# Tsunami Refuge Facility Choice Model for Visitors in Beach

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## 1. Background and Purpose

Many tsunami refuge facilities for ensuring refugees' safety are necessary and have been being constructed. In order to place Tsunami refuge facilities effectively, we need to estimate the necessary number of people who evacuate to each facility<sup>1</sup>). Not only the residents but also the visitors in coastline area have to be considered. However there are no practical models which estimate the evacuation behavior which enables to predict refugees' choice of facility.

This study purpose is to make choice model of tsunami refuge facilities for visitors. In this study, we interviewed visitors about refuge place from tsunami disaster and the reason. By using the interview data, we made choice model of tsunami refuge facilities. Furthermore, we estimated visitors' choice of facility using the proposed choice model for tsunami refuge facilities.

# 2. Research Methods and Data Analysis

Case study area is Katase Nishihama beach in Fujisawa City, Kanagawa Prefecture. The main reasons of selection of the area are the followings. (1) This area is at the high risk of inundation by tsunami. (2) This area is lowland along coastline. (3) Large number of people visits this area but there isn't enough number of tsunami refuge facilities. We showed visitors the map of tsunami refuge facilities, based on hazard map of Fujisawa city, on which the number of floors and capacities of tsunami refuge facility are indicated. We asked visitors where they will evacuate when tsunami warning was announced and the reason why they answered. Totally 241 visitors answered and nearly 90% of respondents chose the tsunami refuge facilities for the destination of evacuation.

#### **3. Facilities Choice Model**

Figure 1 shows places of visitors and tsunami refuge facilities in the beach. As a result, the visitors tended to be two types of respondents. One of types prefers the facility close to visitors. Another type prefers the facility far from sea. When refugees choose a facility, we assume that they choose facility considering the utility of facility. We made a logit model with the utility function of each facility.



Figure 1. Visitors and tsunami refuge facilities in the beach

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Figure 2. Definition of each parameter

Figure 2 shows the positional relation of refugee *i* and refugee facilities j and the variables.  $V_{ij}$  is the utility which individual *i* chose facility j;  $\theta_{ij}$  is the angle between coastline and direction of refuge, which is represented as Figure 1;  $D_{ij}$  is the distance between individual *i* and facility *j*;  $L_j$  is the distance between facility *j* and coastline;  $H_j$  is the number of floors of facility *j*;  $C_j$  is the capacity of facility *j*;  $S_j$  is the square of facility *j*;  $R_{ij}$  is presence or absence of river between individual *i* and facility *j*. We take logarithm of  $H_j$  to treat as intensity and take logarithm of  $C_j$  and  $S_j$  to avoid independence from irrelevant alternatives.

$$V_{ij} = \alpha \sin \theta_{ij} + \beta D_{ij} + \gamma L_j + \delta \ln(H_j) + \varepsilon \ln(C_j) + \zeta \ln(S_j) + \kappa R_{ij}$$
(1)

 $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\delta$ ,  $\varepsilon$ ,  $\zeta$  and  $\kappa$  are coefficients of parameters.

When individual *i* choose facility  $\hat{J}$  in tsunami refuge facilities J, choice probability  $P_{ij}$  is given in Equation 2.

$$P_{ij} = \frac{\exp(V_{ij})}{\sum_{j=1}^{J} \exp(V_{ij})}$$
(2)

#### 4. Results

The result of calculation of parameters and analysis, Table 1 is the optimal parameters of proposed model which maximize the likelihood respectively.

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variable	coefficient	coefficient value
sin $ heta$ ij	α	1.9879***
D ij	β	-0.0053***
Lj	γ	0.0028**
Hj	δ	1.1400***
Сј	ε	-0.0754
S j	ζ	0.8049***
R ij	ĸ	-1.0522**
likelihood ratio		0.45
predictive value		43.96%
$-:$ : $f_{1}$ $f_{2}$ +++ + + 10/ ++ + $f_{2}$ / + + 100/		

Table 1. Estimated result of the parameter

significance level \*\*\*: 1%, \*\*: 5%, \*: 10%

## 5. Conclusion

This study modeled a refuge facility choice considering the position from coastline and from facility. It has quantitatively explained the mechanism how visitors choose facility. And we have determined factors and parameters which affect visitors' choice of facility. Calculating likelihood ratio and significance level, we confirmed suitability of parameters.

# *Keywords: Tsunami Refuge Facility, Choice Behavior, Multinomial Logit Model* Reference:

1) DIRECTOR GENERAL FOR DISASTER MANAGEMENT, CABINET OFFICE, GOVERNMENT OF JAPAN (2005), Guideline of tsunami refuge buildings, p.17