Factors in Stimulating Evacuation Behavior on Flood

Ryuji Kakimoto and Fumihiko Yamada

Graduate School of Science and Technology
Kumamoto University

Background

Northern Kyushu Torrential Rain on July, 2012

It went on raining hard in Northern Kyushu area for several hours from midnight to morning on July 12th, 2012.

- The maximum rainfall per an hour hours: 108mm
- The maximum rainfall per 24 hours: 507.5mm

Damage

- Loss of lives 31
- Injured 11
- Totally destroyed house 363
- Seriously damaged house 1500
- Partially damaged house 313
- House flooded above the floor level 1175
- House flooded below the floor level 1019

The Shirakawa River

Catchment Area : 480 km², Length : 74 km

凡	例
流域界
想定氾濫区域
県界
ダムサイト
基準地点

Annual rainfall

Amount of Rainfall (Aso Area), June-July, 2012

Aso Valley

Nango Valley

Rainfall per an hour (Aso Area) 7.12, 2012

Characteristic of the Shirakawa River

The torrential rain in Aso area rushes down a steep slope of the middle of river, and runs in the downtown of Kumamoto city.

It takes 120 minutes for the rain in Aso area to flows through Shira river into the downtown area of Kumamoto city.

Tatsuda-1chon

Tatsudajinnai-4chome

Shirakawa River

Kumamoto University.

The Aim of This Study

- ◆ To survey evacuation behavior on the flood on July 12th, 2012.
- ◆ To analyze factors of promoting autonomous evacuation.
- ◆ To analyzes whether households' participation level of common activities in a local community affected their evacuation behavior.
- ◆ To analyzes whether the difference of ordinary activities between the two local communities leaded the difference of their evacuation behavior.

Hazard map of study area

Legend	Expected depth
Under 0.5 m
0.5-1.0 m
1.0-2.0 m
2.0-5.0 m

- 32 people were rescued by the helicopters.
- 50 people were rescued by the boats.

- Totally or seriously destroyed house: 211
- House flooded: **309**

Summary of questionnaire survey

Study Area	Tatsudajinnai-4chome and Tatsuda-1chome, Kitaku, Kumamoto
Date	December 8 th and 9 th , ,2012
Method of survey	Visiting and asking questions
Num. of household in study area	Tatsudajinnai-4chome : 175 households Tatsuda-1chome : 435 households
Num. of respondents	Tatsudajinnai-4chome : 92 households Tatsuda-1chome : 209 households
Summary of questions	
Personal attribute	Sex, Age, Can or not evacuate by yourself
Household attribute	Num. of family, Year of living, Structure of house
Evacuation behavior and awareness	Change of awareness before/after flooding and evacuation behavior Acquisition conditions of information about weather and flood
Understanding of social conditions in your neighborhood	Conditions of commuting and going to school of neighbors, Evacuation conditions of neighbors, Business conditions of neighborhood stores, Conditions of neighborhood roads
Conscious of Disaster prevension	Experience of flood, possibility of flood of the Shirakawa River, Preparedness of flood
Relationship with community	Association with your neighbors, Participation in common activities in local community, etc.

Time series of flood risk awareness and evacuation rate.

Recognition of neighbors' conditions. (n=288)

Acquisition rate of information by group

Means of information acquisition		All n=264	Evacuated n=121	Not n=143	t-value
River conditions	Oneself	70%	82%	59%	4.13**
	TV · Radio	17%	19%	15%	0.77
	Internet	2%	2%	2%	0.21
	Relation etc.	6%	6%	6%	-0.17
	Neighbors	12%	13%	10%	0.68
	Fire volunteer	3%	3%	3%	0.24
	Male	0%	1%	0%	1.00
Weather information	Oneself	32%	32%	31%	0.13
	TV · Radio	22%	17%	26%	-1.87*
	Internet	3%	3%	3%	0.24
	Relation etc.	5%	7%	4%	0.86
	Neighbors	7%	7%	6%	0.36
	Fire volunteer	1%	2%	1%	0.70
	Male	0%	1%	0%	1.00
Evacuation order	TV · Radio	4%	2%	5%	-1.05
	Internet	2%	2%	1%	0.17
	Relation etc.	2%	2%	3%	-0.63
	Neighbors	6%	7%	5%	0.59
	Fire volunteer	3%	4%	2%	0.93
	Male	1%	0%	1%	-1.42
Advice	Relation etc.	11%	14%	9%	1.24
	Neighbors	25%	31%	19%	2.34*
	Fire volunteer	10%	14%	6%	2.06*

Time series of evacuation rate in terms of a check on the river conditions and advice of evacuation.

(a) The relation between evacuation and a check on the river conditions.

(b) The relation between evacuation and advice of evacuation.

Scoring means of each item of the questionnaire

Probability of flood		Certain :4, High probability :3, Medium probability :2, Low probability :1, Not at all:0
Preparedness		Have you read a flood hazard map and recognized a flood risk? Yes :1, No :0
		Have you confirmed the evacuation route and place? Yes :1, No :0
		Have you prepared the emergency kits? Yes :1, No :0
		Have you participated in the evacuation drill? Yes :1, No :0
		Have you participated in fire volunteer or activity of voluntary disaster prevention? Yes :1, No :0
Relationship with community	Complaint or worries	Do you have any neighbors hear your complaints or worries? Yes :1, No :0
	Care	Do you have any neighbors take care of you when you are sick? Yes :1, No :0
	Familiar with neighbors	I have neighbors cooperate a living :3, Daily stand chatting :2, Only greeting :1, Not at all :0
	Acquaintance with neighbors	Acquaintance with all neighbors :3, Half of neighbors :2, A few neighbors :1, Not at all :0
	Frequency of greeting	Everyday :4, Once a week :3, Once a month :2, Once a year :1, Not at all :0
	Prevention of crime and fire	Have you participated in the prevention activity of crime and fire? Yes :1, No :0
	Community learning	Have you participated in protective activity of community history or culture? Yes :1, No :0
	Activation of community	Have you participated in the activation activity of community? Yes :1, No :0
	Sports	Have you participated in the community activity of sports or taste? Yes :1, No :0
	Community development	Have you participated in activity of community development or community support? Yes :1, No :0

Comparison between daily activity of evacuated household and non-evacuated household.

	Evacuated n=121	Not n=143	t-value
Probability of flood	1.41	1.06	2.18*
Preparedness	Flood hazard map	0.12	0.08
	Evacuation route and place	0.29	-0.08
	Emergency kit	0.22	2.23*
	Evacuation drill	0.19	2.11*
	Fire volunteer	0.07	1.38
Relationship with community	Complaint or worries	0.80	1.52
	Care	0.57	0.81
	Familiar with neighbors	2.26	1.88*
	Acquaintance with neighbors	2.02	1.64*
	Frequency of greeting	3.62	-0.49
	Residents' association	0.70	0.05
	Prevention of crime and fire	0.16	0.89
	Community learning	0.13	0.67
	Activation of community	0.09	0.62
	Sports	0.35	1.31
	Community development	0.23	2.57**

What kind of household evacuated ?

About flood probability of the Shirakawa River

⇒ The household who evaluated the probability high evacuated.

About the preparedness for disaster

⇒ The household who prepared emergency kit and/or participated in an evacuation drill evacuated.

About relationship with community

⇒ The household who was familiar with neighbors, acquaintance with neighbors, and/or participated in community development.

** 1 % level of significance, * 5% level of significance

EVACUATION BEHAVIOR MODEL

$$P(\text{evacuate}) = \frac{\exp(V)}{1 + \exp(V)}$$

$$V = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$$

Variable		Parameter	t-value
Constant		-1.82	2.73**
X1:Area dummy		-0.49	1.55
X2:Expected flood depth on hazard map		0.31	1.79*
X3:Dummy of checking river conditions		1.12	3.31**
X4:Dummy of urging to evacuate		0.69	2.55**
Likelihood ratio 0.215	Hitting ratio 66.9%	Num. of sample 260	

** 1 % level of significance, * 5% level of significance

The evacuation simulation for food.

The relation between relationship with community and the advice of evacuation

	Advised to evacuate (n=100)	Not (n=164)	t-value
Complaint or worries	0.86	0.69	3.23**
Care	0.60	0.51	1.25
Relationship with neighbors	2.31	2.06	2.46**
Acquaintance with neighbors	2.20	1.74	4.06**
Frequency of greeting	3.64	3.65	-0.06
Residents' association	0.75	0.67	1.46
Prevention of crime and fire	0.20	0.10	2.17*
Community learning	0.16	0.08	1.87*
Activation of community	0.07	0.09	-0.48
Sports	0.33	0.30	0.57
Community development	0.24	0.12	2.32*

** 1 % level of significance, * 5% level of significance

The households forming proper human relationship with their neighbors were advised to evacuate.

The state of evacuation in Tatsudajinnai-4chome and Tatsuda-1chome

Many households in Tatsudajinnai-4chome were rescued.
Many households stayed in flood hazard area.

The relation between relationship with community and area.

		Jinnai-4 (n=92)	Tatsuta1 (n=208)	t-value
Preparedness	Flood hazard map	0.13	0.08	1.21
	Evacuation route and place	0.23	0.31	-1.46
	Emergency kit	0.16	0.16	-0.01
	Evacuation drill	0.04	0.16	-3.59**
	Fire volunteer	0.02	0.07	-1.97*
Relationship with community	Complaint or worries	0.83	0.73	1.99*
	Care	0.56	0.53	0.40
	Relationship with neighbors	2.22	2.11	1.11
	Acquaintance with neighbors	2.01	1.85	1.46
	Frequency of greeting	3.50	3.71	-2.18*
	Residents' association	0.81	0.63	3.40**
	Prevention of crime and fire	0.08	0.14	-1.82*
	Community learning	0.11	0.10	0.34
	Activation of community	0.07	0.08	-0.35
	Sports	0.30	0.30	-0.13
	Community development	0.12	0.19	-1.64*

Usual activities of local community lead the emergency activities which are advice of evacuation and the lead of evacuation.

CONCLUSION

The factors affected the evacuation behavior were follows.

- Check on the river condition
- Advice of evacuation
- Preparation of emergency kit
- Participation in an evacuation drill
- Familiar with their neighbors
- Acquaintance with their neighbors
- Participation in activities of community development

From the evacuation behavior model,

it was made clear that a check on the river conditions and advice of evacuation would promote an autonomous evacuation.

CONCLUSION

- ◆ First, it is necessary for the households in the flood hazard area to recognize a flood risk through a risk communication.
- ◆ Usual activities of local community lead the emergency activities.
- ◆ It is rediscovered that daily practice of common activities in local area is the key to constructing the disaster mitigation type society.