Sixth DPRI-IIASA Forum on Integrated Disaster Risk Manage

A Flood Risk Communication Support System to Promote Safe Autonomous Evacuation

Michinori HATAYAMA: DPRI, Kyoto University / LSA, ETH
Kenichi KAWASHIMA: NTT DATA CORPORATION
Hirokazu TATANO: DPRI, Kyoto University

Background

記事全文

この記事を印刷する

豪雨被害：3万9000人に避難指示・勧告　鹿児島・熊本

活発な梅雨前線の影響で、九州は23日も各地で大雨となり、鹿児島、宮崎両県の山間部では降り始めからの総雨量が1200ミリを超えた。死者数4人、行方不明者数1人は22日から変わっていないが、けが人は鹿児島県と宮崎、熊本の3県でさらに増えて計13人となった。避難指示・勧告は23日午後9時現在、鹿児島、熊本両県で1万6722世帯計3万9245人に出されている。

大雨で冠水した水俣市内＝熊本県水俣市で23日午前8時36分、木葉健二写す

鹿児島県のまとめでは、川内川や米ノ津川(出水市)などの計19カ所で堤防決壊やはんらんが起き、さつま町や大口市など6市町の1905棟が床上・床下浸水。川内川周辺では集落の周囲が完全に水没し、孤立状態になった所もあった。

土砂崩れで1人が亡くなった現場＝鹿児島県姶良町で23日午後0時55分、木葉健二写す

毎日新聞　2006年7月23日　19時32分　（最終更新時間　7月23日　22時47分）

Damage in Japan

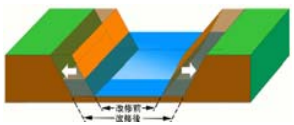
k ts	Dead	Injured	Damaged Buildings
	5	19	10600
	15	3	25000
	10	98	71000

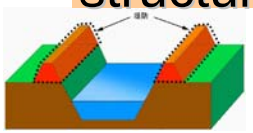
Human Damage

Physical Asset Loss

→ Decrease down to 0

Human behavior under inundation





Limit of actions based on structure construction

+

Non-construction approach to mitigate flood damage

Rescue activity from residents' community

Causes of human damage under flood disaster

Prof. Ushiyama have classified them to 5 categories as follows;

- Land slide — Including avalanche of rocks and earth
- Tidal waves
- Strong wind

Typhoon & Heavy rain

Early warning is effective.

- Inundation — Drowning in their house, on the way to evacuate
  Accident of their passive behavior
  (fall down to sewage…)
- Accident — Drowning :results of their active behavior
  (checking their crops, conditions of irrigation canal…)

These damages depend on individual human behavior based on their will.

It is necessary for human damage mitigation to approach to individual human behavior.

Human Behavior under Flood: Current Status

- Low ratio of evacuation
- Failure to evacuation

On Tokai heavy rain (2000) , in Nishi-biwajima area
8.6% people wanted to but could not evacuate,
10.6% people could not evacuate and was rescued.

Some people ignore it, because they think they are safe. (Low Awareness)

Evacuation Order from Local Government

Some people cannot evacuate without it.

Some local government cannot issue, because they don't have draft guidelines and be afraid of mistake of judgment.

Safe autonomous evacuation based on the judgment by residents is needed

Research Purpose

Human damage mitigation based on non-construction approach.

↓

Risk communication is one of the most powerful tool for non-construction approach.

↓

Development of flood risk communication support information system

In this presentation

Modeling of human evacuation behavior as a mental model

Development of GIS based support information system
for construction and reconstruction of users' mental model

Flood risk communication using developed support system
in Kiyosu City, Aichi Pref., Japan

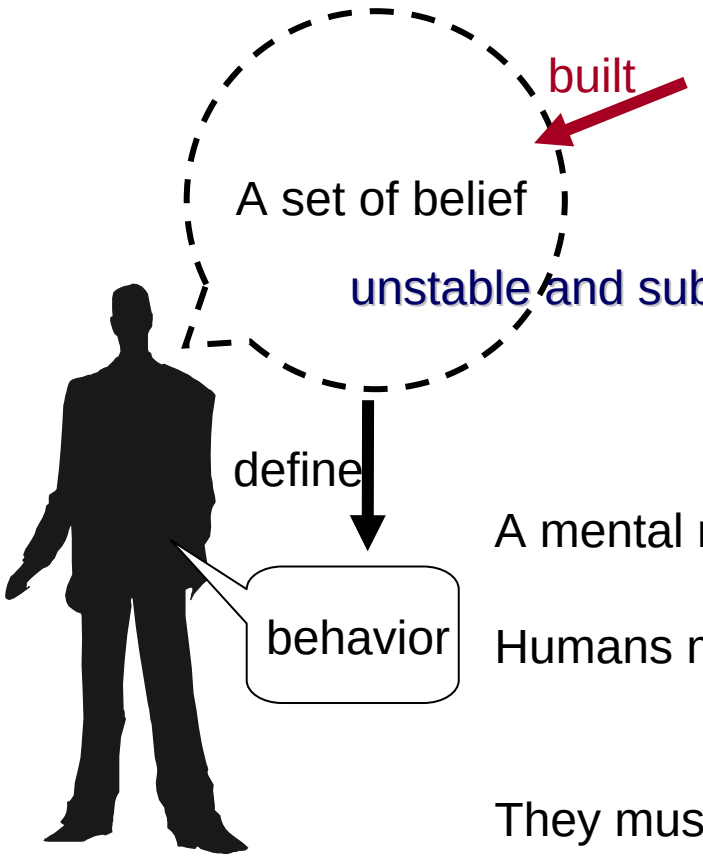
Mental model approach

To built a concept for system

Personal decision making is based on their internal “mental model.”

For purposes of the discussion we consider the following descriptions of mental models.

A mental model is a set of belief and
an internal scale-model representation of an external reality.



knowledge of prior experience, perception,
and problem-solving strategies.

A mental model must be able to provide feedback on the results.

Humans must be able to evaluate the results of action
or the consequences of a change of state.

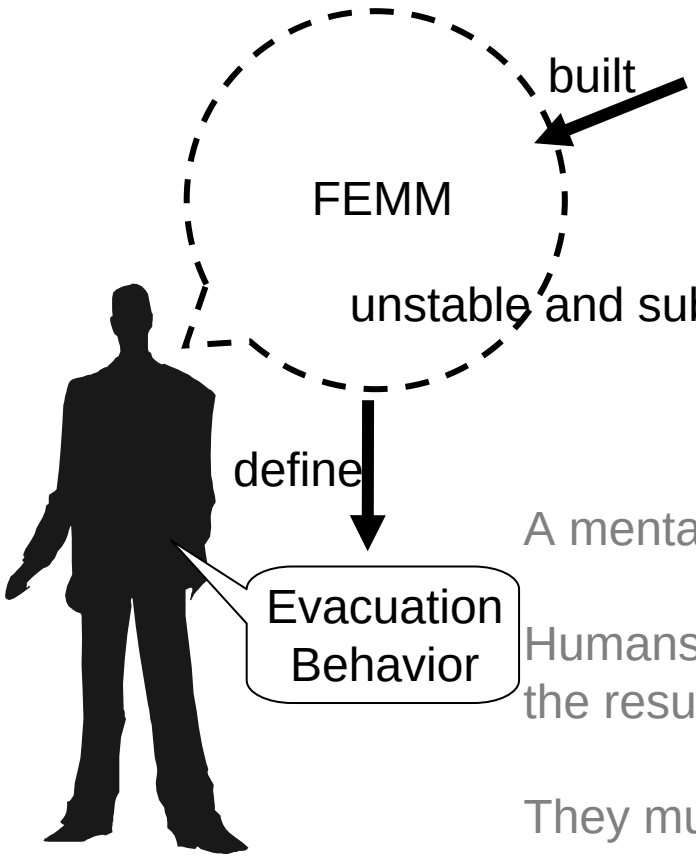
They must be able to mentally rehearse their intended actions.

Flood Evacuation Mental Model (FEMM)

defined as a mental model in terms of flood evacuation

Evacuation decisions based on the personal FEMM which is a set of belief on the possible evacuation plans, includes

- “message” to know what is the current situation,
- “knowledge” to categorize the situation,
- “alternatives set” for evacuation plans.



knowledge of prior experience, perception, and problem-solving strategies.

Personal Experience can change their “mental model” and change their actual behavior.

A mental model must be able to provide feedback on the results.

Humans must be able to evaluate the results of action or the consequences of a change of state.

They must be able to mentally rehearse their intended actions.

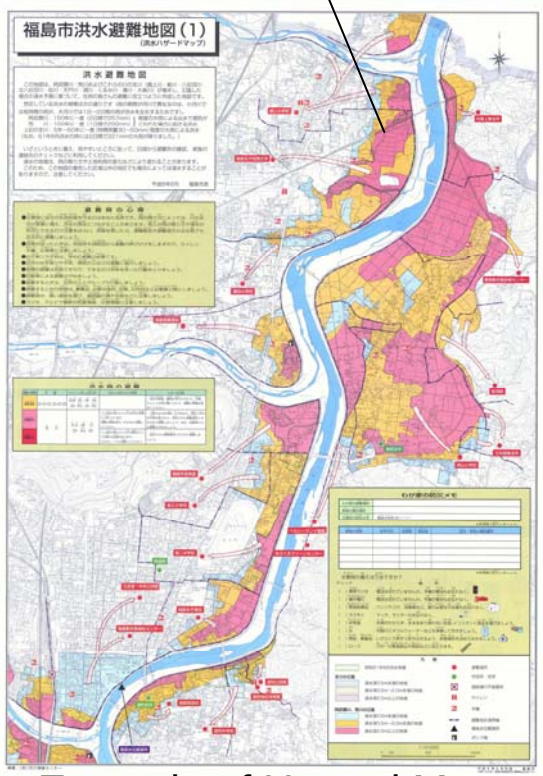
Flood Hazard Map

To realize a paradigm shift

made and provided by local government is one of the most powerful tool.

Purpose: to lead to residents' effective (fast and smooth) evacuation under flood
to increase residents' awareness of flood risk

Overlay the values of max depth based on the result of simulation



Example of Hazard Map

However, according to fact-finding inquiry

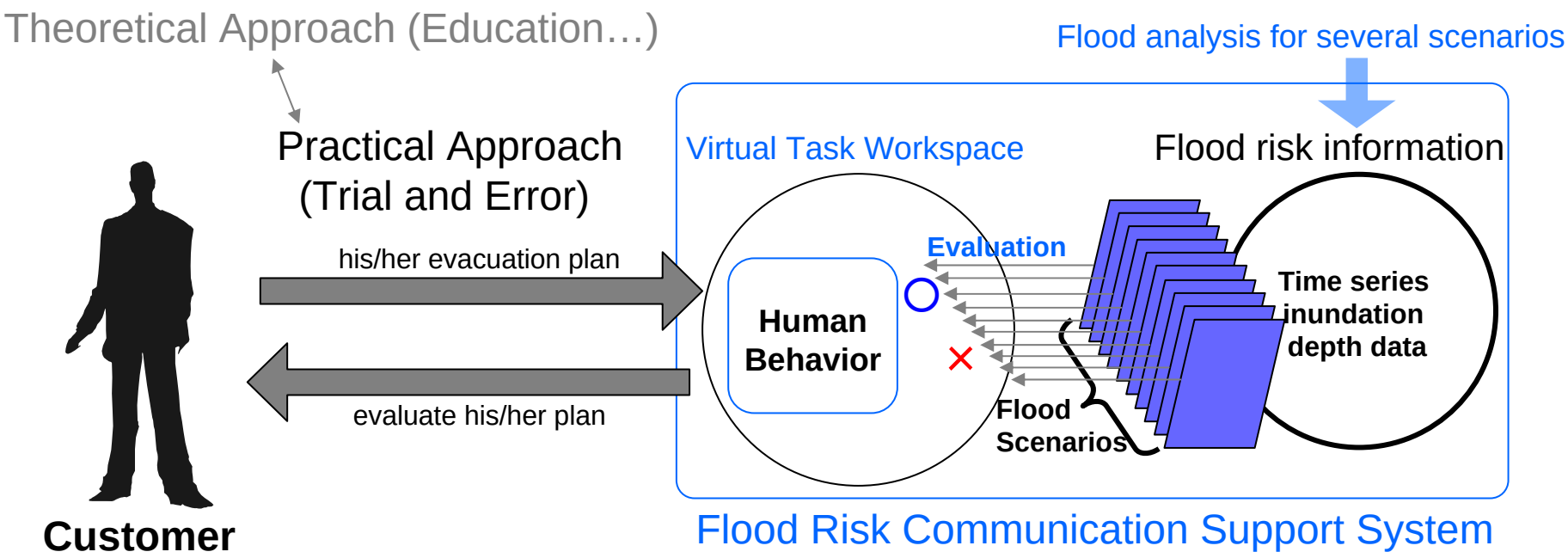
It is pointed out that
flood hazard maps often leads citizens
to fixed and inflexible belief about flood risk.
Despite the governments' effort,
many households lost the maps and
some of them don't recognize the existence of the maps.

What is a Lack of Hazard Map?

It is hard for residents to change their FEMM
from macro information.
They need follow up communication
to change information for from area to individual.

Flood Risk Communication Support System

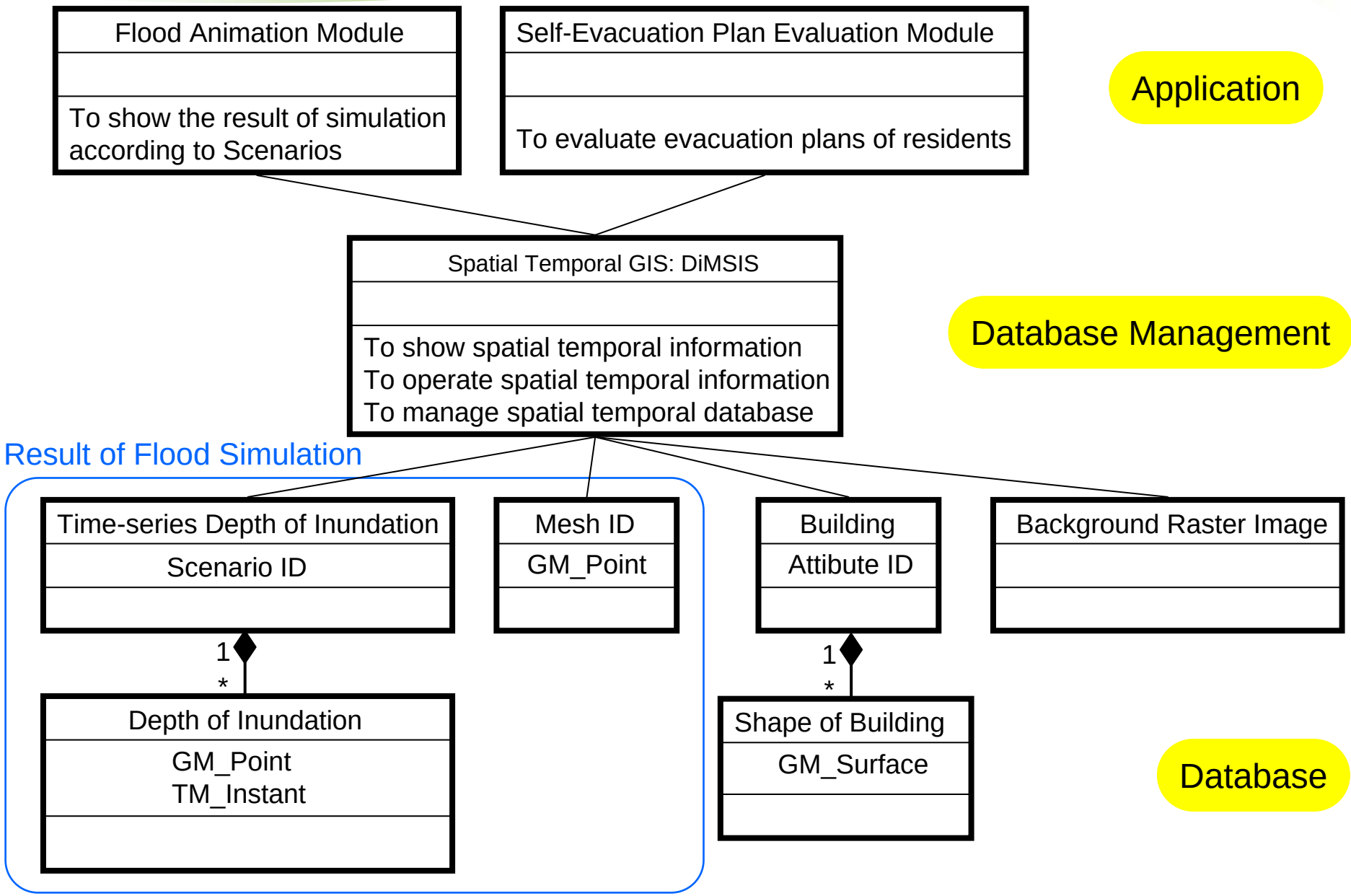
The system will help citizens making their own evacuation plans by providing evaluation of their self-developed plans across different flood scenarios.



Custer tests their plan to several scenarios by trial and error to check and reconstruct, if need, their FEMM.

From Hazard Map to Risk Imasimulator
(Imasimulator = Image + Simulation)

UML Diagram of developed information system



Risk Communication Case Study

Date: 2nd, 3rd Feb. 2006

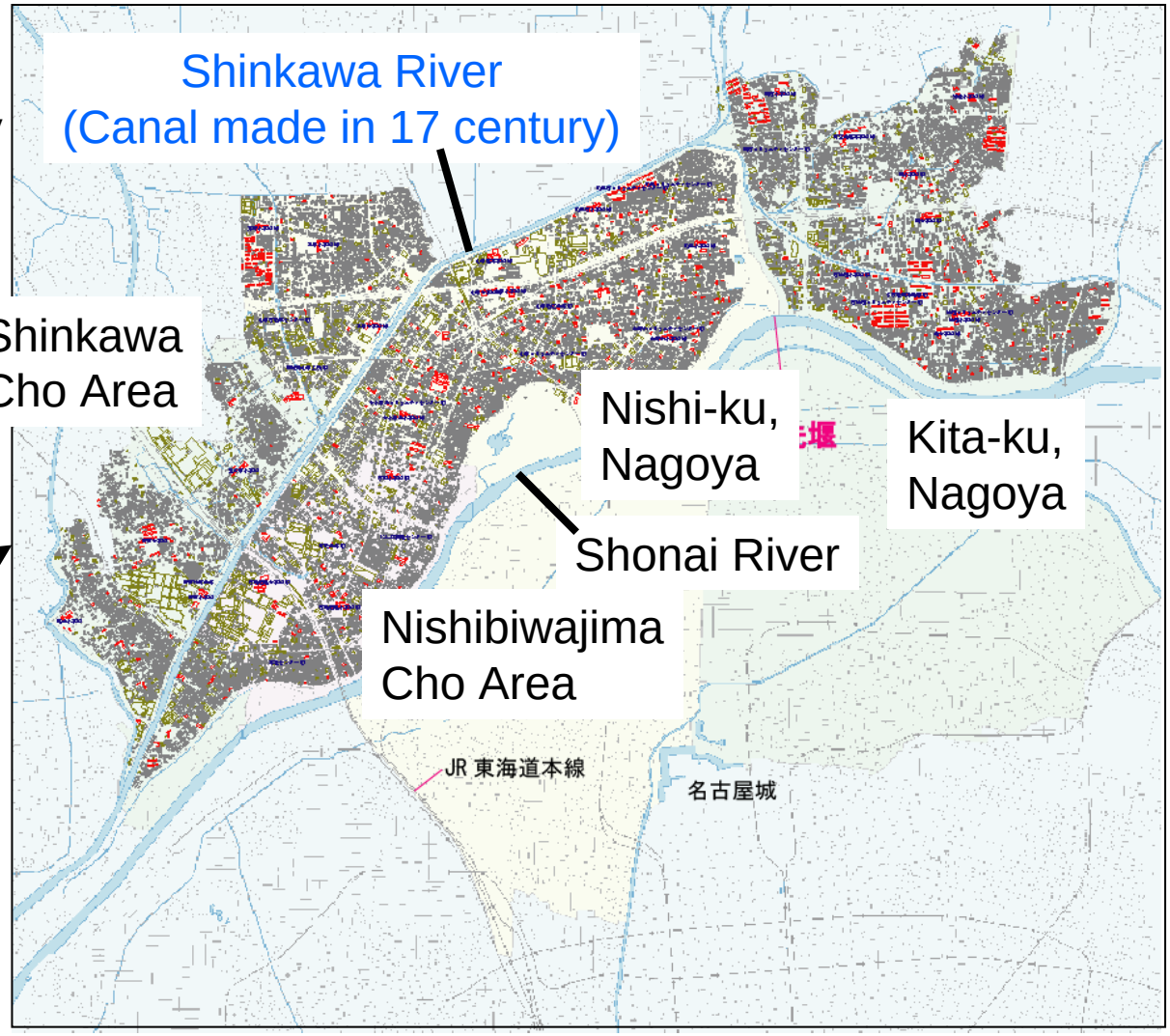
Target Area: Kiyosu City, Aichi Pref.

Target Area: Shinkawa River Basin in Kiyosu City

Nishibiwajima cho area (Population: 19,000, Area: 4.70km^2)
Shinkawa cho area (Population: 8000, Area: 3.36km^2)
2005

frequently flood disaster stricken area from 17 century

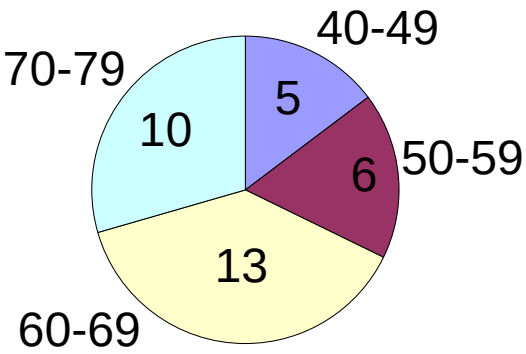
Heavy damaged area in Tokai Heavy Rain (2000)



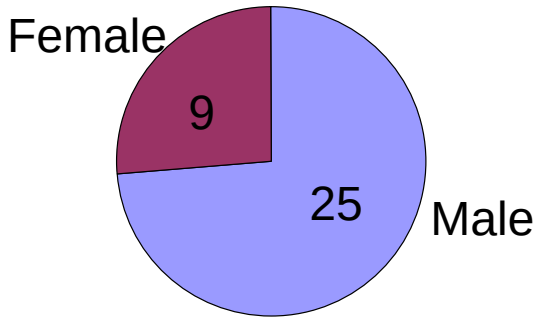
Risk Communication Case Study

Date: 2nd, 3rd Feb. 2006 Target Area: Kiyosu City, Aichi Pref.

Participants: 34 person (Shinkawa area(17), Nishi-ku(3), Nishibiwajima(14))

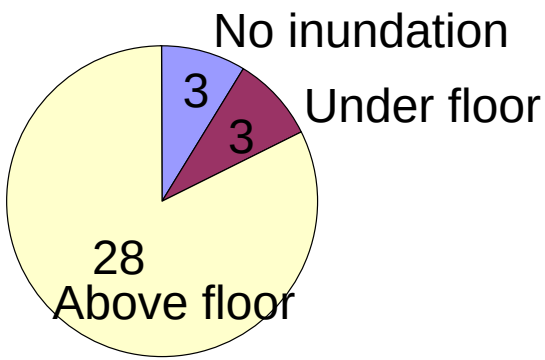


Age Composition

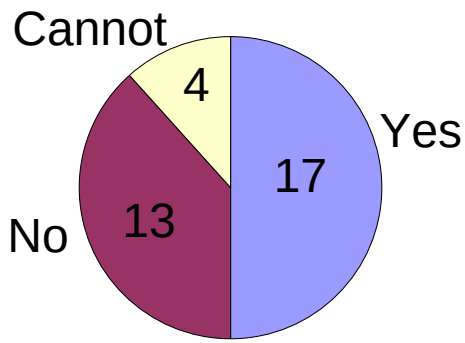


Sexuality

Experience of Tokai Heavy Rain(2000)



Inundation of house



Evacuation

Flood Disaster Simulation Data

Made by River Division of Aichi Pref.

- 50m Mesh Data
- Integrated 68 scenarios

  5 scale of rainfall (including Tokai Heavy Rain)

  Break in dykes of Sinkawa River (Break point 1km pitch)

  Inner water（Sewage: w>=1m, Waterway:w>=3m)

Evacuation Trigger

From this data and standard guideline of evacuation order of local government, we set following timing as “evacuation trigger”

- Evacuation Order
- Flood Prediction
- River Water Levels
- Rainfalls

Human Evacuation Behavior

We assume that HEB is regulated by
the place (from, to), route, and trigger to evacuate

Self-Evacuation Plan Evaluation Module

Evacuation Shelter

Official Shelter
Alternative Shelter
(Buildings more Than 5m high)
Other Places

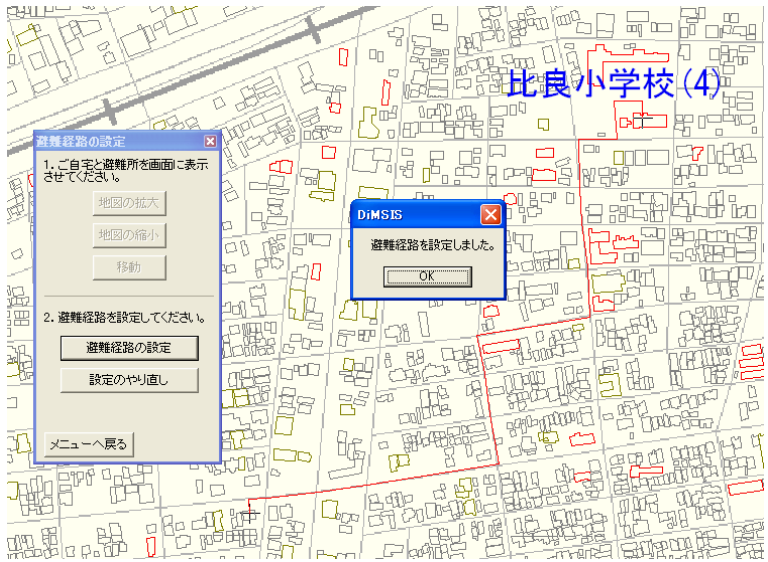
Route

can be chosen arbitrary.

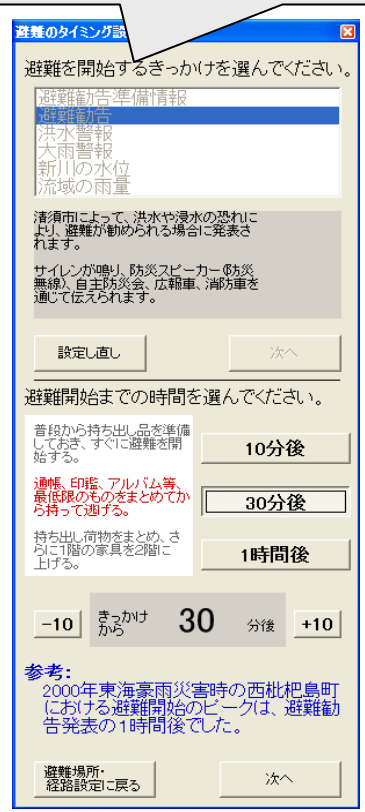
Trigger information

Evacuation Order
Flood Prediction
River Water Levels
Rainfalls

Personal Data Input

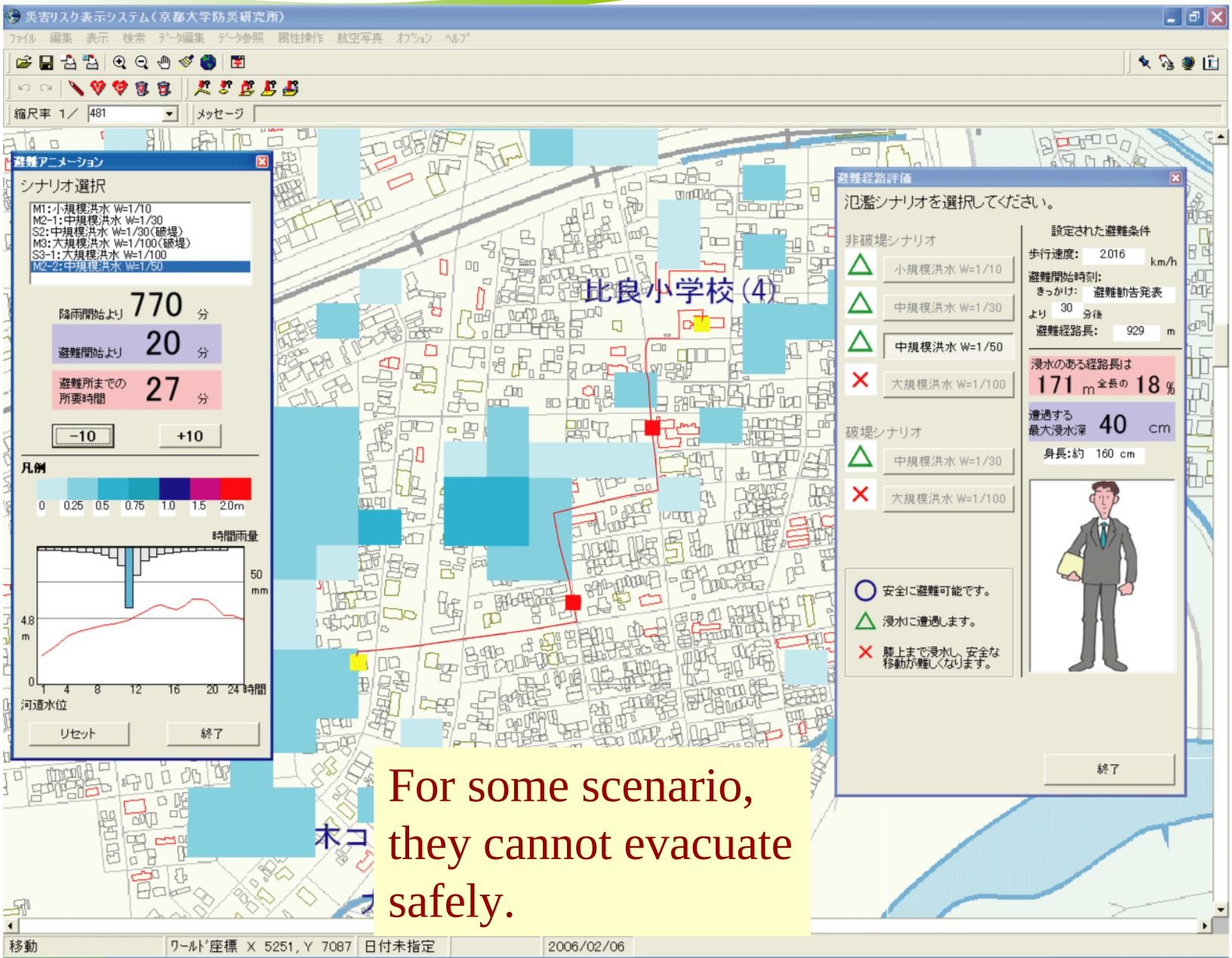


Route and Shelter selection



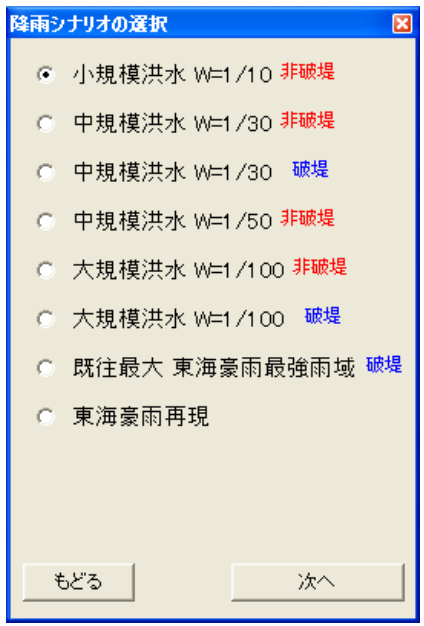
choice based on their own Flood Mental Model

Self-Evacuation Plan Evaluation Module

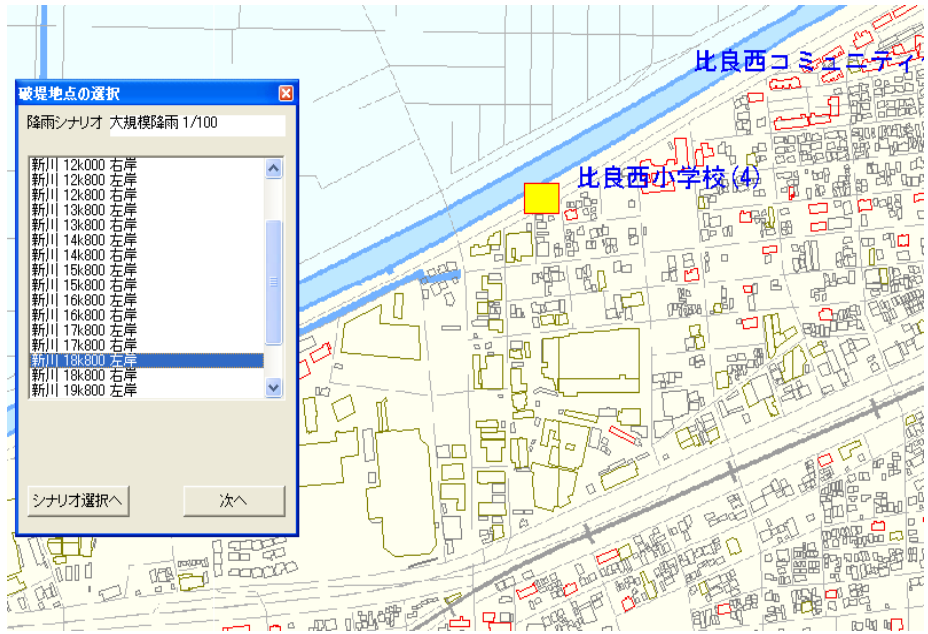


For some scenario, they cannot evacuate safely.

Flood Animation Module

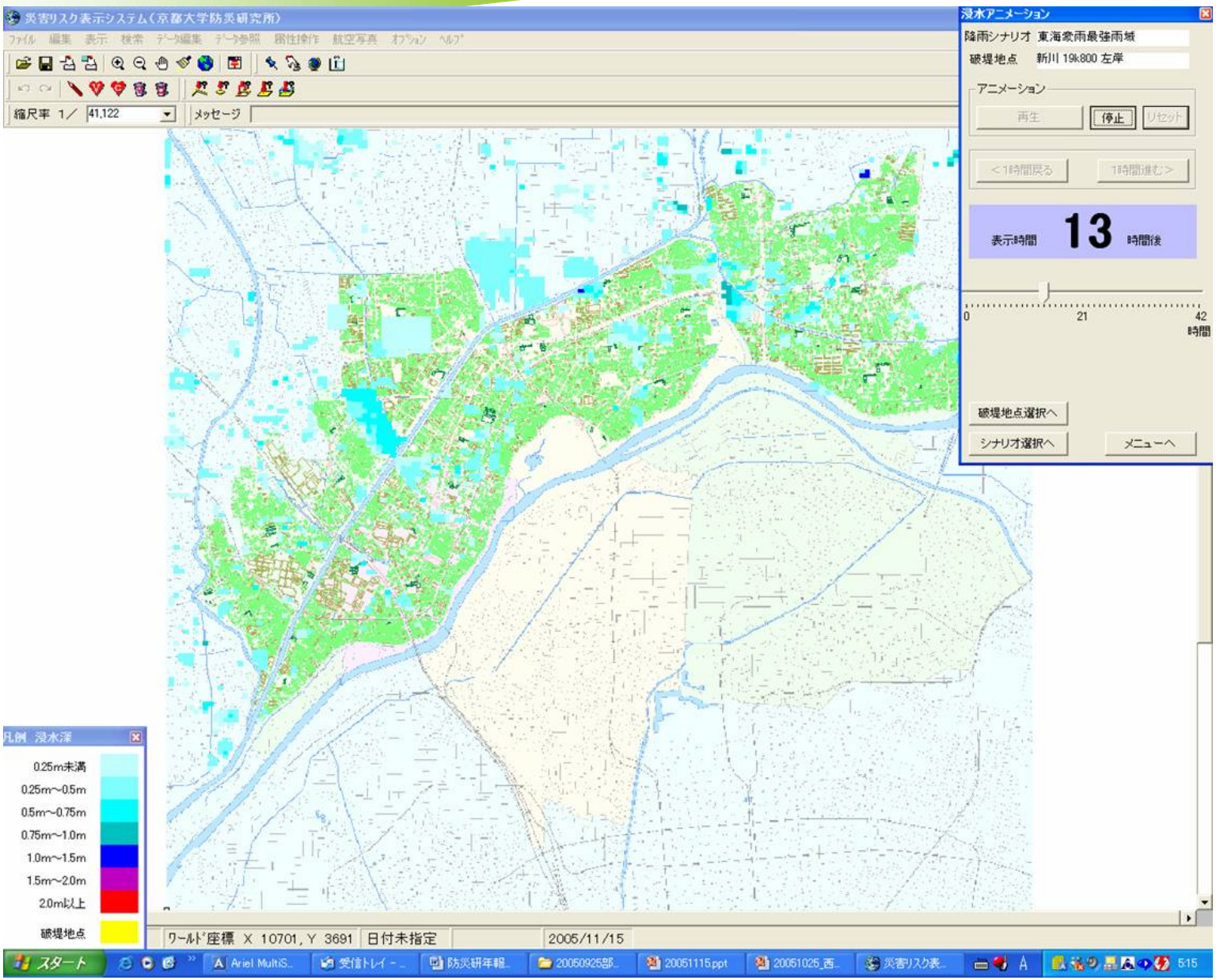


Choose a Return Period of the Event

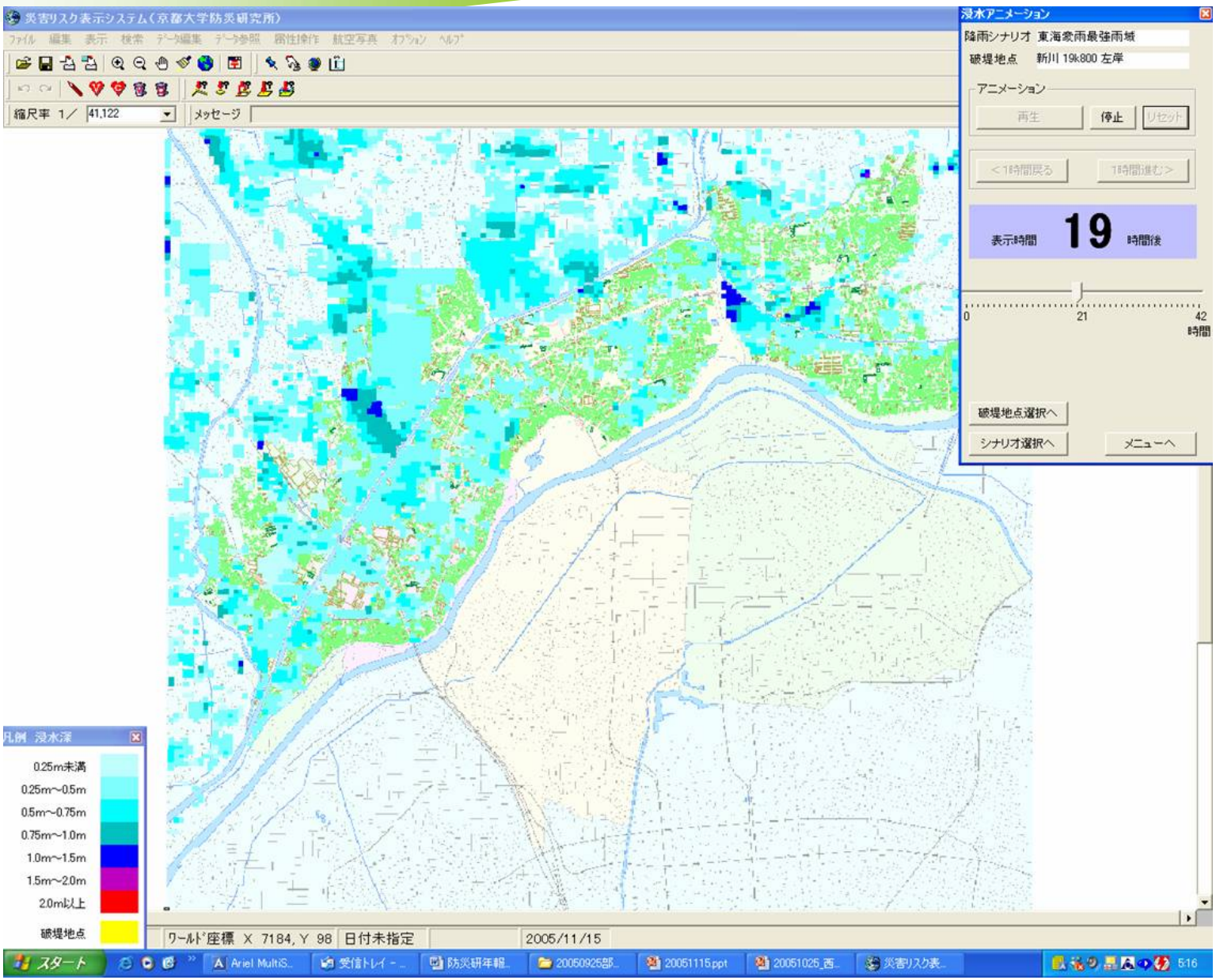


Choose a Dyke Break Point

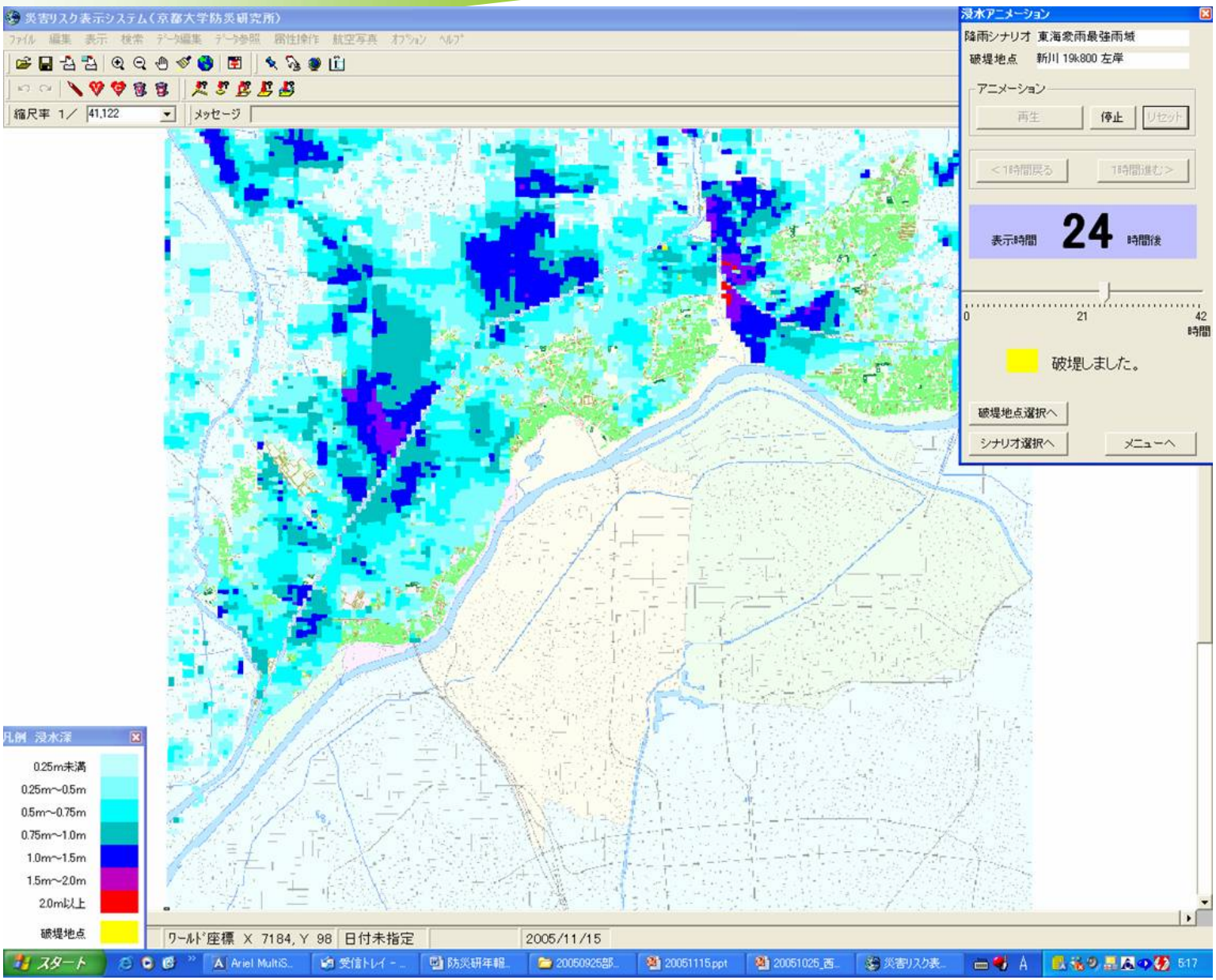
Flood Animation Module



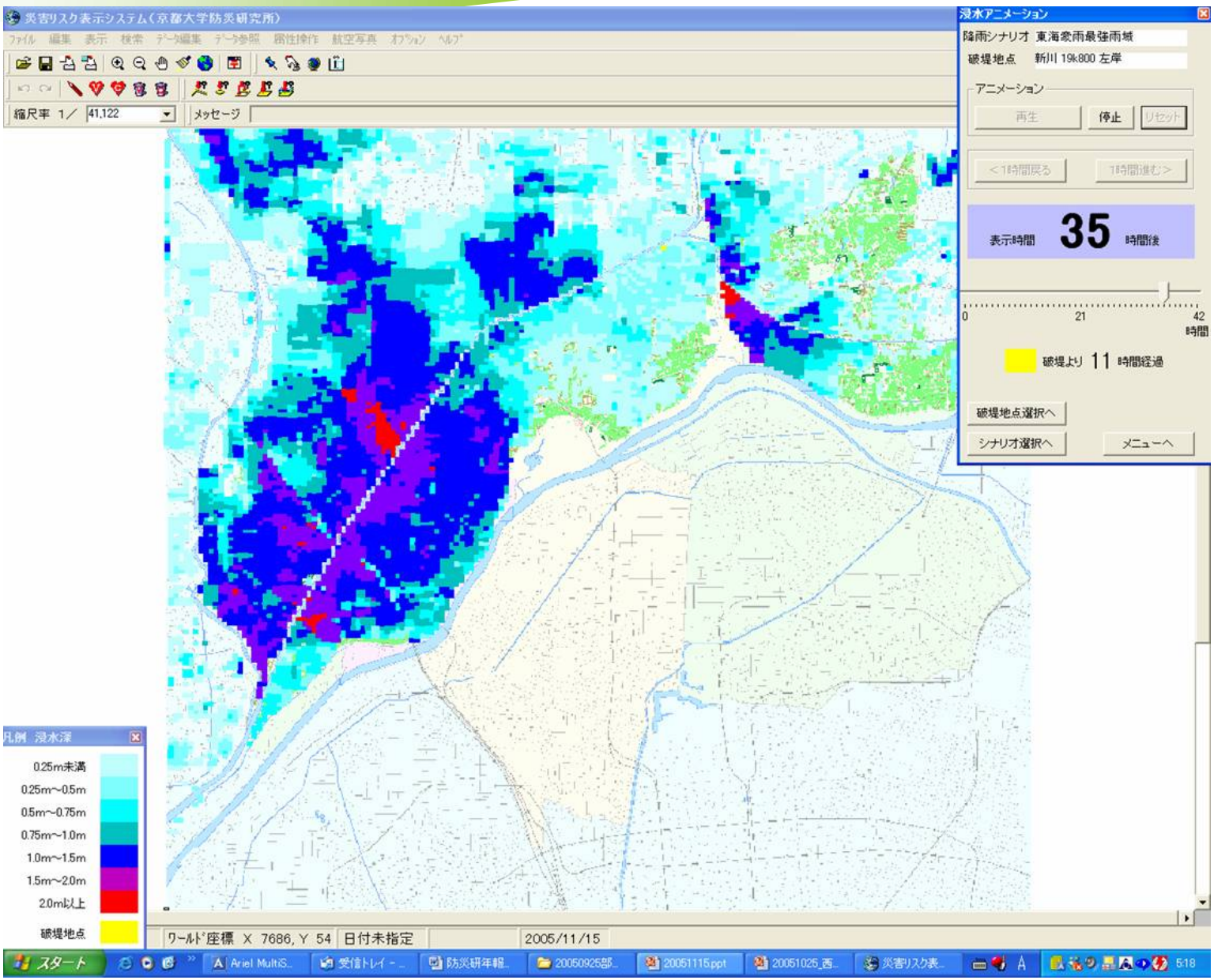
Flood Animation Module



Flood Animation Module



Flood Animation Module



Flow of Experiment

Questionnaire (check their status before experiment)

Make small group

Trial of developed system one by one
(The other people in same group watch his/her trial)

Group communication

Questionnaire (check their status after experiment)

Evaluation from Questionnaires

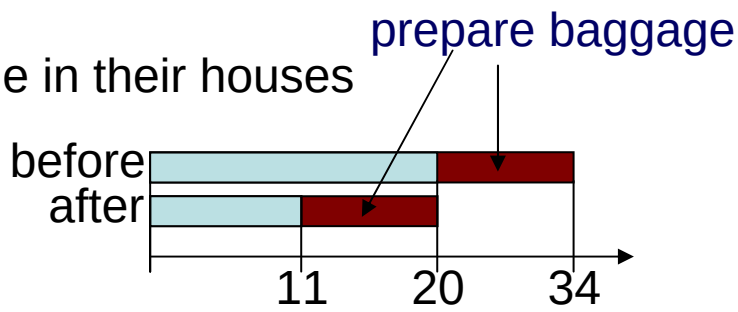
Did they increase their awareness?

Question on probability of inundation (under/above floor) of their houses in 7 stages evaluation

		before		after	
We can find the increasing	Under floor	5.46	→	6.21	on the average
	Above floor	5.21	→	6.00	

Did they increase their preparedness?

Question on preparedness of emergency baggage in their houses



20/34 people had never prepare before.
After experiment 11/20 people changed their mind and decided to prepare it.

Next I show the explicit knowledge from group communication..

Communication result 1

In this case, before warning information for evacuate is provided,
their route to reach the official shelter is not available for the most of scenario.

Half of Participants of this group changes the shelter location and new self evacuation plans after using the system

An example of change of evacuation plan

Before　　After

The workshop which using the FRC support system helps citizens to obtain more appropriate self-evacuation plan.

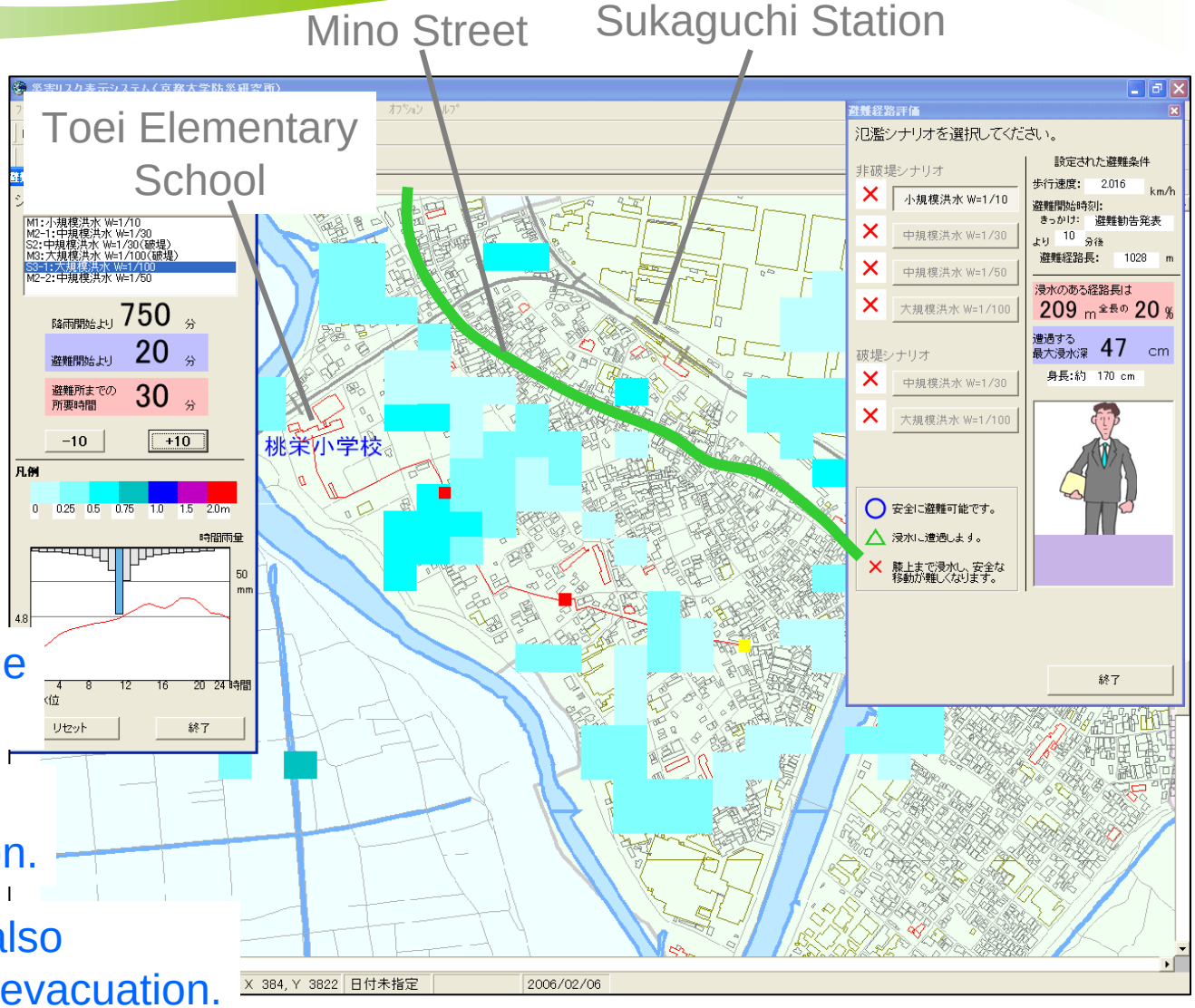
Communication result 2

Official Shelter
Toei Elementary School

Isolated area when LG issues an evacuation order.

Remark of participant

- “Mino Street” is available to reach official shelter.
- It is also available for temporary evacuation.
- “Sukaguchi Station” is also available for temporary evacuation.



Through group discussion, participants shared some evacuation plans

To improve system

I can show the possibility to reconstruct individual FEMM by our developed system.
Our group have a plan to continue risk communication in this area.
Through this case study, I get some idea to improve our support system as follows;

It is important to input the explicit knowledge from participant.
It is also important to input the historical incidents such as Tokai Heavy Rain.
We have to relay the knowledge
to the other person or next generation through the system.

We have to collaborate theoretical approach system,
because correct understanding is also important for risk communication.
In the first step, it is desired to be able to select theoretical or practical approach

From individual evacuation to community evacuation,
We try to extend communication topics to help the disaster weak people.
(Most of drowning people in their house are aged and disable.)

Conclusion

Modeling of human evacuation behavior as a mental model

Development of GIS based support information system
for construction and reconstruction of users' mental model

Flood risk communication using developed support system
in Kiyosu City, Aichi Pref., Japan