Tsunami Refuge Facility Choice Model for Residents in Coast Area

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1. Background and Purpose

The damage caused by tsunami is enormous. In order to avoid tsunami, migration to highland area is desirable, but many people cannot move and continue to live in lowland area. Accordingly, facilities for tsunami refuge, which protect refugees who evacuated from coast area, are spotlighted in recent years. It can be a place for refuge from tsunami. In order to estimate damages and casualties, former studies usually hypothesize simply that everyone will choose the closest facility[1)] or facilities in the direction of inland, but refugees will not always choose such facilities. It is assumed that they choose facilities considering distances, directions, size of facilities and others. This study models the evacuee's choice of tsunami refuge facilities for the prediction of evacuation behavior from tsunami.

2. Interview Survey

We conducted an interview survey to investigate the choice behavior of tsunami refuge facility. In the interview, we asked examinees to choose a facility which he or she likes to evacuate on a map where 27 facilities are distributed in the virtual city. We asked examinees to choose a facility which he or she likes to evacuate among the remaining facilities. Removing the facility chosen by the examinee, we repeated to ask examinees to choose a facility of highest preference until all facilities are chosen and removed from the map. Figure 1 is the interview screen on a personal computer.

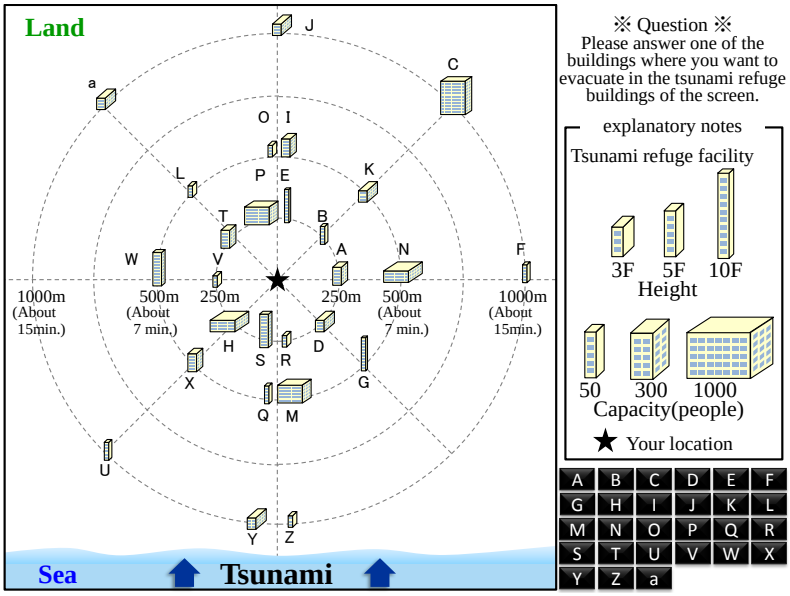

Figure 1. Interview screen

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3. Choice Behavior Model of Tsunami Refuge Facilities

As a result, the examinees tended to be two types of refugees. One of types prefers the facility close to examinees like facility "P", "A", "E" and "T". Another type prefers the facility far from examinees like facility "C", "J" and "a".

Analyzing the order of choices, we used the logit model in order to treat the choice as a stochastic event. We model choice of examinees, whose utility value (V_{ij}) is given in Equation 1

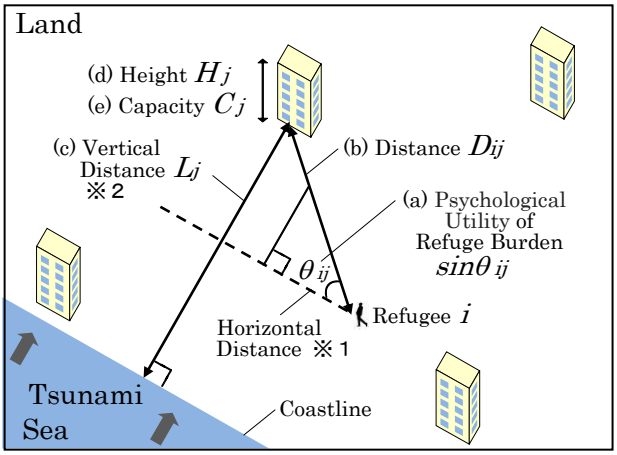
$$V_{ij} = \alpha \cdot \sin\theta_{ij} + \beta \cdot D_{ij} + \gamma \cdot L_j + \delta \cdot \ln(H_j) + \varepsilon \cdot \ln(C_j) \quad (1)$$

V_{ij} is the utility which individual i chose facility j; θ_{ij} is the angle between coastline and direction of refuge, which is represented as Figure 2; 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; $\alpha, \beta, \gamma, \delta$ and ε are coefficients of parameters. We take logarithm of H_j to treat as intensity and take logarithm of C_j to avoid independence from irrelevant alternatives.

By the logit model, the choice probability (P_{ij}) that individual i chooses facility j is given in Equation 2.

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

J : 2 - 27 (number of facilities)



※1 : Parallel line of refugee i from coastline
※2 : Vertical line from facility to coastline

Figure 2. Variables in this model

Furthermore, this study estimates parameters by the maximum-likelihood estimation (MLE). Specifically, it estimates the parameters which makes the likelihood function (L^*) given in Equation 3 the largest.

$$L^* = \prod_i \prod_j (P_{ij})^{\phi_{ij}} \quad (3)$$

ϕ_{ij} is given in Equation 4.

$$\begin{cases} \phi_{ij} = 1 & \text{(when individual } i \text{ chose facility } j \text{)} \\ \phi_{ij} = 0 & \text{(other than the above)} \end{cases} \quad (4)$$

4. Results

Table 1 shows the estimated parameters. α is a positive value. The utility has high value when refugee evacuate to inland direction. β is a negative value. The utility has low value when facility distance is far from the refugees. γ is a positive value. The utility has high value when facility distance is far from the sea. δ is a positive value. The utility has high value when facility floor is high. ε is a positive value. The utility has high value when facility capacity is large.

Table 1. Estimated result of each parameter

variable	coefficient	coefficient value
$sin\theta ij$	α	0.9106***
$D\,ij$	β	-0.0033***
$L\,j$	γ	0.0021***
$H\,j$	δ	0.7018***
$C\,j$	ε	0.2663***
likelihood ratio		0.25
predictive value		44.65%

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

5. Conclusion

We modeled the choice behavior of tsunami refuge facilities. This model is characterized by considering five characteristics which facility has. Proposed model in this study will enables to estimate number of users and to simulate human's evacuation much precisely.

***Keywords**: tsunami evacuation, facility choice, logit model*

Reference:

1) D.OHATA, N.TAKAI, H.KAGAMI, 2007, Spatial Evaluation of Tsunami Refuge Facilities in the Central Kushiro City; Simulation of evacuation behavior from tsunami utilizing multi agent system Part 2, J. Archit. Plann. AIJ, No.612, 87-91. (In Japanese with English Abstract)