prefecture. Though we used ArcMap ver.10 to analyze the geographic property of relationship between the distribution of residents and the flooded areas map in Komatsushima city, we received the information about the flooded areas by Nankai Trough earthquake from the disaster prevention section of Tokushima prefecture. As for the residential property of Komatsushima city, we used the report of "Fact-finding about the care prevention business", which Komatsushima city carried out in 2011. Since we focus the disaster prevention plan or diminishing disaster plan, we extracted only Komatsushima city from these data of the flooded areas and describe the flooded area map in Figure 1 if Nankai Trough earthquake is the largest scale. In this case most of the cities will be damaged by the Tsunami, which is caused by the largest earthquake in Nankai Trough. Particularly, the part of coast area will suffer damage from inundation damage more than 4 meters. Supposed that the earthquake at 8.6-magnitude was generated, it is predicted that the Tsunami cause by earthquake will arrive at Komatsushima from34 minutes to 54 minutes. Thus, the residents have to evacuate from Tsunami within 30 minutes after waiting for the earthquake to blow over. Particularly, the residents in the area near the coast must move more than 4 kilometers to the safety area within 30 minutes. It is not easy to move to the safety area within 30 minutes taking account of average walking speed. Thus, the Komatsushima city government has to consider the disaster prevention plan and take into account that the residential property.

3. Residential property and optimal disaster prevention policy in Komatsushima city

In the previous section, we referred to geographical properties of Komatsushima city and the data of the flooded areas of Tsunami caused by the largest earthquake in Nankai Trough. When the largest earthquake will be generated in Nankai Trough, it is not enough time for any residents to move to the safety area by arriving at their location. Disaster prevention policy has been drafted from the perspective of disaster prevention engineering and such policy often ignore the property of residents, who have to move to the safety area. However, in fact, the policy maker of disaster prevention must take account of those residential properties to consider the policy because it is important to protect their own live from the big disaster.

Here we analysis about the characteristics of residential distribution of Komatsushima city before considering the disaster prevention policy. When a disaster occurs, the weak for a disaster is often high age people.

Figure 2 describes the distribution of high age residents in each region of Komatsushima city. From Figure 2, we know that the distribution of the high age residents is different in each region of Komatsushima city. The regions with relative high age residents are around downtown. This is because there are many people have lived these districts for a long term. Generally, the movement cost of old generation tends to become higher than that of young generation. Thus, it is difficult that the local government makes them move to continental plateau even if the reason of movement is to save their lives from Tsunami disaster. Moreover, we combine the Hazard map of flooded areas with the distribution of high age residents in each region of Komatsushima city. Figure 3 describes the distribution of high age residents and flooded areas in Komatsushima city. From Figure 3, most of districts, in which many high age residents reside, are covered

by the Tsunami. As we know

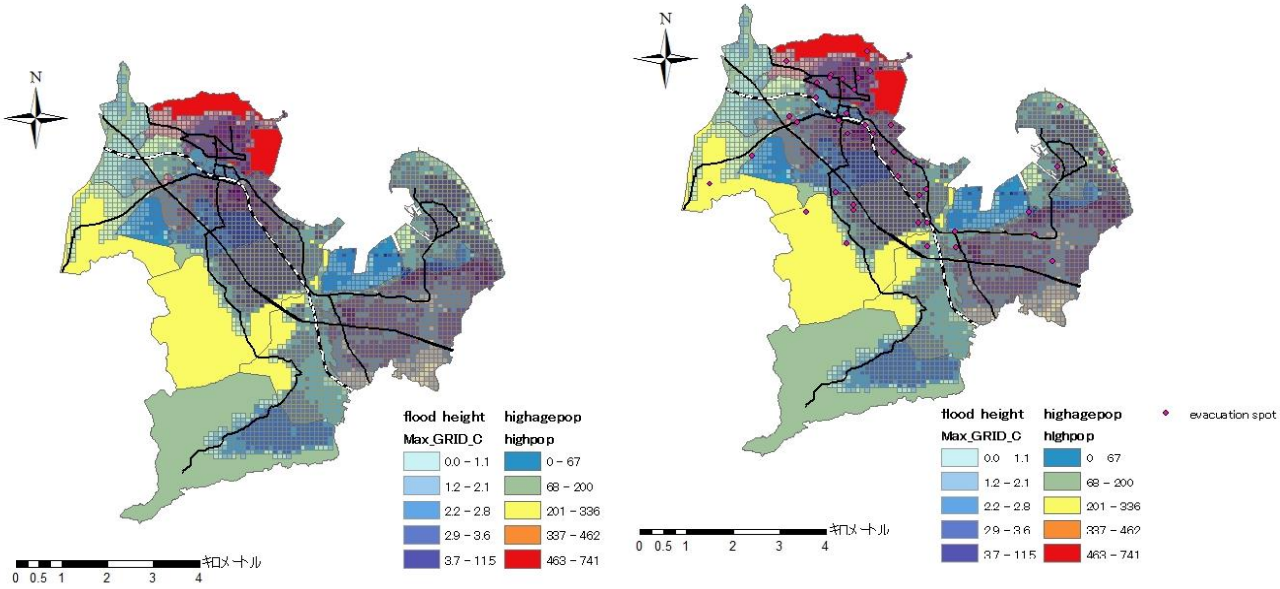

Figure 3 (left): High age residents and Hazard map in Komatsushima city

Figure 4 (right): the location of temporary emergency evacuation spots and Hazard map in Komatsushima city

from Figure 3, it is expected that Tsunami than over 3 meters arrive at this downtown area. According to Hazard map created by the Komatsushima city, the Tsunami will arrive at this region within 40 minutes. A distance from the downtown district to the nearest safety area is over two kilometers. Moreover, we find that it is difficult to make high age residents move to the area outside flooded areas of Tsunami smoothly. Moreover, it is possible that the earthquake and Tsunami cut off traffic at places along the road and railway network because JR Mugi line and main bus routes is concluded in the expected flooded areas of Tsunami. Thus, it is necessary to construct the alternative logistic route for the neighborhood.

Since it is difficult to make high age residents move to the area outside flooded areas of Tsunami smoothly, we have to consider alternative disaster prevention policy for the disaster weak. Though the first best disaster prevention policy is to promote these high age residents to move continental plateau as safety area, it is not easy to make all of them move there. However, it is necessary to keep such facilities in which these residents can evacuate from Tsunami temporarily. Since most of area in Komatsushima city is organized by plain area, it is possible that the flood can reach the areas of 4 kilometers inside from the coast. As it will take about 40 minutes that the Tsunami arrives at the coast of Komatsushima city. Thus, residents in the most of Komatsushima city need to keep his safety place within 30 minutes. So the Komatsushima city determines the temporary emergency evacuation spots. The construction of temporary emergency evacuation spots are reinforcing rod buildings and are higher. The Komatsushima city recruited those spots in city and assigned those places as emergency evacuation spots. Now we plot the location of temporary emergency evacuation spots on Figure 3. We get the information about location of temporary emergency evacuation spots in Komatsushima city from the homepage of Komatsushima city.[3] Moreover, we got the

[3] http://www.city.komatsushima.tokushima.jp/soshiki/3/hazard-map.html However, this location of temporary emergency evacuation spots in Komatsushima city was determined based on the information of Nankai Trough earthquake before the Great East Japan earthquake. Though Komatsushima city are

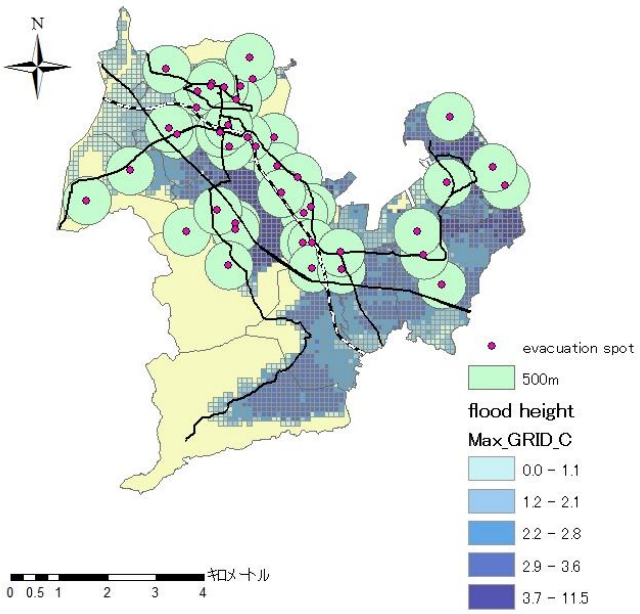

Figure 5: the location within 500 m from temporary emergency evacuation spots and Hazard map in Komatsushima city

geographic information of location of temporary emergency evacuation spots with CSIS address matching service of University of Tokyo. Figure 4 describes the location of temporary emergency evacuation spots determined by the Komatsushima city. The purple spots denote the location of temporary emergency evacuation spots in Komatsushima city.

As we know from Figure 4, these spots are located along the bus routes and roads JR Mugi line. Moreover, some spots agglomerate in the downtown near the Minamikomatsushima station. However, there is no facility in the southwestern part of the city though the expected flooded areas are over four meters. Now Though the number of high is residents are relatively small in this area, it is expected that aging of this district also proceed as well as the aging of the downtown in the future. Thus, the Komatsushima city need to determine the location of temporary emergency evacuation spots to keep safety area for those spots.

Finally we analyze how this spot can cover about a Komatsushima city. We analyzed how areas of 500 meters radius from each temporary emergency evacuation spot can cover the flooded area by Tsunami. We use buffer analysis with ArcMap to analyze this question. We combine the areas of 500 meters radius from each temporary emergency evacuation spot with Figure 4 in Figure 5.

As we know from Figure 5, the only areas of 500 meters radius from each temporary emergency evacuation spot is not enough to cover all over Komatsushima city. The cluster of temporary emergency evacuation spots around the downtown can cover those areas roughly. Since many high age people reside in the area around the downtown and it is difficult for them to move to the safety area with height within 30 minutes, the Komatsushima city government has to set up such spots in this area. On the other hands, Kushibuchi area in the southwest area of Komatsushima city urgently lacks temporary emergency evacuation spots and is not covered by those spots. Though the number of high age people is not so many relatively at present, it is

---

planning to reconsider the location of emergency evacuation spots based on the flood information shown by Tokushima prefecture on December in 2012, this information is not made public now. Thus we use the information based on the standard before the Great east Japan earthquake.

necessary to construct the temporary emergency evacuation spots here, too. Moreover, the center of Komatsushima city is also covered with such spots. This district is nearer to the coast line than Kushibuchi area and the height of flood there is higher than four meters. Moreover, since the area is a network of JR Mugi line and main bus routes, this area is most important disaster prevention area. So the government has to increase such spots there and keep alternative logistics and should always be fully prepare for an earthquake.

4. Concluding remarks

We analyze the relationship between the residential property and the expected flood area by Tsunami caused by Nankai Trough earthquake. Particularly we focus the case of Komatsushima city in Tokushima prefecture Japan. Since most of studies about earthquakes analyze it from a point of engineering view, they don't refer to this relationship. However, residents and the properties of each area is different even if each area locates in the same city. We get the data about residential properties from the report of "Fact-finding about the care prevention business" in 2011 and that about the floods area from Tokushima prefecture. Moreover, we use geographic information system software to analyze the optimal disaster prevention plan in Komatsushima city. As the results of our analysis, we found that it should be reconsidered at some point in relation to disaster prevention. First, it is possible that the earthquake and Tsunami cut off traffic at places along the road and railway network because JR Mugi line and main bus routes is concluded in the expected flooded areas of Tsunami. Thus, it is necessary to construct the alternative logistic route for the neighborhood. Secondary high age residents agglomerate in the downtown of Komatsushima city which is near the Minamikomatsushima station, Komatsushima city Hall, and Tokushima Red Cross hospital. This area is not too far from the coast line and Tsunami will arrive at this area within 40 minutes. Thus, it is necessary to attempt to enhance temporary emergency evacuation spots when we reconsider new disaster prevention plan for Nankai Trough earthquake, which will happen within 30 years. Though such temporary emergency evacuation spots agglomerate around the downtown, the southwest area of Komatsushima city urgently lacks them. Since the flood area higher than four meters involves a part of this district, some measures for an earthquake need to be taken quickly.

In this paper we limited analysis to Komatsushima city due to a limit of the acquisition of data. Therefore, we must analyze the case about the other cities or towns of the coast in Tokushima prefecture. This point is the subject after this.

Reference

1. Koarai, M., T. Okatani, T. Nakano, and I. Kamiya, (2011) "Geographic Characteristics of Tsunami Flooded Area by the Great East Japan Earthquake," *Kokudochiriin Jiho,* 122*,* pp.97-111.
2. Hashimoto, Y. (2012), "Analyses of Impact of the Great East Japan Earthquake and Tsunami Risk in Hokkaido by utilizing the Basic Geo-spatial Information of Japan," *The Annual Report on Cultural Science*, 136, pp.141-203.
3. Nakagawa, M., M. Saito, and H. Yamaga, (2007), "Earthquake risk and housing rents: evidence from the Tokyo Metropolitan Area," *Regional Science and Urban Economics,* 37, (1), pp. 87-99.
4. Naoi, M., M. Seko, and K. Sumita, (2009), "Earthquake risk and housing prices in Japan: Evidence before and after massive earthquakes," *Regional Science and Urban Economics,* 39, (6), pp. 658-669.