Regional Disaster Prevention Countermeasures Considering Inhabitants' Risk Acceptance of Tsunami

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Abstract: Prediction of tsunami inundation area was announced in Hokkaido on June 28th, 2012. Local governments reconsider tsunami prevention. Countermeasures of tsunami prevention are divided by non-structural measures including tsunami hazard map and structural measures including seawall. However, the priority of order is not clear among those countermeasures. The governments cannot decide a policy of tsunami prevention in the future. For this reason, the aim of this study is to propose the suitable countermeasure according to the needs of the people by applying prospect theory. As a result of questionnaire survey in Kushiro city, when non-structural measures and structural measures are improved, non-structural measures are more important than structural measures. Meanwhile, when non-structural measures and structural measures are nothing, these measures don't have difference. That is, the countermeasures which inhabitants want to improve are non-structural measures. However, structural measures should be satisfied with the minimal role for inhabitants.

Keywords: Prospect theory, Tsunami disaster, Risk, Disaster prevention

1. INTRODUCTION

Serious damages happen when tsunami occurs. Recently, serious damage happened in Japan by Great East Japan Earthquake on March 11th, 2011. The damage occurred mainly along the east coast of Hokkaido. Moreover, several problems occur due to the previous countermeasures used. Inhabitants escaped by using their cars. To make matters worse, inhabitants could not get through the bridges because many bridges are submerged. This caused heavy traffic jam. In addition, the height of the wave is larger than what is indicated in the tsunami hazard map. There were many victims of tsunami in the area where awareness of inhabitant was low.

After the occurrence of Great East Japan Earthquake, the tsunami prevention countermeasures become more important in Hokkaido. Prediction of tsunami inundation area was announced in Hokkaido on June 28th, 2012. The potential damage area is larger than the previous prediction in 2009. Local governments thus reconsider tsunami prevention. Several countermeasures have been raised including seawall and tsunami hazard map. Among those countermeasures, the governments mainly enforce countermeasures of evacuation. However, the priority of order is not clear. The governments cannot decide a policy of tsunami prevention in the future. In reconstruction plan of Tohoku area after Great East Japan Earthquake, government promotes the countermeasure of moving the residents to the high ground. However, it is difficult to move the residents to the high ground in Hokkaido. Then, it is important to enforce countermeasures of evacuation in Hokkaido.

On the other hand, inhabitants who live in the tsunami inundation area are anxious about tsunami disaster. That is, inhabitants do not feel safe for disaster prevention in order to announce the inundation area. Local government should reconstruct safety of disaster prevention.

In study of evaluation about tsunami prevention, for example, Tang *et al.* (2008) mention that vulnerability of tsunami disaster can be reduced by effective hazard management plans. Tang *et al.* (2008) regard no studies which have been conducted to determine how local jurisdictions have incorporated tsunami hazard management into their planning frameworks as a problem. Therefore, Tang *et al.* (2008) analyze the quality of hazard management plans from 43 coastal countries. Plan quality was measured by a plan evaluation protocol defined by five components and 37 indicators. In conclusion, local jurisdictions need to build a solid factual basis about tsunami hazard, set appropriate goals and practical objects. In addition, Studies of the tsunami concluded that there is a need for more effective warning and preparedness to evacuate threatened population (Tang *et al.*, 2008). For this reason, governments should set appropriate goals for evacuation.

On the other hand, in studies for human loss, Shishido *et al.* (2009) focus on damage evaluation of human loss through reviewing previous studies and proposing a new method to estimate the tsunami casualty by using fragility function and evacuation. Shishido *et al.* (2009) compare the results of evaluated casualty by using them to know their differences and applicability at Higashi Matsushima in Japan.

In summary, people felt safe for the countermeasure of tsunami prevention until now. However, people did not feel safe for tsunami prevention by prediction. No study considers the loss of safety in human mind.

In studies applying prospect theory, Senbil *et al.* (2003) is an investigation into the applicability of this method in the situation of morning commutes. This study assumed that commuters have two decision frames with multiple reference point and a maximum satisfaction point. Studies on travel behavior applying prospect theory exist like this study. However, no study about the prevention disaster applies prospect theory.

This study applies prospect theory which can evaluate losses and express the human mind about the prevention disaster. Consequently, the aim of this study is to propose the suitable countermeasure according to the needs of the people. Since the perception of gain and loss of a human is different, the prospect theory is applied to capture the needs of the people. Investigation area of this study is Kushiro city.

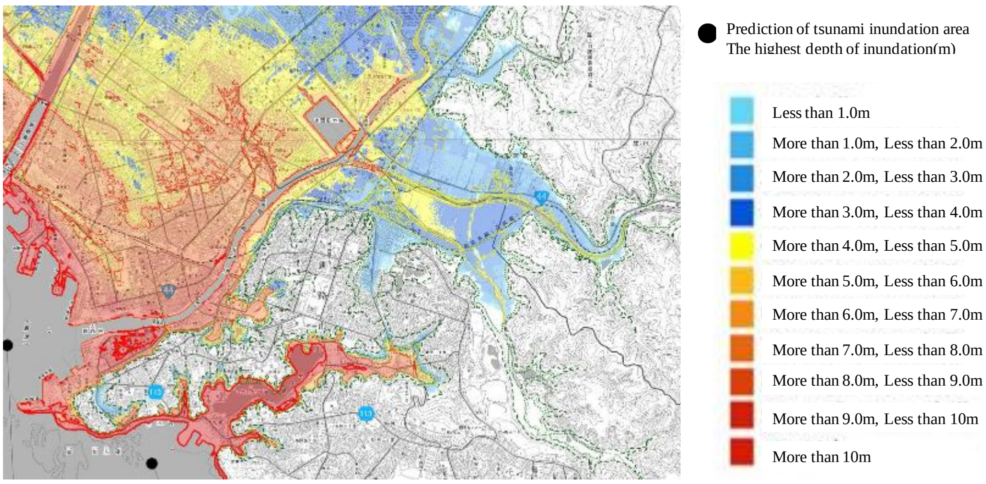

Figure 1. Prediction of inundation area in Kushiro city

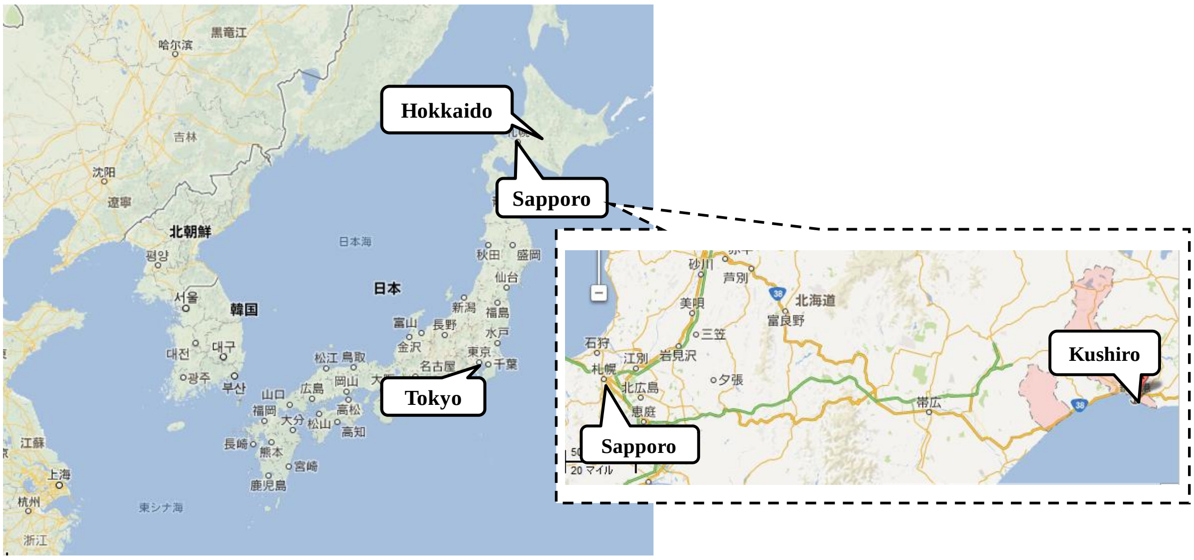

Figure 2. Location of Kushiro city

The map of inundation area in Kushiro city which was announced on June, 2012 is shown by Figure 1. Location of Kushiro city is shown by Figure 2.

2. METHODOLOGY

Prospect theory was made by Daniel Kahneman and Amos Tversky in 1979. Prospect theory is decision making under the risk. This theory can explain decision making which expected utility theory cannot explain. This theory constitutes value function corresponding to utility function of standard economics and weighting function about weight probability.

The features of this theory have four factors.

1) Reference point: it is standard that people judge whether values are gains or losses. The central point means reference point which divide gains and losses. This point usually corresponds to the current asset position.
2) Steeper for losses than for gains: evaluation of losses is relatively larger than that of gains in case of the same expected value both gains and losses.
3) Generally concave for gains and commonly convex for losses: the marginal value of both gains and losses generally decrease with their magnitude. This means gains are risk avoidance and losses are risk preference.
4) Decision weight: objective probability is weight by decision makers. Small probability was overweight. Large probability was underestimated.

Equation of value function and weighting function shows below.

Value function:

$$v(x) = \begin{cases} x^{\alpha} \, (x \geq 0) \\ -\lambda |x|^{\beta} \, (x < 0) \end{cases} \tag{1}$$

where,

$v(x)$: subjective value

α, β : parameters ($0<\alpha<1$, $0<\beta<1$),

λ : coefficient of loss avoidance ($1<\lambda$)

In the previous study (Kahneman *et al.*, 1979), these parameters measured standard value: $\alpha = \beta = 0.88$, $\lambda = 2.55$ The graph of value function is shown by Figure 3.

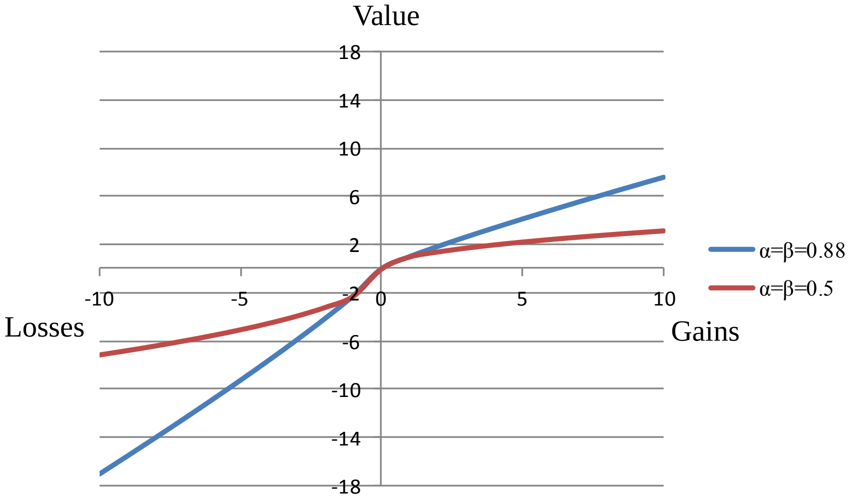

Figure 3. The graph of value function

Weighting function:

$$\pi(p) = \frac{p^{\gamma}}{\left\{p^{\gamma} + (1 - p^{\gamma})\right\}^{1/\gamma}} \tag{2}$$

where,

$\pi(p)$	: decision weight
p	: stated probability
γ	: parameter

In the previous study(Kahneman *et al.*, 1979), this parameter measured $\gamma = 0.69(losses)$, $\gamma = 0.61(gains)$ The graph of weighting function is shown by Figure 4.

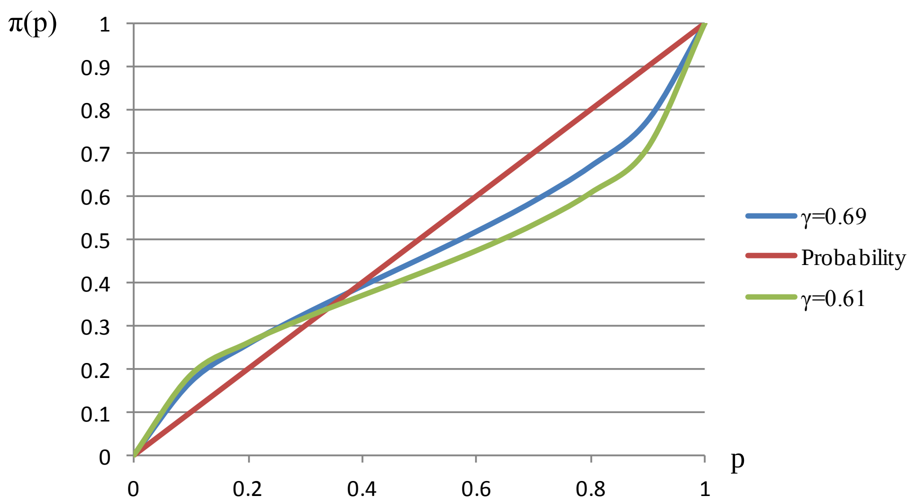

Figure 4. The graph of weighting function

3. QUESTIONNAIRE SURVEY

3.1 Outline of Questionnaire Survey

This study area is Kushiro city in the east of Hokkaido. There are two main reasons to select the city. One reason is that this city has suffered damage from tsunami disaster four times. Second reason is that one hundred thousand people should escape from the biggest tsunami by prediction of tsunami inundation area. For these reasons, new more effective countermeasure should be proposed to the city. The city enforces the countermeasures of tsunami prevention including structural measures and non-structural measures at present. Structural measure is tsunami screen. Non-structural measures are evacuation drill, tsunami hazard map and warning sign for tsunami disaster.

Questionnaire survey was conducted on November 7th and 8th, 2012. One thousand questionnaires were distributed, also the respondents are asked to send back, via the post.

Distribution area set four areas. Table 1 shows the feature of distribution area. Distribution area of questionnaire survey is shown by Figure 5. The reason of selecting these areas is to grasp influence for inhabitants' risk acceptance by difference of geographical condition.

Table 1. The features of distribution area

Area	Feature	
Musa	Inland	High ground
Minami Odori, Fujimi	Coastal area	High ground
Aikoku Higashi, Nishi, Bunen	Coastal area	Low ground
Kushiro station	Inland	Low ground

Figure 5. Distribution area of questionnaire survey

Number of Distribution and Ratio of collection is shown by Table 2.

Table 2. Distribution and collection

Distribution area	Distribution	Collection	Ratio of Collection(%)
Musa area	140	38	27.1
Minami Odori, Fujimi area	250	69	27.6
Aikoku Higashi, Nishi, Bunen area	291	66	22.7
Kushiro Station	319	83	26
Unknown		3	
Total	1000	259	25.9

3.2 Personal Attribute

Result of questionnaire survey, Figure 6 shows measures of disaster prevention which inhabitants carry out in daily life. There are 4 measures of disaster prevention. One is to participate in voluntary prevention disaster organization. This organization is optional group which local voluntary residents carry out working of prevention disaster. Second is to carry out evacuation education. This education has been raised including how to evacuate and where evacuation places are. Third is to conduct evacuation drill. Forth is to prepare for disaster prevention goods including water and some foods. These measures are promoted by Hokkaido government in Hokkaido Regional Disaster Prevention Plan.

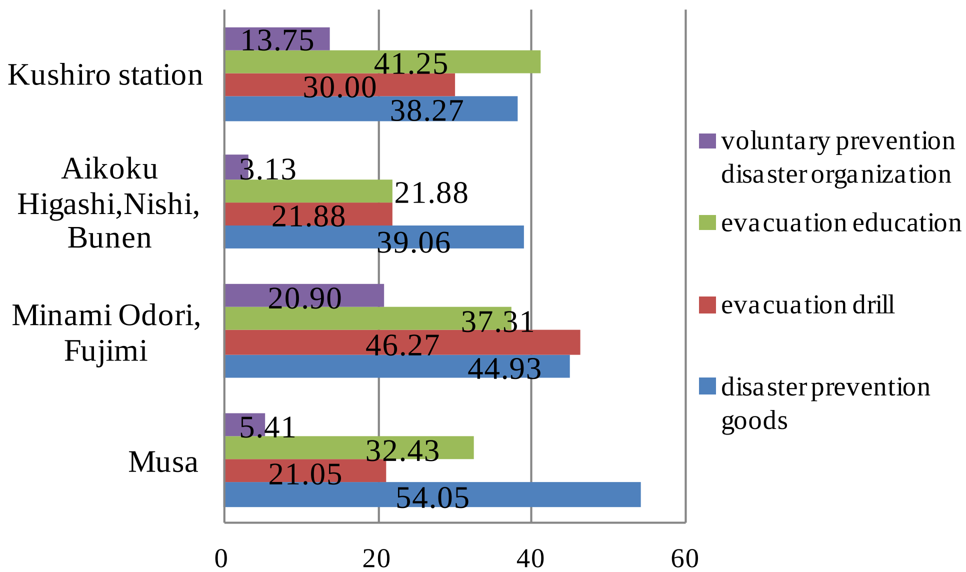

Figure 6. Measures of disaster prevention which inhabitants carry out in daily life

From Figure 6, evacuation drill was conducted by only 22% of inhabitants living in Aikoku

Higashi, Nishi, Bunen area. Before inundation area was predicted, tsunami did not come in this area. Therefore, a rate of conducting evacuation drill is low in this area.

A rate of conducting evacuation drill and evacuation education in coastal area is larger than that of inland. That is, inhabitants living in coastal area are more important countermeasures of evacuation than inhabitants living in inland.

4. ANALYSIS FOR ACCEPTANCE OF TSUNAMI RISK

4.1 Awareness of Inhabitants for Tsunami Disaster

Figure 7 shows awareness of inhabitants living in each area for tsunami disaster. Five rank evaluation was applied for analysis of inhabitants' awareness. By using five ranks, inhabitants' awareness can be understood more detailed.

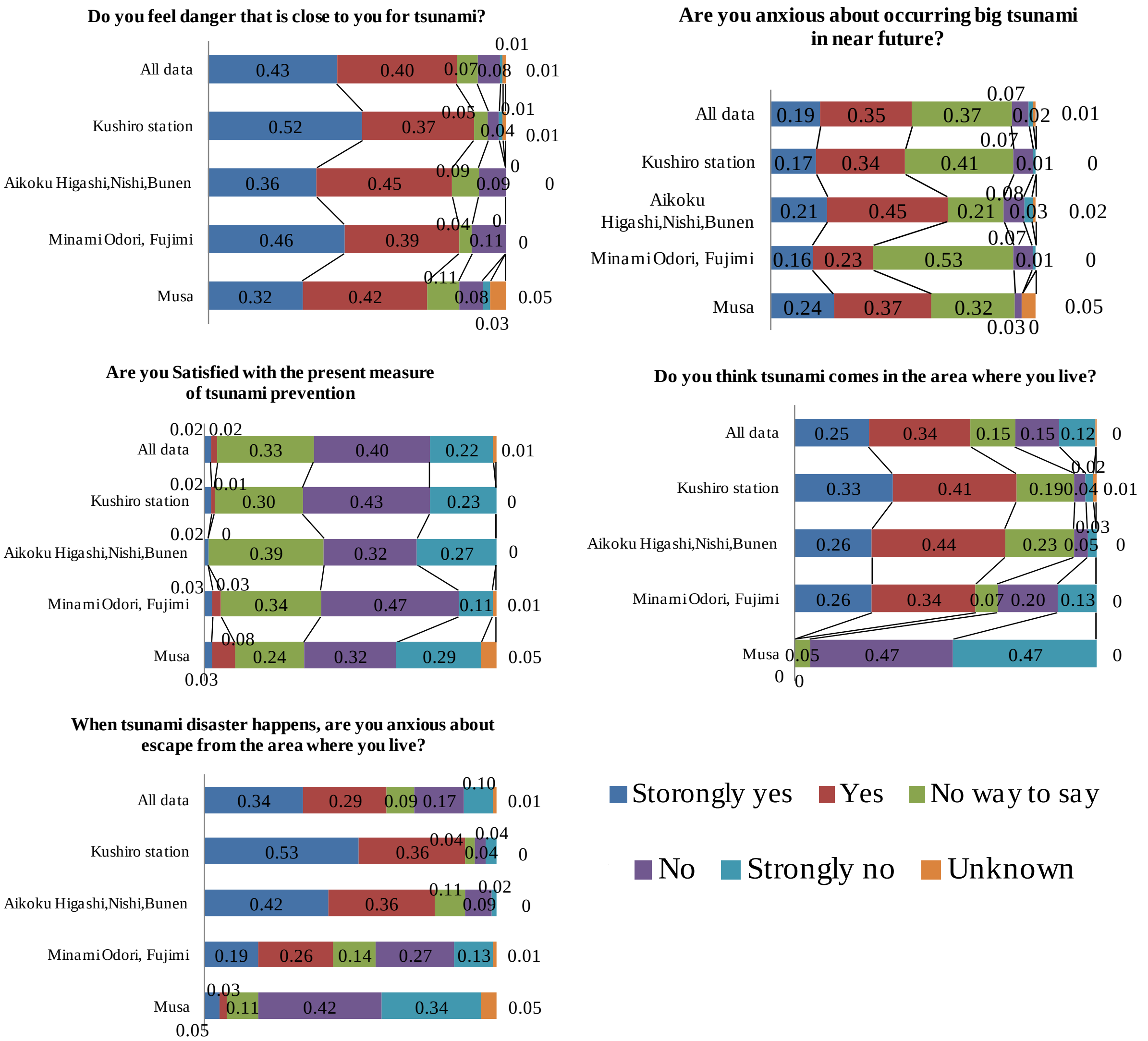

Figure 7. Awareness of inhabitants living in each area for tsunami disaster

From Figure 7, 89% of inhabitants living in the area around Kushiro station are anxious to escape from tsunami. Seventy-eight percent of inhabitants living in Aikoku Higashi, Nishi, Bunen area are anxious to escape from tsunami. However, only 8% of inhabitants living in Musa area are anxious to escape from tsunami.

Then, 74% of inhabitants feel that tsunami comes around Kushiro station where inhabitants live. Seventy percent of inhabitants feel that tsunami comes in Aikoku Higashi, Nishi, Bunen area where inhabitants live. However, all inhabitants do not feel that tsunami comes in Musa area where inhabitants live.

That is, inhabitants living in the low ground greatly feel they are anxious to escape from tsunami. Inhabitants living in the low ground also feel tsunami comes in the area where they live than inhabitants living in the high ground.

4.2 Classification of Tsunami Risk by Applying Discriminant Analysis

This study applies discriminant analysis for classifying inhabitants into two groups, avoidance of tsunami risk and preference of tsunami risk. Gains in this study mean "people can live in the same place without anxiety". Avoidance of tsunami risk defines "though people live in the same place, people are anxious about tsunami disaster". Preference of tsunami risk defines "people do not care about tsunami disaster even if they live in the same place".

Dependent variable is the question, "do you feel danger that is close to you for tsunami?" In the case that the answer of the respondents is "strongly yes" and "yes", these respondents belong to the avoidance of tsunami risk. Avoidance of tsunami risk corresponds to 1 as dummy variable. In the same way, in the case that the answer of the respondents is "strongly no" and "no", these respondents belong to the preference of tsunami risk. Preference of tsunami risk corresponds to 0 as dummy variable. Independent variables are four questions showing Figure 8 from 1 to 4. "Strongly no" through "strongly yes" of four questions' answer corresponds to from 1 to 5 in discriminant analysis.

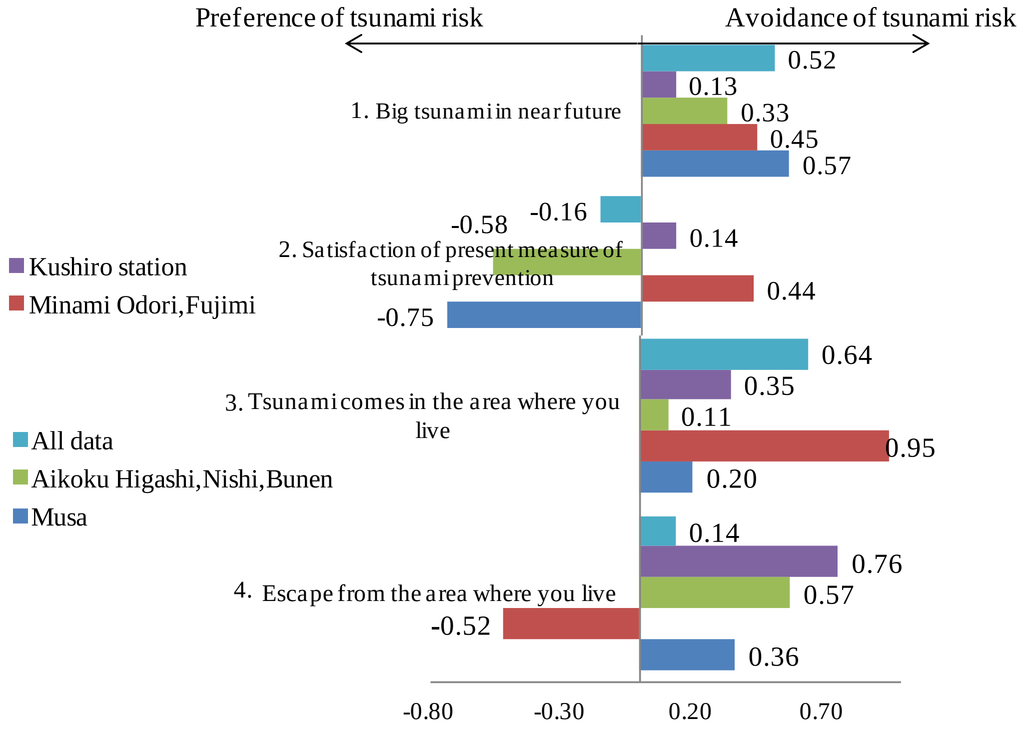

Figure 8. Standardized coefficient of regular discriminant function in all area

From Figure 8, the most important factor for classification of tsunami risk in Kushiro station is "Escape from the area where you live". This value of the factor is 0.76. If inhabitants agree this factor, these inhabitants are avoidance of tsunami risk. Moreover, important factor for classification of tsunami risk in Aikoku Higashi, Nishi, Bunen area is also "Escape from the area where you live". If inhabitants agree this factor, these inhabitants are avoidance of tsunami risk. This value of the factor is 0.57. That is, inhabitants living in the low ground influenced evacuation during tsunami disaster.

5. EVALUATION OF DISASTER PREVENTION

5.1 Model Equation of Value Function

This study makes model equations of value function. Moreover, it does not make weighting function. That is because probability of disaster is unclear. X contains structural measure and non-structural measures. Structural measure applies height of seawall. Non-structural measures apply "conducting evacuation drill", "making tsunami hazard map" and "ensuring evacuation road". The reasons of selecting these non-structural measures are to be conducted many cities. Y applies the satisfaction of safety. The present countermeasures of disaster prevention were scored 50 in this study. Respondents can score from 0 to 100 for combinations both structural measure and non-structural measures.
After all, the model can be obtained as follows.

Gains: $y = x^{\alpha}$

$$x = t_1 * x_1 + t_2 * x_2 + t_3 * x_3 + t_4 * x_4 \tag{3}$$

where,

y	: satisfaction of safety (score * 0.1)
x	: Countermeasure of prevention disaster (structural measure + non-structural measures)
x_1	: height of seawall (+1m, +2m, +4m)
x_2	: conducting evacuation drill (0: present, 1: improved)
x_3	: making tsunami hazard map (0: present, 1: improved)
x_4	: ensuring evacuation road (0: present, 1: improved)
t_1, t_2, t_3, t_4	: parameters for each countermeasure

In the same way, Losses: $y = -\lambda |x|^{\beta}$

$$x = c_1 * x_1 + c_2 * x_2 + c_3 * x_3 + c_4 * x_4 \tag{4}$$

where,

x_1	: height of seawall (-1m, -2m, -4m)
x_2	: conducting evacuation drill (-1: nothing, 0: present)
x_3	: making tsunami hazard map (-1: nothing, 0: present)
x_4	: ensuring evacuation road (-1: nothing, 0: present)
c_1, c_2, c_3, c_4	: parameters for each countermeasure

Three dummy variables namely x2, x3 and x4 are used in the model. In case of improving non-structural measure, this study defined as follows.

1) Conducting evacuation drill improved: increasing number of conducting evacuation drill and conducting large-scale training of disaster prevention twice a year
2) Making tsunami hazard map improved: indicating information about inundation area both large-scale earthquake and frequently occurring earthquake
   Inhabitants can always get information about the present sea wave.
3) Ensuring evacuation road improved: the countermeasures of fallen objects and constructing support system for uninterrupted evacuation
   Common knowledge of evacuation road and evacuation sign

In this study, reference point determines 4m of seawall. Moreover, non-structural measures determine the situation in which each measure is conducting.

5.2 Estimation of Parameters for Value Function

This study estimates the parameters of value function for each area. Estimation of value function applied non-linear regression analysis. Therefore, these parameters were calculated by the least squares method. Table 3 means the estimation of the parameters for value function in gains. Table 6 means the estimation of the parameters for value function in losses. In Table 3 and Table 6, the only statistically parameters were shown. Table 4 and Table 5 mean the coefficient of graph's determination for each area in gains and losses.

Table 3. Estimation of value function (gains)

area		α	t_1	t_2	t_3	t_4
All data	parameter	0.87	0.32	2.00	1.63	1.87
	t-value	26.21	10.09	8.01	4.38	12.45
	p-value	2e-16***	2e-16***	1.93e-14***	1.62e-5***	2e-16***
Musa area	parameter	0.93	0.58	-	-	1.66
	t-value	7.21	3.93	-	-	4.99
	p-value	2.43e-08***	0.00041***	-	-	1.88e-05***
Minami Odori, Fujimi area	parameter	0.99	0.38	1.64	1.24	1.68
	t-value	18.38	8.03	5.13	2.99	6.77
	p-value	2e-16***	3.96e-12***	1.75e-6***	0.00363**	2.21e-9***
Aikoku Higashi, Nishi, Bunen area	parameter	0.88	0.23	1.96	1.72	1.94
	t-value	11.56	3.69	4.64	1.99	7.10
	p-value	2e-16***	0.000381***	1.16e-5***	0.049234*	2.60e-10***
Kushiro station	parameter	0.84	0.26	1.73	-	2.07
	t-value	12.75	4.50	3.00	-	7.93
	p-value	2e-16***	1.71e-5***	0.00337**	-	2.20e-12***

<Significant level> ***: 0.001, **: 0.01, *: 0.05, -: not significant

Table 4. Coefficient of determination (gains)

area	All data	Musa area	Minami Odori, Fujimi area	Aikoku Higashi, Nishi, Bunen area	Kushiro station
R^2	0.67	0.95	0.58	0.69	0.75

Table 5. Coefficient of determination (losses)

area	All data	Musa area	Minami Odori, Fujimi area	Aikoku Higashi, Nishi, Bunen area	Kushiro station
R^2	0.83	0.75	0.81	0.81	0.85

Table 6. Estimation of value function (losses)

area		β	λ	c_1	c_2	c_3	c_4
All data	parameter	0.33	3.35	0.30	0.89	-	1.39
	t-value	8.36	37.56	9.74	3.05	-	7.14
	p-value	1.22e-15***	2e-16***	2e-16***	0.00243**	-	4.78e-12***
Musa area	parameter	0.41	3.27	0.45	-	-	1.00
	t-value	3.51	12.47	6.64	-	-	3.58
	p-value	0.00118**	5.33e-15***	7.5e-8***	-	-	0.000949***
Minami Odori, Fujimi area	parameter	0.43	3.02	0.41	-	-	0.76
	t-value	14.36	3.94	10.40	-	-	3.55
	p-value	2e-16***	0.000173***	2e-16***	-	-	0.000649***
Aikoku Higashi, Nishi, Bunen area	parameter	0.42	3.38	0.31	0.71	0.88	0.90
	t-value	4.55	19.94	9.92	3.24	2.05	6.77
	p-value	1.4e-5***	2e-16***	2e-16***	0.00161**	0.04244*	7.78e-10***
Kushiro station	parameter	0.26	3.58	0.24	1.46	-	1.34
	t-value	4.32	24.28	5.58	2.00	-	4.72
	p-value	3.21e-5***	2e-16***	1.52e-7***	0.048*	-	6.62e-6***

<Significant level> ***: 0.001, **: 0.01, *: 0.05, -: not significant

If these equations comply prospect theory, α, β, λ must be satisfied with these conditions($0<\alpha<1$, $0<\beta<1$, $1<\lambda$). In this result, all parameters are satisfied with these conditions. That is, these equations follow prospect theory.

Figure 9 shows the graphs of value function by using these parameters.

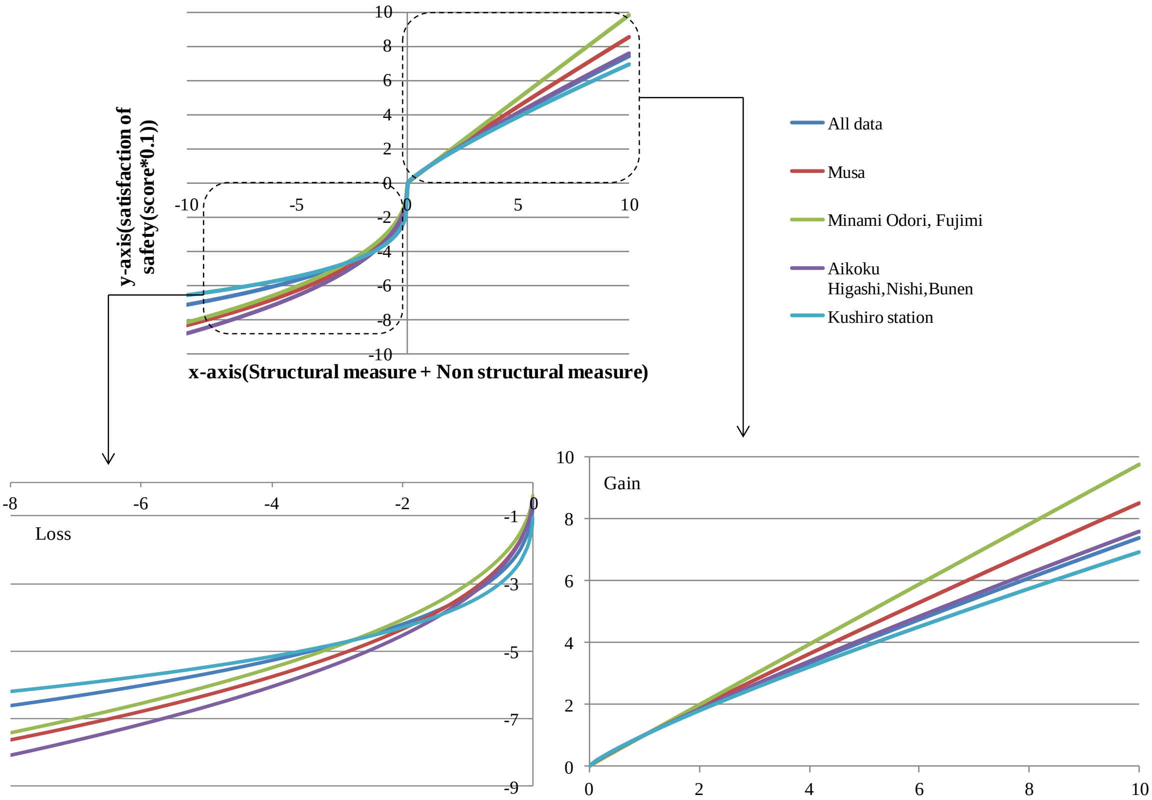

Figure 9. The graphs of value function for all areas

From Figure 9, the equation can be divided into gains and losses. This study's data set non continuous value on the basis of 0.

The satisfaction of safety in Kushiro station does not increase comparing with the others area in gains. Moreover, the satisfaction of safety in the low ground is less than that of safety in the high ground. Inhabitants living in the low ground feel less safety than inhabitants living in the high ground even if the countermeasures are improved. In other words, inhabitants living in the high ground feel safety by improving a little quality of disaster prevention.

On the other hand, the rate of decrease in Kushiro station is larger than the others when x value is small in losses. In addition, the amount of decrease in Aikoku Higashi, Nishi, Bunen area is larger than the others when x value is large in losses. Inhabitants living in the low ground tend to decrease satisfaction of safety by falling a little quality of disaster prevention.

5.3 Evaluation about the Countermeasure of Disaster Prevention

The result of satisfaction of safety for each countermeasure is shown in Table 7. This analysis is reliable. That is because coefficients of determination for each graph in gains and losses are almost high. From this result, the highest score for all countermeasures is 68.41 in gains. Ensuring of evacuation road in Kushiro station marked this score. Moreover, evacuation drill in Aikoku Higashi, Nishi, Bunen area is 68.09. This score means the second highest score for all areas in gains. On the other hand, the lowest score for all countermeasures is 52.75 in gains. Height of seawall in Aikoku Higashi, Nishi, Bunen area marked this score. That is, it is safer for inhabitants to improve non-structural measures than structural measure.

The highest score for all countermeasures is 29.37 in losses. Height of seawall in Minami Odori, Fujimi area marked this score. On the other hand, the lowest score for all countermeasures is 10.47 in losses. Evacuation drill in Kushiro station marked this score. From result of gains and losses, inhabitants living in the area around Kushiro station are easily influenced by quality of disaster prevention.

Table 7. Satisfaction of safety for each countermeasure

Gain	All data	Musa area	Minami Odori, Fujimi area	Aikoku Higashi, Nishi, Bunen area	Kushiro station
Height of seawall raise 1m	53.69	56.07	56.92	52.75	53.27
Evacuation drill improve	68.26	N/A	62.04	68.09	65.86
Tsunami hazard map improve	65.30	N/A	60.85	66.15	N/A
Ensuring of evarcuation rout improve	67.21	66.00	62.17	67.95	68.41
Loss	**All data**	**Musa area**	**Minami Odori, Fujimi area**	**Aikoku Higashi, Nishi, Bunen area**	**Kushiro station**
Height of seawall is 1m low.	27.47	26.34	29.37	29.26	25.36
Evacuation drill is nothing	17.70	N/A	N/A	20.68	10.47
Tsunami hazard map is nothing	18.79	N/A	N/A	17.96	N/A
Ensuring of evacuation rout is nothing	12.65	17.22	23.12	17.66	11.38

N/A: not significant parameter

The result of converting satisfaction of safety for each countermeasure from reference point into height of seawall is shown in Table 8. This analysis is reliable. That is because coefficients of determination for each graph in gains and losses are almost high. From this result, ensuring evacuation road in Kushiro station is the same as 5.62m of seawall in gains. Moreover, evacuation drill in Aikoku Higashi, Nishi, Bunen area is the same as 6.57m of seawall in gains. Non-structural measures are more important than structural measure in the low ground.

On the other hand, ensuring evacuation road in Kushiro station is the same as 1.57m of seawall in losses. Moreover, evacuation drill in Aikoku Higashi, Nishi, Bunen area is the same as 1.41m of seawall in losses. Structural measure and non-structural measures in the low ground do not have difference in losses.

Table 8. Result of converting satisfaction of safety into height of seawall

Gain	Height of seawall	Evacuation drill	Tsunami hazard map	Ensuring evacuation road
Musa area	1.00	N/A	N/A	2.64
Minami Odori, Fujimi area	1.00	1.74	1.57	1.76
Aikoku Higashi, Nishi, Bunen area	1.00	6.57	5.86	6.52
Kushiro station	1.00	4.85	N/A	5.62
Loss	**Height of seawall**	**Evacuation drill**	**Tsunami hazard map**	**Ensuring evacuation road**
Musa area	1.00	N/A	N/A	1.39
Minami Odori, Fujimi area	1.00	N/A	N/A	1.30
Aikoku Higashi, Nishi, Bunen area	1.00	1.41	1.55	1.56
Kushiro station	1.00	1.60	N/A	1.57

N/A: not significant parameter

6. CONCLUSION

From inhabitants’ awareness for tsunami risk, 89% of inhabitants living in the area around Kushiro station are anxious to escape from tsunami. From value function, Ensuring of evacuation road in Kushiro station is the highest score 68.41 in gains. Commitment of tsunami prevention is ensuring evacuation road around Kushiro station. If inhabitants are anxious about evacuation from tsunami disaster, these inhabitants are avoidance of tsunami risk. Therefore, it is important for guarantee of safety to make support system of evacuation. For instance, evacuation road can get through even if tsunami disaster happens. It is effective to prevent evacuation road from being obstructed by building restrictions. In the future, study on evacuation behavior considering car users is needed in order to solve traffic jam during tsunami disaster.

In addition, from inhabitants' awareness for tsunami risk, 78% of inhabitants living in Aikoku Higashi, Nishi, Bunen area are anxious to escape from tsunami. From value function, evacuation drill in Aikoku Higashi, Nishi, Bunen area is the second highest score 68.09 in gains. Commitment of tsunami prevention is conducting evacuation drill in Aikoku Higashi, Nishi, Bunen area. Inhabitants living in Aikoku Higashi, Nishi, Bunen area thought tsunami did not come in this area before prediction of inundation area. For this reason, a rate of conducting evacuation drill is low. However, this area has probability of coming tsunami by the prediction. Inhabitants are anxious to escape from tsunami. It is important for guarantee of safety to increase number of evacuation drill and to prepare against tsunami disaster through large-scale training of disaster prevention. It is important for the future study to make the methods of conducting evacuation drill which inhabitants' awareness of tsunami disaster rise.

On the other hand, non-structural measures are more important than structural measures generally. This thing is especially important for inhabitants living in the low ground in gains. From result of Table 8, ensuring evacuation road in Kushiro station is the same as 5.62m of seawall in gains. Evacuation drill in Aikoku Higashi, Nishi, Bunen area is the same as 6.57m of seawall in gains. Moreover, non-structural measures and structural measures do not have difference in losses. From result of Table 8, ensuring evacuation road in Kushiro station is the same as 1.57m of seawall in losses. Moreover, evacuation drill in Aikoku Higashi, Nishi, Bunen area is the same as 1.41m of seawall in losses. Decline of satisfaction in losses is larger than improvement of satisfaction in gains. In other words, people are pretty anxious about falling quality of disaster prevention. In the future, a study considering the change of evaluation for structural measures and non-structural measures in case of constructing tsunami escape building in the low ground is needed.

The results of this study are evaluation of tsunami prevention considering tsunami risk of inhabitants and area. The results of this study are also evaluation introducing to loss of human mind. Furthermore, non-structural measures are more important than structural measures in gains, while non-structural measures is approximately equal to structural measures in losses. That is, the countermeasures which inhabitants want to improve are non-structural measures. However, structural measure should be satisfied with the minimal roles for inhabitants.

Future issues are inspection of value function and making model which can consider the other countermeasures of tsunami prevention. Making weighting function is also future issue. Although probability of tsunami is unclear, probability which people think may have some similarities by subdividing magnitude of tsunami. In this case, weighting function can be estimated.

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