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THE EFFECT OF SOME EXPERIENCES AND THE PUBLICATION OF POTENTIAL DISASTER RISK INFORMATION ON INHABITANTS' BEHAVIOR IN STORM SURGE DISASTER

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***ABSTRACT*:** The purpose of this study is to verify an influence of inhabitants' disaster experiences and the publication of potential disaster risk information on the inhabitants' consciousness and action, using the data from a questionnaire survey instancing the case of Takamatsu in storm surge by Typhoon 0416 and 0418. The followings are revealed through this survey

In the case of typhoon 0416 in August 30, 2004, the damage caused by a storm surge in Takamatsu was very serious. But both the government and inhabitants could not deal with the emergency and were in a state of disorder, because it was an extremely rare case and most people believed that this district is a safe place against natural disasters. So, it seems that this case corresponds to the case of no experiences of disaster. However, in the case of inhabitants who recognized the potential risks through the hazard maps, there is higher incidence of proper action than in the inhabitants who lacked its recognition. Such a tendency is confirmed mainly among the inhabitants with short residence in this district.

In the case of typhoon 0418 in September 7, 2004, both the government and inhabitants dealt with the situation promptly for fear of the same storm surge. But there ware almost no damages due to the storm surge. So, this case corresponds to the no damage experience of disaster.

KEYWORDS: effect of disaster information, a storm-tide warning, inhabitants' behavior

1. INTRODUCTION

In early stage of natural disasters such as storm surge disaster, it is considered that most people take the next step of action based on some knowledge or folklore accumulated from the past experiences. However, in the cases of no damage experience or no experience, it is feared that the lack of knowledge for proper action leads to delay of evacuation behavior and serious damage. In such cases, the improvement of inhabitants' perception of potential risks through the educations for disaster mitigation such as a publication of hazard maps plays an important role in practice proper action.

The purpose of this study is to verify an influence of inhabitants' disaster experiences and the publication of potential disaster risk information on the inhabitants' consciousness and action, using the data from a questionnaire survey instancing the case of Takamatsu in storm surge by Typhoon 0416 (T16) and 0418 (T18).

In the case of T16 in August 30, 2004, the damage caused by a storm surge in Takamatsu was very serious. But both the government and inhabitants could not deal with the emergency and were in a state of disorder, because it was an extremely rare case and most people believed that this district is a safe place against natural disasters.

In the case of typhoon 0418 in September 7, 2004, both the government and inhabitants dealt with

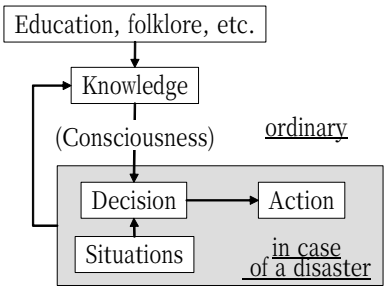

Figure 1. Outline of influencing factors to preventive action

Table 1. Summary of the Questionnaire survey design

Period	Aug. 28, 2004～Oct. 25, 2004
Subject area	Inundated area of T16 in Takamatsu city, Kagawa prefecture
Recovery	32.9% (1,447 / 4,402)
Distribution	We visited every household in the subject area, and dropped into letter boxes.
Return	By mail (free)

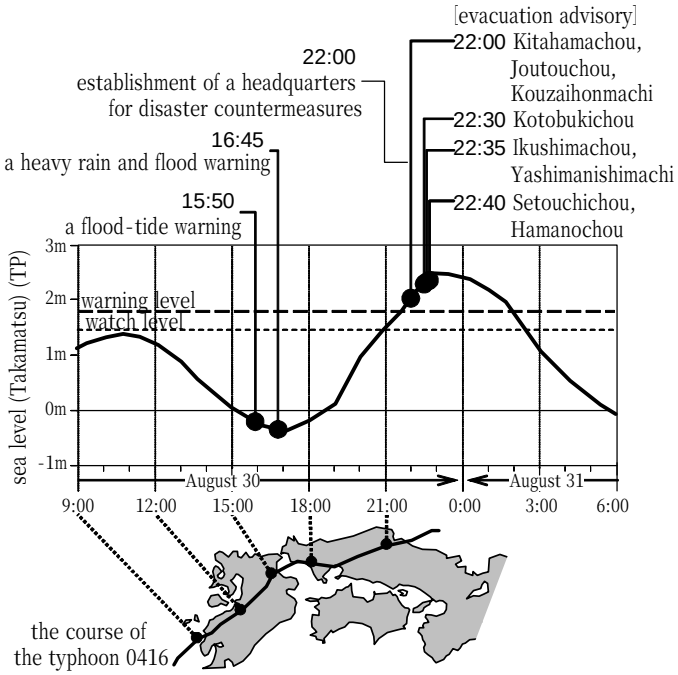

Figure 2. Time history of the sea level and some related matters.

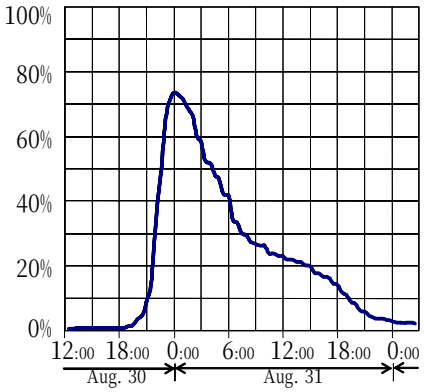

Figure 3. Percentage of inundated respondents

the situation promptly for fear of the same storm surge. But there ware almost no damages due to the storm surge.

2. FRAMEWORK OF ANALYSIS

2.1 Outline of influencing factors to preventive action

It is considered that the relationship between inhabitants' preventive action and influencing factors can be summarized as Figure 1. Basically, in case of a disaster, the factors influencing to inhabitants' decision what preventive action should be taken can be divided into two elements. One is situations such as inundation, warning, watch and so on. And the other is knowledge accumulated through the education, folklore, experiences and so on before. Needless to say, the process of the decision and action on that occasion is accumulated as an experience.

It may be said that this feedback loop occurred twice in the case of Takamatsu in 2004.

2.2 Questionnaire survey design

In order to verify the above structure and grasp the actual state of storm surge disasters, we set out a questionnaire survey on inhabitants in the inundated area of T16 in Takamatsu city, Kagawa prefecture. The period of the questionnaire was from August 28, 2004 to October 25, 2004. The enforcement plan of the questionnaire is summarized in Table 1.

Figure 4. Transition of inundated respondents

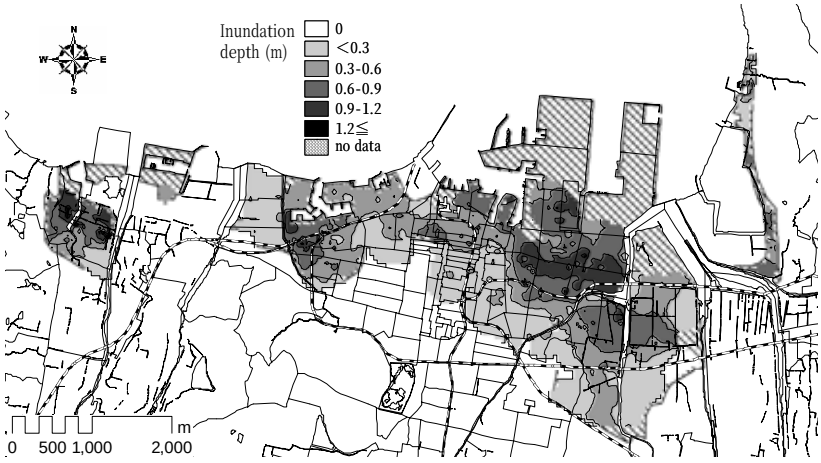

Figure 5. Distribution of maximum inundation depth based on the replies submitted to this questionnaire

3. THE ACTUAL STATE OF STORM SURGE BY TYPHOON 0416 IN TAKAMATSU

Time history of the sea level, the course of the T16 and some related matters are summarized in Figure 2. In the period up to highest sea level, evacuation advisory was issued to a part of inundation area.

Based on the replies submitted to this questionnaire, the time series changes of the percentage of inundated respondents are shown in Figure 3. As may be seen from Figure 3, the percentage increases suddenly to the peak in the period from 21:00 to 0:00. On the other hand, it is found out that the curve has two trends of decrease.

So, Figure 4 showing the transition of the distribution of inundated respondents by word and Figure 5 shows the distribution of inundation depth lead to confirmation that the area with prolonged inundation overlaps with the area with deep inundation.

4. PREVENTIVE ACTION IN TYPHOON 0416

4.1 Transition of action, consciousness and information

Figure 6 shows the Transition of preventive action, consciousness and getting some related information. Through this result we found the following.

In early stage, only a few percent of inhabitants act to prevent household effects from inundation. This percentage increases suddenly from 21:00 to 0:00. This trend overlaps with the increasing trend of inundation (Figure 3).

On the other hand, in early stage, inhabitants get some information and thought that storm surge might occur in Takamatsu at a high rate. However, almost all inhabitants had not have no idea of inundation at home concretely till being inundated. For these reasons, many inhabitants' action to prevent household effects from inundation was behind.

4.2 Previous consciousness before T16

So, it seems that the improvement of inhabitants' perception of potential risks plays an important role in practice proper action.

Accordingly, in this section, we study the inhabitants' previous disaster consciousness before T16 using a principal component analysis (PCA) on

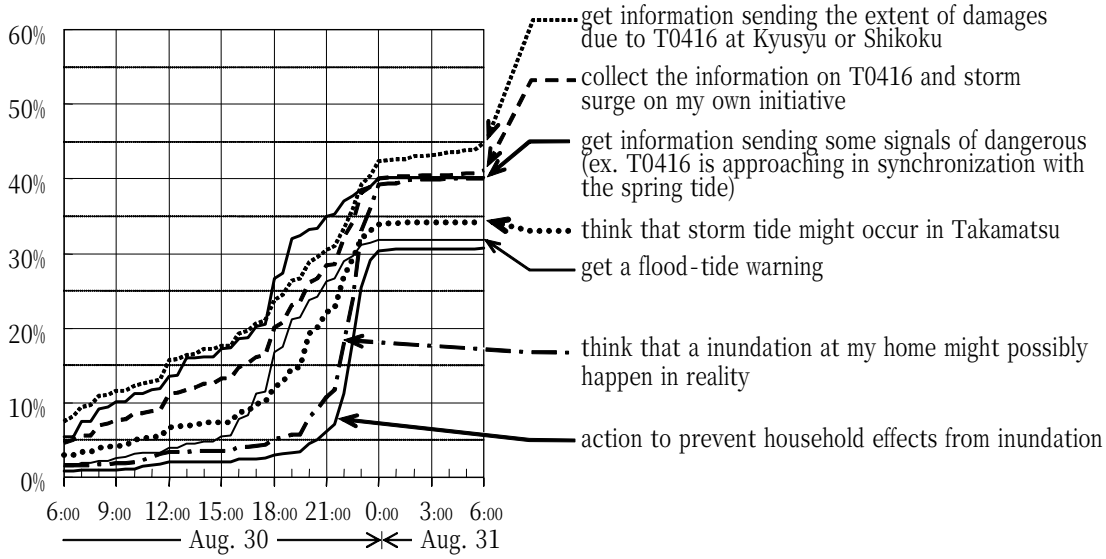

Figure 6. Transition of action, consciousness and information

Table 2. Result of principal component analysis for respondents' previous consciousness

Variable	Description	Criterion					Principal Component Analysis*		
		5	4	3	2	1	Axis 1	Axis 2	Axis 3
PC1	[Previous consciousness (1)] Before T0416, under the impression that Kagawa prefecture was safety against high tide disaster?	No	rather No	neutral	rather Yes	Yes	**0.711**	-0.017	0.004
PC2	[Previous consciousness (2)] Before T0416, had never imaginated the high tide disaster at home?	No	rather No	neutral	rather Yes	Yes	**0.849**	-0.156	-0.197
PC3	[Previous consciousness (3)] Before T0416, had never imaginated the inundation by high tide at home?	No	rather No	neutral	rather Yes	Yes	**0.793**	-0.211	-0.186
PC4	[Previous consciousness (4)] Before T0416, had supposed that home would be inundated a little?	Yes	rather Yes	neutral	rather No	No	-0.191	**0.872**	0.162
PC5	[Previous consciousness (5)] Before T0416, had susposed that home would be inundated considerably?	Yes	rather Yes	neutral	rather No	No	-0.092	**0.904**	0.106
PC6	[Previous consciousness (6)] Before T0416, had the neighboring areas submerged by high tide?	Yes	rather Yes	neutral	rather No	No	-0.144	0.203	**0.763**
PC7	[Previous consciousness (7)] Before T0416, had the neighboring areas submerged slighter than T0416 high tide ?	Yes	rather Yes	neutral	rather No	No	-0.100	0.051	**0.842**
	Eigenvalue						1.930	1.692	1.400
	% of Variance						27.6	24.2	20.0
	Cumulative %						27.6	51.7	71.7

* Rotation Method: Varimax with Kaiser Normalization.

seven variables. The description of variables and the result of PCA are shown in Table 2.

Through this result, we found that these variables were summarized into three axes of variation. The first component summarizes the cognition level of occurrence potential of disaster, the second summarizes the awareness level of possibility of inundation damage, and the third summarizes the experience level of inundation damages.

It is expected that the component scores of PCA axes calculated for each inhabitants play an important role in decision in case of a disaster.

4.3 Logistic regression of preventive action in T16

In order to examine the magnitude and direction of the elements, knowledge, situations, on the decision of the preventive action in case of T16, we use logistic regression model. The logistic regression

Table 3. Logistic regression of action to prevent household effects from inundation in T0416

	Coefficient	t-stat
Constant	-2.003	13.787
Warning(T16)	0.547	2.737
Warning(T16) * CS1	0.302	2.734
Warning(T16) * CS2	-	-
Warning(T16) * CS3	-	-
CS1	-	-
CS2	0.270	2.897
CS3	-	-
Chi-square	25.993	
df	3	
Significance	0.000	
% Correct	84.2	
Likelihood Ratio	0.393	
Cases	816	

Dependent Variable : action(T16)
(1 if act before 10:30, 0 otherwise)
Method : Backward Stepwise (Likelihood Ratio)

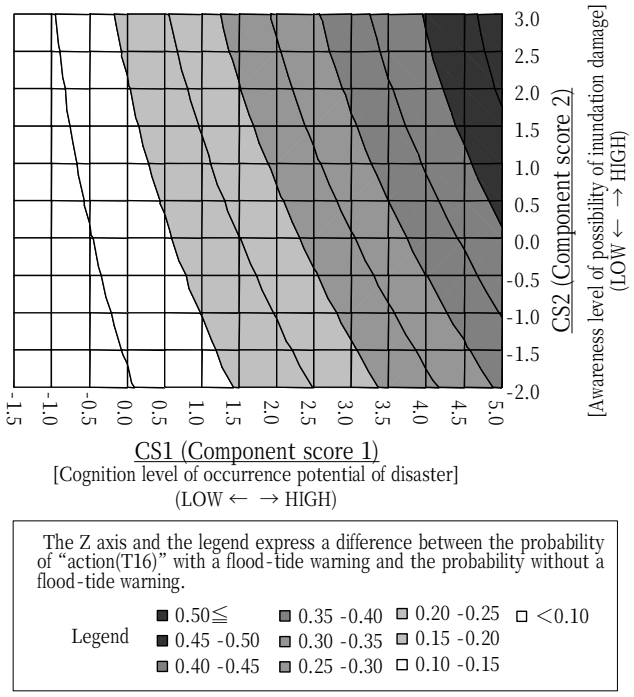

Figure 7. Effect of getting a flood-tide warning on inhabitants' action to prevent household effects from inundation

model is a choice provability model that uses the preventive action decision as the dependent variable. The provability of preventive action is estimated as:

$$P(\text{preventive action}) = \frac{1}{1+e^{-Z}} \qquad \cdots\cdots\cdots(1)$$

$$Z = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \cdots + \alpha_k x_k \qquad \cdots\cdots\cdots(2)$$

where α is regression coefficients and x is a independent variables. The provability of preventive

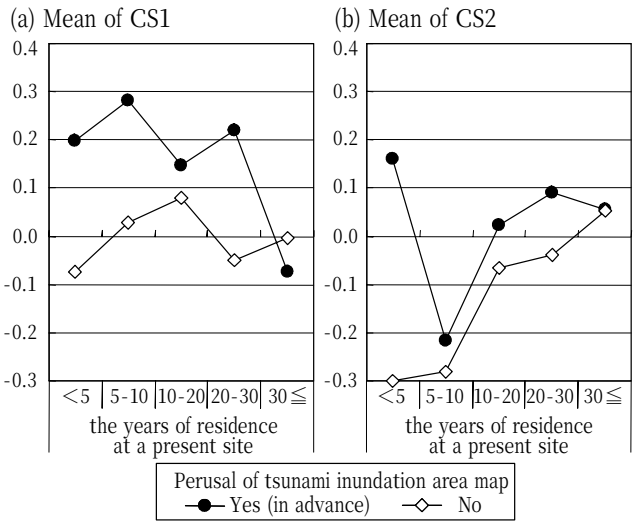

Figure 8. Effect of the publication of potential disaster risk information on respondents' previous consciousness

action increases as the value of Z increases.

The result of logistic regression model of prevent action in T16 are shown in Table 3. The coefficients are jointly significantly different from zero according to the chi-square statistic. The following equation is rearranged this result according to equation(2).

$$Z = -2.003 + warning(T16)\cdot(0.547 + 0.302\cdot CS1) + 0.270\cdot CS2 \qquad \cdots\cdots\cdots(3)$$

Through this result, we found that getting a flood-tide warning was not only an effectiveness factor independently in increasing the provability of preventive action increases, but also more effective in case of the higher cognition level of occurrence potential of disaster. Figure 7 shows the effect of getting a flood-tide warning on inhabitants' preventive action graphically in a difference between the probability with a flood-tide warning and the probability without a flood-tide warning. From the result, it is confirmed that getting a flood-tide warning was more effective in case that of the higher previous consciousness of disaster.

4.4 Effect of potential disaster risk information

The importance of the previous consciousness in the preventive action is shown in the above section,

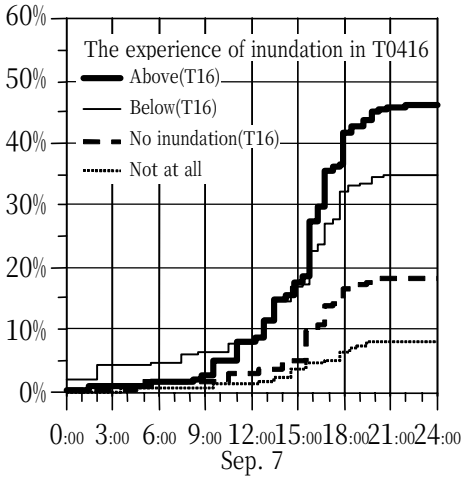

Figure 9. Transition of preventive action in T0418 by the experience in T0416

so in this section, we would like to verify the effect of the beforehand publication of potential disaster risk information.

Figure 8 shows the effect of the perusal of tsunami inundation area map in a difference between the mean of component score of PCA axis 1 (CS1) or axis 2 (CS2) by the years of residence at a present site. From the result of the calculation, it is understood that the previous consciousness of inhabitants who recognized the potential risks by the perusal of tsunami inundation area map in advance is a higher than among the inhabitants who lacked recognition of it. Such a tendency is confirmed mainly among the inhabitants with short residence in this district.

In the subject area of this survey, storm surge hazard map was not published at that time, but tsunami inundation area map was published at June, 2004. This map is not for a storm surge exactly, but it is considered that this map took an important role for inhabitants without any inundation experiences in the judgment whether the neighboring area is a lower land to be submerged in sea water or not.

5. PREVENTIVE ACTION IN TYPHOON 0418

Figure 9 shows the transition of preventive action in T18 by the experience or inundation in T16. When

Table 4. Summary of variables

Variable	Description
Action (T16)	1 if took an action to prevent household effects from inundation in T16, 0 otherwise
No Inundation (T16)	1 if no inundation (the neighborhood was inundated) in T16, 0 otherwise
Below (T16)	1 if inundated below the floor in T16, 0 otherwise
Above (T16)	1 if inundated Above the floor in T16, 0 otherwise
Warning (T18)	1 if given a flood-tide warning in T18, 0 otherwise
Action (T18)	1 if took an action to prevent household effects from inundation in T18, 0 otherwise

Table 5. Logistic regression of action to prevent household effects from inundation in T0418

	Coeff.	t-stat
Constant	-2.784	8.874
Experiences in T0416		
No inundation(T16)	-	-
Below(T16)	1.098	2.045
Above(T16)	1.361	2.452
Action(T16)	2.451	5.465
Action(T16) * No inundation(T16)	-	-
Action(T16) * Below(T16)	-1.393	2.725
Action(T16) * Above(T16)	-	-
Extent in T0418 and interaction		
Warning(T18)	-	-
Warning(T18) * No inundation(T16)	1.706	4.575
Warning(T18) * Below(T16)	1.151	2.650
Warning(T18) * Above(T16)	1.669	3.037
Warning(T18) * Action(T16)	-	-
Warning(T18) * Action(T16) * No inundation(T16)	-1.650	2.955
Warning(T18) * Action(T16) * Below(T16)	-	-
Warning(T18) * Action(T16) * Above(T16)	-2.158	4.236
Chi-square	203.815	
df	9	
Significance	0.000	
% Correct	69.1	
Likelihood Ratio	0.177	
Cases	994	

Dependent Variable : Action(T18) (1 if act , 0 otherwise)
Method : Backward Stepwise (Likelihood Ratio)

Figure 6 (T14) and Figure 9 (T18) are compared, we found that the rate of preventive action increases gentler as it's close to the time at high water in spite of almost no inundation in T18 than in T16. And the experience of inundation in T16 had a great effect on a predictive action in T18.

So in this chapter, we verify the factors of preventive action in T18 in detail.

We use logistic regression model in order to examine the magnitude and direction of the experiences in T16 as a knowledge factor and getting a flood-tide warning as a situations factor on the decision of the preventive action in case of T18. The

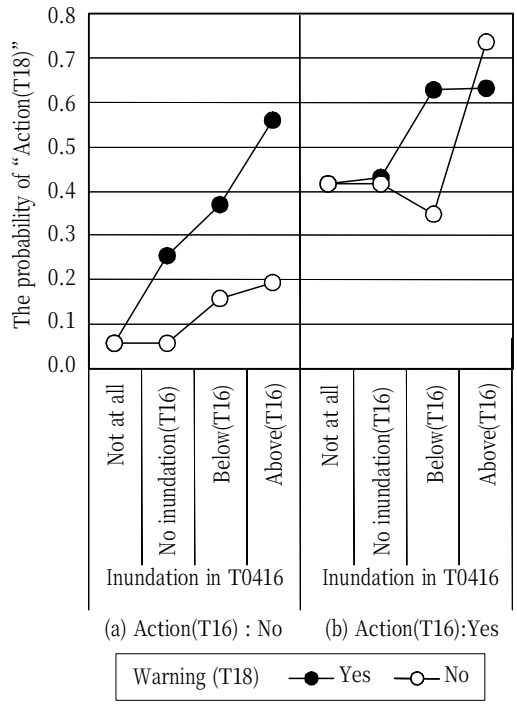

Figure 10. Effect of getting a flood-tide warning in T0418 on inhabitants' preventive action

list of variables in this model is shown in Table 4.

The result of logistic regression model of prevent action in T18 are shown in Table 5. The coefficients are jointly significantly different from zero according to the chi-square statistic. Figure 10 shows the effect of getting a flood-tide warning on inhabitants' preventive action graphically in the probability with a flood-tide warning and the probability without a flood-tide warning by the experience of inundation and preventive action in T16. Through this result we found the following.

In the case of inhabitants that act to prevent household effects from inundation in T16, the probability of preventive action in T18 is high, particularly with a serious inundation in T16. On the other hand, in the case of inhabitants that did not act to prevent household effects from inundation in T16, the effect of getting a flood-tide warning in T18 on preventive action is clear mainly in the case with a serious inundation in T16. In other words, it is considered that where the fact of saving from inundation certify the validity of decision not to act any preventative in the past, the preventive action is not likely to be carried out at the next disaster.

6. CONCLUSION

In this paper we consider the effect of the publication of potential disaster risk information and the experience on inhabitants' behavior in storm surge disaster, using the data from a questionnaire survey instancing the case of Takamatsu in storm surge by T16 and T18.

In the case of T16 in August 30, 2004, the damage caused by a storm surge in Takamatsu was very serious, but both the government and inhabitants could not deal with the emergency and were in a state of disorder, because it was an extremely rare case and most people believed that this district is a safe place against natural disasters. So, it seems that this case corresponds to the case of no experiences of disaster. However, in the case of inhabitants who recognized the potential risks through the beforehand publication of disaster risk information, there is higher incidence of proper action than in the inhabitants who lacked recognition of it. Such a tendency is confirmed mainly in the inhabitants with short life in this district.

In the case of T18 in September 7, 2004, both the government and inhabitants dealt with the situation promptly for fear of the same storm surge. But there ware almost no damages due to the storm surge. So, this case corresponds to the no damage experience of disaster.

As a result of above complications, it is apprehensive that the above experiences have a bad influence on the intension of evacuation behavior in the case of the future disaster. In order to avoid this apprehension, we point out that the promotion for suitable disaster consciousness in ordinary through the beforehand publication of tsunami hazard map and storm surge hazard map is important.

ACKNOWLEDGMENT

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