Bottleneck Analysis of Disaster Risk Communication Problems Based on Post-disaster Field Surveys --- Case Studies of Two Typhoon Disasters in Japan

Chao ZHANG[1], Norio OKADA[1], Muneta YOKOMATSU[1] and Yoko MATSUDA[2]
[1] Disaster Prevention Research Institute, Kyoto University;
Graduate School of Urban Management Engineering, Kyoto University
[2] (NPO) Rescue Stockyard, Nagoya

(Received for 28 Feb., 2007 and in revised from 19 Sep., 2008)

ABSTRACT

Identifying and overcoming various bottlenecks of disaster risk communication is considered an essential problem for the betterment of disaster early warning and quick response. In this paper, a systematic method of formalizing and analyzing these bottlenecks is proposed. Two typhoon disasters are focused on and field surveys are conducted. Several conceptual models have been proposed. The C-E-D model can be used to analyze the bottlenecks of information processing within one agent. It can also be extended to analyze inter-organizational information problems among different agents and organizations. To explicitly examine information-sharing devices for the different agents involved, the proposed hierarchical and sharing model can be used. The three-layer risk communication model associated with the pagoda model helps us position the level of bottlenecks in disaster risk communication. Policy implications are also derived from the proposed approach. Our methodological approach (if further improved) will also serve to systematically guide field investigations during and after a particular disaster if we intend to analyze a diverse spectrum of disaster risk communication problems.

1. INTRODUCTION

Japan is one of the countries severely affected by typhoon disasters. Sometimes, a typhoon will cause huge property loss and human injury. To reduce life and economic losses due to typhoon disasters, the importance of the role of an effective early warning system and evacuation action is obvious. But from the viewpoint of coping with typhoon disasters in recent years in Japan, there appear to be many issues that need to be addressed to improve early warning information and communication for effective evacuation.

Based on the method of questionnaire investigation, the researchers have made many findings on early warning and evacuation (Hiroi et al., 2005; Katada et al., 2003; Takeuchi et al., 2006).

In this paper, these issues are examined first from the viewpoint of disaster risk communication. We focus on the communication of “risk” in the period of disaster early warning and quick response. By examination and evaluation of various failures or obstacles in the risk communication system in the real situation and the various natural, technical, and social factors behind them, conceptual risk communication models are proposed as a framework to formalize and analyze them. In this respect, the uniqueness of this research lies in proposing a framework for discussing (as well as formalizing and designing) comprehensive post-disaster social surveys. This point is extremely important since to our best knowledge, such a systematic framework has not been well addressed or proposed. Therefore, it is yet a missing research theme to be explored, even though there have already been numerous field surveys and investigations conducted for specific disaster-stricken areas in Japan as well as for other countries.

We also attempt to set up a method to systemize the lessons or bottlenecks of early warning and evacuation actions exercised under different real contexts. The proposed approach is intended to help us better understand the complex process of disaster early warning and evacuation action systematically. We also note that the findings of this paper are expected to provide a preliminary basis for designing and conducting both adaptive investigation and follow-up research by continuous monitoring and verification to be carried out in the same and in other survey fields.

Case studies have been conducted for two disaster-damaged fields. One is the northern region of Kyoto Prefecture, which suffered heavy rainfall and flood disaster from Typhoon No. 23 in October 2004 (Ministry of Land, Infrastructure and Transport Kinki Regional Development Bureau, 2004). The other is a part of the Kyushu region, which suffered flood disaster from Typhoon No. 14 in September 2005 (Cabinet Office Government of Japan, 2005). Case studies have been conducted by first analyzing the data and information available on the official websites of the central and local governments, local newspapers (Kyoto Shinbun; Miyazaki NichiShinbun), etc. Thereafter, field surveys were conducted by the authors. The locations of the field surveys are shown

KEY WORDS: bottleneck analysis, disaster risk communication, field survey, typhoon disaster, case studies

in **Fig. 1**. The town offices, local households, and some enterprises in the affected areas were interviewed. For Typhoon No. 23, we visited the town of Oe Cho (it has now been combined with the city of Fukuchiyama) in the north of Kyoto Prefecture. A field survey was conducted on November 29, 2005. For Typhoon No. 14, field surveys were conducted twice in the town of Kitakata Cho and Hinokage Cho (now amalgamated into Nobeoka City) in the north of Miyazaki Prefecture. The dates of the field survey were November 10 - 11 (2005) and January 12 - 13 (2006), respectively.

In the field surveys, questions on the following aspects were asked of the interviewees:

(1) The circumstances of information dissemination of early warning and evacuation action
(2) The personal risk perception and evacuation behavior of the individual interviewed
(3) Past disaster experience and lessons in the same area
(4) The role played by the local disaster prevention organization in the evacuation action

2. INVESTIGATION RESULTS REVEALED FROM THE FIELD SURVEYS

2.1 Basic facts

The basic facts of the two case studies are given in the following table. It is added that the two case study areas (Oe Cho in Kyoto Pref. and Kitakata Cho in Miyazaki Pref.) are located very distant from each other but both have common characteristics. For example they are similar in the size of population (Oe Cho having a population of c.a. 5600, and Kitakata Cho, c.a. 5000 as of year 2004). The former town (c.a. 200 km^2) is twice as large as the latter (c.a. 100 km^2) in the area of jurisdiction. Both towns are mountainous communities and suffering from rural decline and excessive aging.

In Japan, there are three natural disaster warning modes disseminated from the town office to the local residents according to the degree of emergency: voluntary evacuation, advice to evacuate, and instructions to evacuate. Compared with the case of Oe Cho in Typhoon No. 23, in the case of Kitakata Cho in Typhoon No. 14, the local residents who live in a region frequently revisited by typhoons (such as the 2004 Typhoon 15) tend to have more experience of coping with typhoon disasters and are liable to conduct voluntary evacuation.

2.2 Findings

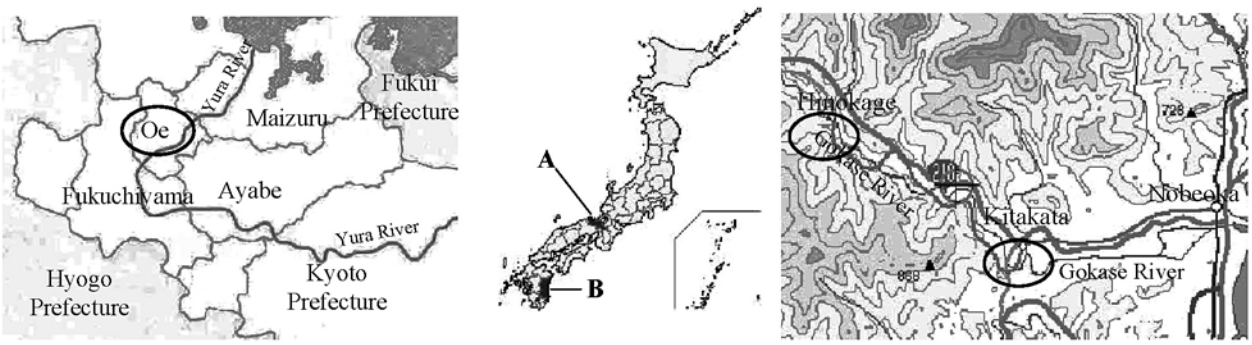
There are several problems (or bottlenecks) regarding disaster risk communication revealed from the case studies. They will be discussed from the following viewpoints:

(1) Town office inundated (Source: interviews and newspaper reports)

Some town offices that were assumed to serve as emergency management headquarters were inundated during the flood. In the case of Oe Cho, the room of *bousaimusen* (a kind of tone-alert radio system) on the ground floor of the town office building was inundated. Electric power was shut down. Communication facilities failed to receive related information from other agencies. It was also impossible to send out an evacuation message to the local residents. In the case of Kitakata Cho, although the *bousaimusen* system installed on the second floor still worked, dissemination of evacuation instructions was delayed because the facilities of the disaster information-processing system on the ground floor were inundated and could not be used to receive and analyze meteorological and hydrological data.

(2) Information-receiving procedure for local residents (Source: interviews)

In the case of Oe Cho, five villages were isolated by the flood or landslide. Roads and electricity were cut off. Hinokage Cho experienced a similar situation. Three villages were isolated by landslide. Telecommunications and electric lines connected to the outside were damaged. The on-site condition could only be obtained on foot. Under these circumstances, usually local residents must depend on their own knowledge and judgment to survive and evacuate. In the survey of Kitakata Cho, the complaint of some households of "forgetting to put the battery in" was found. In normal periods, some residents took out the battery from the *bousaimusen* receiver, forgetting to return it during emergency periods, so they could not receive related disaster information via this device.



A: Oe Cho (in Kyoto Pref.)

B: Kitakata Cho & Hinokage Cho (in Miyazaki Pref.)

Fig. 1 Location of field surveys
A: Oe Cho (in Kyoto Pref.) B: Kitakata Cho & Hinokage Cho (inMiyazaki Pref.)

Table 1 Basic information on the two case studies

Items	Typhoon No. 23, 2004 (Oe Cho)	Typhoon No. 14, 2005 (Kitakata Cho)
Day	2004/10/20	2005/9/6
Flood peak time	24:00 (Night)	10:00 (Day)
Time of evacuation	15:45(V)* 16:00(A) 19:15(I)	9/5 23:15(V) 9/6 9:46(A)
Status of evacuation	Most people chose the second floor of their house as shelter.	Most people conducted voluntary evacuation to shelters.
Number of dead/injured	2/1	0/0
Number of houses totally destroyed /destroyed & inundated	1/494	47/249
Past flood experience	1972	2004 (Typhoon No. 14)

* Warning modes in Japan: (V) denotes voluntary evacuation. (A) denotes advice to evacuate. (I) denotes instructions to evacuate.

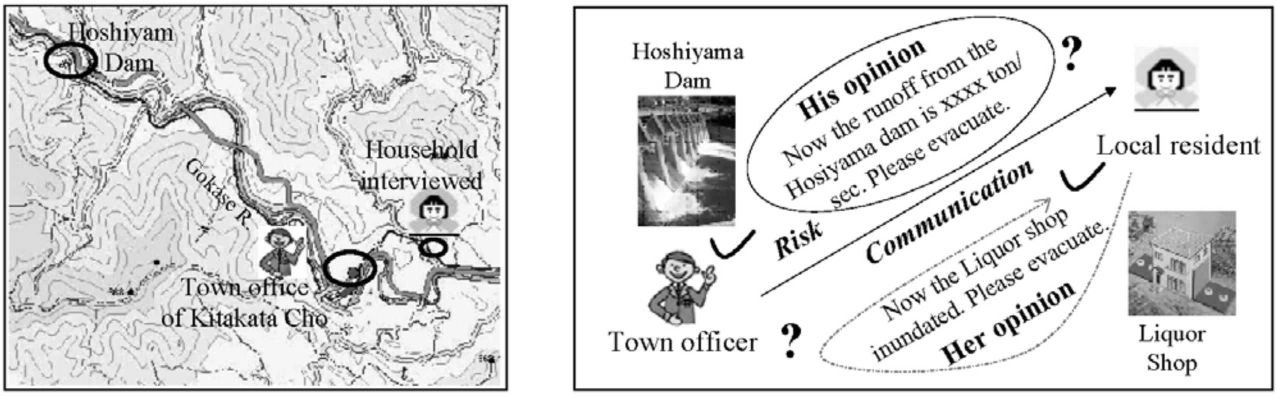


Fig. 2 Gaps in risk perception between town office and local residents

(3) The understandability of "risk" information (Source: interviews)

By a field survey, some gaps in risk perception between local residents and persons of the town office were identified. In the town office of Kitakata Cho beside the Gokase river, dissemination of early warning and evacuation information from the town office is conducted via *bousaimusen*. The content of information is, for example, "Now the runoff from the Hoshiyama dam is xxxx ton/sec. Please conduct voluntary evacuation, etc." The Hoshiyama dam is located upstream of the town, as shown in **Fig. 2**. But our field survey including interviews with local residents has shown that from the viewpoint of the local residents, this kind of information is considered too technical. From only a message like this, it is difficult for the local residents to judge to what extent their home is at risk. So, how the information affects the evacuation behavior of local residents will not be as expected by the town office. It would be easier for the local residents to understand the risk situation by receiving information disseminated to them like this: "The liquor shop is now flooding. Please evacuate." Here, the liquor shop is located near their home. They are familiar with it and would prefer to use it as a reference.

(4) Decision to take evacuation action (Source: reports of newspapers and other researchers)

In the case of Oe Cho, although there were different kinds of evacuation information disseminated from the town office, not more than just 20 percent of local residents followed the instructions to evacuate. A similar situation happened in the other flood-affected region in Kyoto Prefecture, as shown in **Table 2**. In addition, through the field survey, local residents were found to choose the second floor of their house in preference to official designated schools as shelter.

In the case of Kitakata Cho, the situation was different; most

Table 2 Percentage of residents under different warning modes in Typhoon No. 23, 2004
(Source: Committee of Typhoon Disaster Prevention in Kyoto Prefecture)

Warning mode	Number of cities/towns	Percentage of residents following advice
Voluntary evacuation	9	2%
Advice to evacuate	7	15%
Instructions to evacuate	5	12%

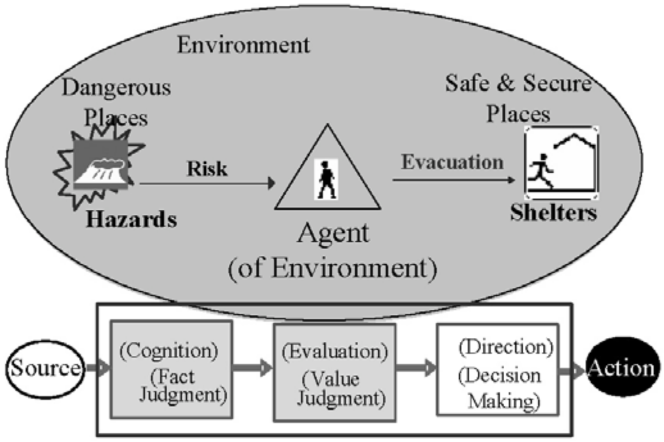


Fig. 3 Communication with agent of the environment

local residents conducted voluntary evacuation to designated shelters. For designated shelters in eleven districts in this town, all 217 refugees adopted voluntary evacuation. Through the field survey, various factors were found to affect the decision regarding evacuation behavior, as shown through the following narratives from interviewees:

i) "I am old, and should evacuate sooner."
ii) "Even if the flood enters my room, I can stay on the second floor temporarily, so I do not need to worry."
iii) "Some valuable articles are still on the first floor, and after taking them up to the second floor, I will evacuate."

The local residents did not usually follow the evacuation instructions instantly; they usually considered their own situation. There were many factors affecting their decision.

(5) Information exchange between organizations (Source: reports of newspapers and other researchers)

There were bottlenecks in this aspect. Here, two examples are given. In the context of Typhoon No. 23, too much information, without its priority of importance being considered, was sent out to the receivers via fax during the period of emergency. This confused the receivers, causing them to spend a lot of time checking. Another example is where a sightseeing bus was trapped in the flood in Typhoon No. 23. On the road to the destination at night, this bus was trapped and stopped by the flood from the Yura river. Thirty-seven passengers had to spend a terrible night on the roof of the bus. From this accident, the issue of ineffective information sharing between traffic and river agencies can be identified.

(6) Designated refugee shelters (Source: the field survey and reports of newspapers)

In the case of Typhoon No. 23, 2004 (in Oe Cho), there were complaints about some designated refugee shelters by the local residents that they were "inundated," "too far away," or "the door had not been opened yet," etc. There were similar circumstances in Typhoon No. 14. In Hinokage Cho, one primary school specified as an official refugee shelter had not been inundated by the river under its foot, but over its head, a severe landslide occurred. The shelter was nearly destroyed.

For the above problems or bottlenecks, it is not enough to only list and record them in a report; it is necessary to analyze them and set up some kind of theory to formalize them. This kind of theory would be useful for decision making in the future. For this purpose we will now turn to conceptualization and modeling.

3. CONCEPTUAL DISASTER RISK COMMUNICATION MODELS

Here, two agent models are proposed for disaster risk communication at the stage of early warning and quick response. One is a special type: communication with agents of the environment. The other type is communication with other agents.

3.1 Communication with agents of the environment

Through instinct, as well as common sense and experience obtained in daily life, human beings are considered to have the capability to communicate with agents of the environment. As natural hazards happen, through their own observation, past experience, and knowledge, some human beings can make correct judgments, such as which place is in danger and which place is safe and secure. For this process from information received to action taken, the so-called C-E-D model can be used to describe it, as shown in **Fig. 3**. The C-E-D model was first proposed by Yoshida (1990) to describe the information process within one agent. Okada (2005) applied the C-E-D model to the field of disaster information dissemination.

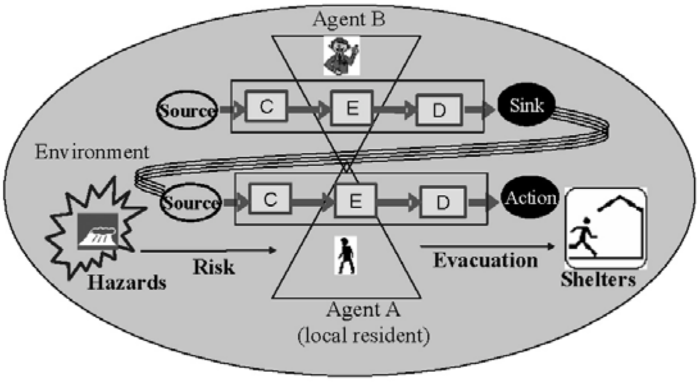


Fig. 4 Communication with other agents

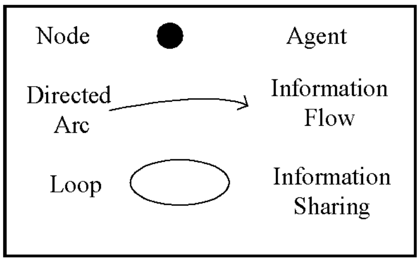


Fig. 5 Three key symbols used in modeling

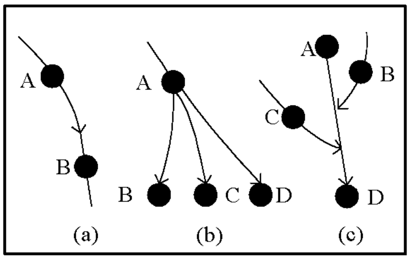


Fig. 6 Hierarchical model

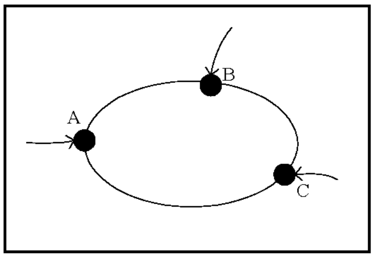


Fig. 7 Sharing model

The agent (here corresponding to the local resident) senses signals from the environment. Through the process of cognition, evaluation, and direction (the so-called C-E-D process), the person makes a decision. In the cognition process, the agent needs to recognize the facts. Then, in the evaluation process, the agent makes a value judgment. In the process of direction, the agent makes a corresponding decision. For the evaluation that a person (agent) makes, such as evaluating how severe a condition is and when he/she must start evacuation, his/her past experience and knowledge gained from routine life play an important role.

3.2 Communication with other agents

Compared with the former case ("communication with the environment"), communication with agents is more common. Here, the agents would be the staff of the town office or the neighbors of local residents, as shown in **Fig. 4**. In this figure, "sink" means the destination (recipient) of the information flow being processed through the agent. This time, the C-E-D process is still valid within each agent. The information source of local residents is not only the direct environment, but also other agents such as the town office. For example, local residents receive information from the town office such as advice to evacuate, combine it with their own observation of the environment, and judge whether or not to evacuate. Once the decision is made, they will go to a safe place, such as an officially designated shelter. This kind of information flow between the town office and local residents is obviously not unidirectional. Sometimes, local residents will give some useful on-site information to the town office.

3.3 Information flow between different agents

As far as the actual context of the risk communication process is concerned, not only various spatial and temporal factors but also the characteristics of the behavior of agents need to be considered. In order to promote participation in terms of information, knowledge, and action sharing, two organizational patterns of disaster risk communication can be identified. They can be generalized as the hierarchical model and the sharing model, respectively. The former can be applied to early warning and quick response retroactive situations, especially command and control situations. The latter can be applied to collaborative and collection situations.

In order to denote these models figuratively, three basic elements are introduced here as shown in **Fig. 5**. They are node, directed arc, and loop, denoting agent, information flow, and information sharing, respectively.

(1) Hierarchical model

In this case, the information flow is commonly one way. Graph (a) in **Fig. 6** gives its basic form, and in actual situations, complex variations of it can be observed, as Graphs (b) and (c) in **Fig. 6** show. Information flows among administrative agencies are illustrated by these graphs. The dissemination of meteorological information from the meteorological agency to related governmental agencies is illustrated by Graph (b). Disaster-related information received by the town office from different sources is illustrated by Graph (c). Here A, B, C in **Figs. 6** and **7** exemplify any possible three agents (administrative agencies) symbolically modeled as nodes.

(2) Sharing model

As **Fig. 7** shows, here, related agents share their information. The loop serves as an information platform. Information flows from different sources are integrated and properly matched on this platform. In the context of early warning and evacuation, two types of sharing model can be identified. One is the external dependent type. The information-broadcasting system on the platform of the Internet illustrates this type. It serves as a common platform to provide external dependent information to the public. The other is the self-reliance type. In the context of community, the evacuation behavior of local residents can be described by this graph. Local residents mutually exchange information or knowledge received from the mass media or related NGOs. Their decision is then made.

4. BOTTLENECK ANALYSIS

Case 1: Town office inundated. The town office lost the capability to receive and disseminate information. Because of inundation, its facilities were physically damaged. Its headquarter functions were paralyzed. Communication between the town office and local residents was blocked. The positions at which bottlenecks occurred are illustrated in **Fig. 8 (a)**.

Case 2: Isolation of the local community. Here, three types of isolation can be identified. One type is physical isolation, which means that the community is not physically accessible. Lifelines and roads were shut off from the outside. The second type is communicative isolation. Communication bottlenecks between residents and the town office were one-way or two-way. A one-way bottleneck was where some households could receive information by bousaimusen, but it was difficult for them to send out information to let the town office know that they were isolated. This is illustrated in **Fig. 8 (b)**. A two-way bottleneck was where households were totally isolated from the outside. They could neither receive information from the outside, nor send out information to the outside for help. The third type is transportation and lifeline supply isolation. In this case, although there was no problem with the communication of the local community with the outside, transportation and lifeline supply were still not functional. Food supply still depended on the outside by helicopter.

Case 3: The contents of *bousaimusen*. From the message, "Now the runoff from the Hoshiyama dam is xxxx ton/sec. Please conduct voluntary evacuation," it was difficult for the local residents to evaluate the risk situation. A decision on whether or not evacuation should begin could not be made. As **Fig. 8 (c)** shows, this time in the information process of C-E-D, a bottleneck occurred in the process of "E," so the process of "D" after that was not active.

Case 4: Problem of self-judgment. Through field surveys, some local residents were found to take action depending more on their own judgment. For them, the messages from the town office were only one information source for reference. In this case, if this judgment comes from past disaster experience, it is reasonable. But if it only comes from self-confidence or taking certain circumstances for granted, it is very dangerous. Bottlenecks could happen in any process of "C-E-D," as shown in **Fig. 8 (d)**. The following three cases, as examples, have been identified from the field surveys.

Local residents may recognize the facts through observation. But sometimes, the scope limitation of their information acquisition and past experience will prevent local residents from making correct factual judgments. So, a bottleneck will occur in the process of "C."

Priority is another factor that needs to be pointed out. It is necessary to evacuate to a safe place for people's lives, but their property is also important. When they decide to adopt a certain

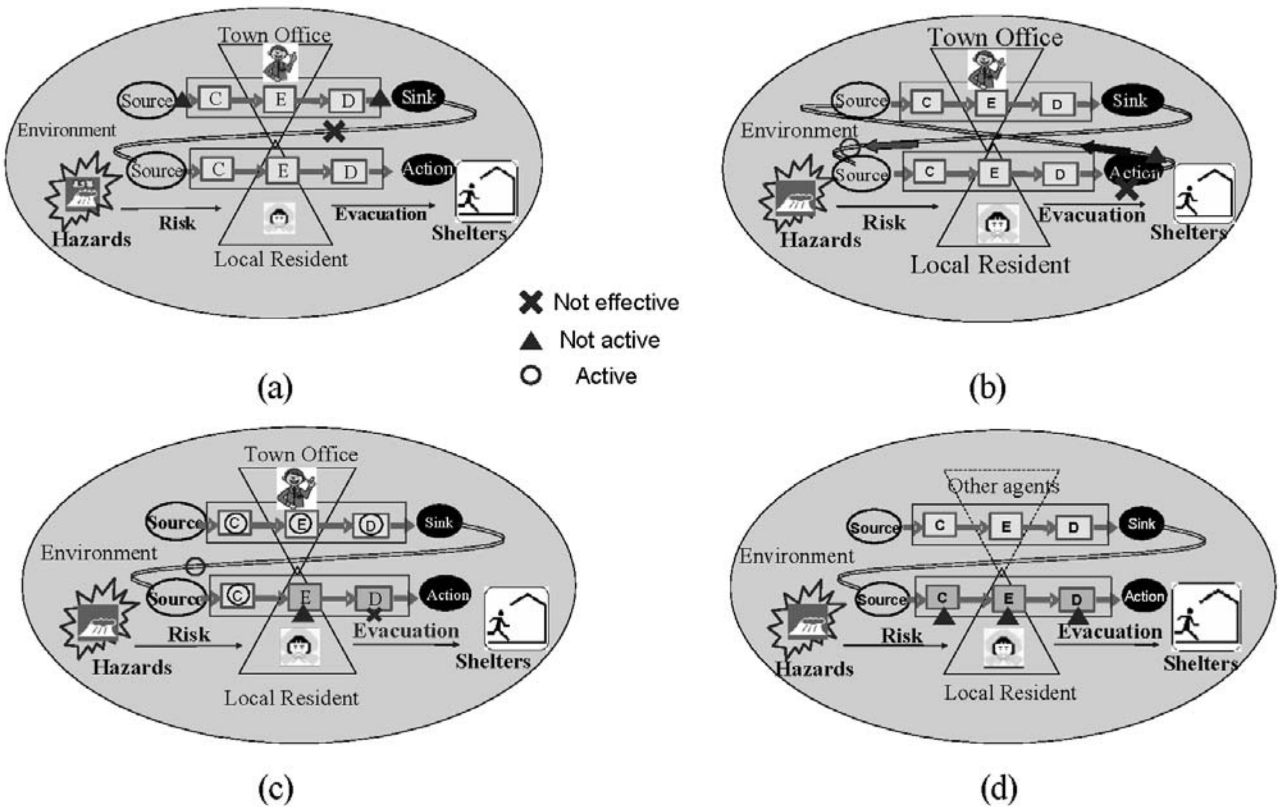


Fig. 8 Various bottlenecks in disaster risk communication

action, they must strike a balance between them. It is one point that needs to be considered not only by local residents, but also by enterprises. This is one of the differences between a flood and an earthquake which is also a common hazard in Japan although it is not discussed in this paper. In a flood, people still have some time to take action. In this case, bottlenecks will happen in the process of "E." If their evaluation is not correct, the wrong decision is then inevitably made.

Incidentally, people with disabilities or elderly people cannot take action themselves easily for immediate evacuation. In the disaster of Typhoon No. 23, among the 96 persons killed, there were 54 persons over 65 years old (Ushiyama, 2005). Although they might have heard the warning message, they would have been unable to make a quick evacuation by themselves. In this situation, the bottleneck can be categorized as happening in the process of "D."

Case 5: Information exchange among agencies. Here agencies mean government agencies such as main and branch offices of different level of local governments which are responsible for information exchange for disaster management. As far as the fax problem is concerned, the bottleneck can be ascribed to the one-directional information flow. There is one weakness in sending messages only via fax, as it is not guaranteed that the message will be received in time and understood completely by the receiver. In addition, staff (in a particular agency) who receive a large number of fax sheets from related agencies are sometimes unclear as to which is more important than the others. The multiple (and non-classified) contents of the fax confused the recipients (Okada, 2005). In the accident of the sightseeing bus, the bottleneck can be ascribed to the lack of an information-sharing system. To solve this problem, only depending on information from one or two agents is insufficient.

Case 6: Designated shelters. Official specified shelters are assumed to be safe enough for one kind of disaster, but sometimes face high risk in other kinds of disaster. The reason for this is lack of sufficient knowledge of the local community.

5. FORMALIZATION OF BOTTLENECKS

5.1 Types of disaster risk communication bottleneck

From the above analysis, for disaster risk communication at the stage of early warning and evacuation, two types of bottleneck can be identified, as shown in **Fig. 9**. Here, each triangle represents each agent, and intra-agent information processing is assumed to be conducted within each triangle (the upper or lower one) as represented by its respective horizontal row. One type of bottleneck (symbolized by small black triangle blocks within the row) is called an inter-agent bottleneck, and the other is an intra-agent bottleneck (symbolized by small black triangle blocks between Agent i and j). Inter-agent bottlenecks occur when two agents engage in communication between different organizations. Intra-agent bottlenecks happen in the C-E-D process within each agent.

5.2 Three-layer disaster risk communication agent model

In order to better understand disaster risk communication bottlenecks, from the viewpoint of integrated disaster risk management, especially considering the activities conducted by the agent who is positioned in a city or region, a three-layer conceptual disaster risk communication agent model is proposed, as shown in **Fig. 10**. The agent model (right-hand triangle) shows that each agent conducts activities based on the regional/social system. This regional/social system can also be modeled as our common temporal/spatial system as represented by the pagoda model (left-hand triangle) first proposed by Okada (2000).

Let us first look at the agent model. From the bottom up, the first layer (OL) is the organizational layer to which agents are related. It represents the organizational structure and framework that governs information flow among the same and/or different organizations (governmental and non-governmental agencies and local residents in the neighborhood community). The second layer (CL) is the cognitive layer. It addresses the risk perception characteristics of different cognitive agents such as local residents and government agencies. The top layer (AL) is the action layer. It is concerned with actions (which may interpretatively include revealed behaviors) taken by different agents as a result of the information-processing process structured by the above-explained C-E-D prototype model. In other words, the second and third (top) layers correspond to the C-E-D prototype model, and the first layer is considered to refer to the relevant organizational framework that provides a platform for information processing by related agents.

Importantly, a fundamental set of the three-layer subsystem needs to be positioned in a common spatial/temporal setting that we call the regional/social system. For instance, the development levels of infrastructural facilities in the regional/social system

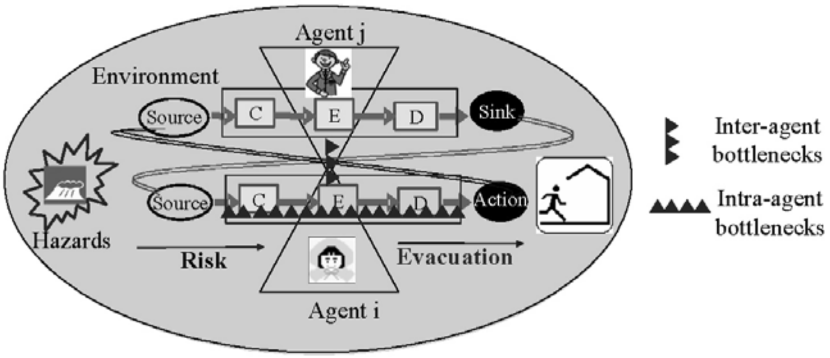


Fig. 9 Intra- and Inter-agent bottlenecks

together set the conditions for the three-layer subsystem to make early warning and evacuation messages accessible and useful to those responsible for this task as well as potential end-victims (local residents, schools, hospitals, companies, etc.) We propose to apply Okada's pagoda model to systematically characterize the regional/social systems. The large pyramid picture on the left in **Fig. 10** illustrates the pagoda system. The top level of this pagoda model, which refers to "life in the community," is interpreted as corresponding to the three-layer system. (See the small pyramid on the right in **Fig. 10**.) This perspective may also be used to position the levels of disaster risk communication bottlenecks.

This layer may be the most complicated, and concerns the kinds of physical, social, or psychological factors that determine whether or not a person adopts the correct action in a disaster emergency. The above three layers are based on a specified regional and social system. The roles played by these layers in disaster risk communication during emergency and quick response periods are highly dependent on the characteristics of this regional/social system. Okada (2004) set up a theoretical model (pagoda model) to describe it, and regards it as a five-story vital system. Basically, the top-level layer (LC) in the pagoda model corresponds to the action, cognitive, and organizational layers in the agent model. The layers (LB) to (NE) in the pagoda model correspond to the regional/social system in the agent model. These relationships between the three-layer disaster risk communication model and the pagoda model are shown by the dotted lines in **Fig. 10**. These models can be used together to classify different disaster risk communication bottlenecks positioned in spatial/temporal systems.

In fact, bottlenecks of disaster risk communication in the real world can occur from different aspects. According to the above conceptual model, the different bottlenecks analyzed in Section 4 are classified in **Table 3**.

6. POLICY ANALYSES

Next, some of the conceptual models proposed above will be used to discuss solutions to various risk communication bottlenecks regarding the early warning and evacuation mentioned in Chapter 4. **Table 3** is also used for this purpose.

6.1 Basic policy issues as a complementary discussion

(1) Layer (I)-(LB)-AL policy issues: An example of preventing the town office from being inundated (Case 1 in Table 3)

These policy issues are basically concerned with aspects of Layer (I)-(LB)-AL, all of which are defined as somewhat physical, location specific, and actionable. So a set of countermeasures may well be selected from this category.

As the center of disaster information receiving and dissemination, the town office plays an important role. Its disaster prevention capability is vital for the whole system of disaster early warning and quick response. Its location should be far from flood-prone areas. If possible, the disaster prevention facility should be backed up. For flood-vulnerable town offices, relocation or setting up a temporary center in the flood season would be an alternative solution. To avoid information cut off in a remote town from the outside, a corresponding wireless or satellite communication system should be set up in the local municipal office (or assumed alternative headquarter building) .

(2) Layer CL policy issues: An example of producing and sending readily comprehensible messages through *bousaimusen* to the public (Case 3 in Table 3)

These policy issues are basically concerned with aspects of Layer CL, which is non-physical and totally cognitive.

So that local residents clearly understand the information from *bousaimusen*, it is necessary to avoid using too many technical terms. Concerning the effectiveness of early warning, the number of broadcasts should be controlled. A standard for different evacuation modes should be set up.

(3) Issues of cooperation among agencies

Let us take the example of Case 5 in **Table 3**. This is the problem of "faxed messages confusingly neglected" caused by simultaneously transferring various kinds of information via fax. It is categorized as an inter-agent problem relevant to CL (cognitive

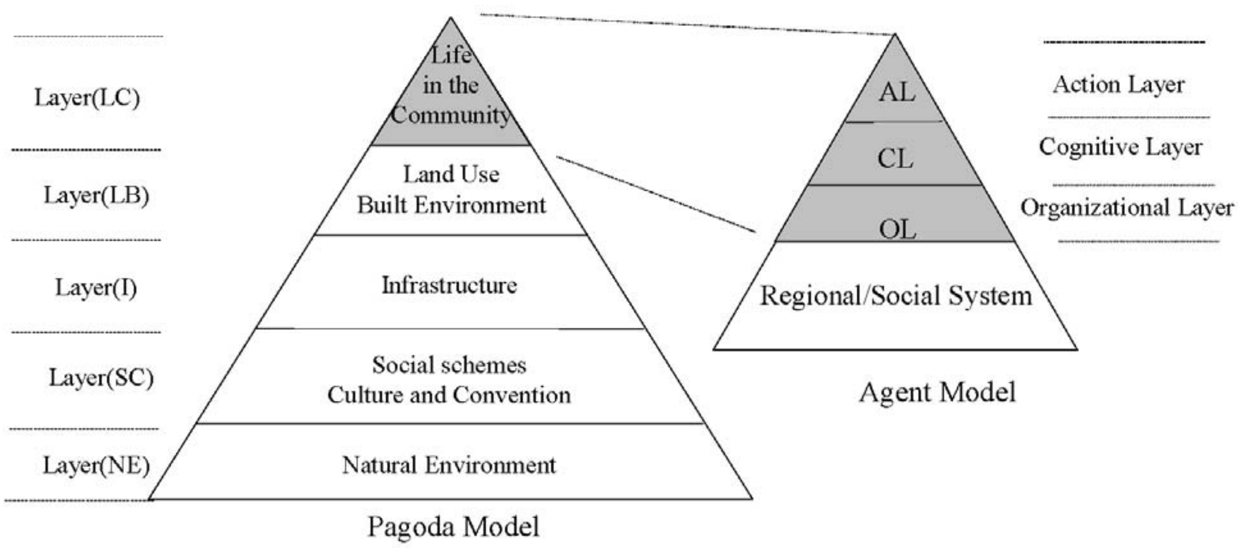


Fig. 10 Three-layer disaster risk communication agent model corresponding to "life in the community" in the pagoda model by Okada (2004)

Table 3 Bottleneck taxonomy of different cases

Case no.	Issue	Inter-agent	Intra-agent	Bottlenecks mainly happening in the layers
1	Town office inundation	○		AL, Layer (I), Layer (LB)
2	Village isolation	○		OL, AL, Layer (I), Layer (NE)
3	Contents of *bousaimusen*	○		CL
4	Self-judgment problem		○	AL, CL, Layer (SC)
5	Fax message issue	○		OL
	Bus accident	○		AL, OL, Layer (I), Layer (NE)
6	Refuge problem	○		CL, OL, Layer (SC), Layer (NE)

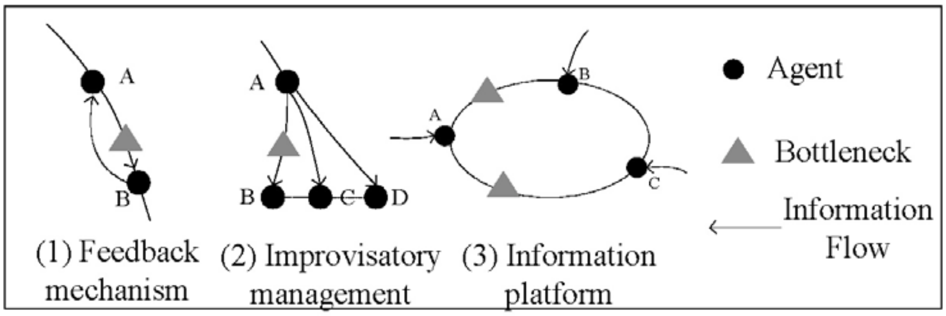


Fig. 11 Some countermeasures against bottlenecks

level). Although it looks relatively simple, definitions have to be examined in a comprehensive manner. Application of **Fig. 11** may well serve this purpose.

To solve the problem of "faxed messages confusingly neglected," a certain feedback mechanism should be set up, as Graph (1) in **Fig. 11** shows. Although it may not always be necessary, upgrading the reliability of the whole communication system will be very effective. It is necessary to set up some kind of feedback mechanism from local residents to the town office in the early warning system. For the communication network, multi-routes are necessary. When disasters occur, some communication routes that work well in normal times are found to fail. So, in this context, improvisatory management should be conducted. Temporary routes of communication should be set up or used as a tentative method of transferring information, as shown by Graph (2) in **Fig. 11**. This kind of temporary (and contingent) management should be involved in routine disaster training programs.

To avoid the accident of the sightseeing bus mentioned above, a platform of information sharing is needed. On this platform, related real-time information from different agencies can be browsed and modified, and can be utilized by other agencies, as shown by Graph (3) in **Fig. 11**.

(4) Issues of participation

Related to the issues of cooperation, we need to discuss issues of participation. A good example is a combination of Cases 4 and 6 (and quite likely also Cases 1, 2, and 3 in **Table 3**). In the issue of shelters, whether a shelter is safe or not should not be determined only by one agent, e.g., the town office. Participatory risk communication is needed among government, NGOs, and local residents. After all, local residents are the victims of natural disasters. Their capability of risk perception of natural disasters should be improved under the help of government and NGOs. So, in normal times, residents, governments, and NGOs should work together, strengthening participatory risk communication among them. Overcoming the bottleneck of "self-judgment" depends on disaster education through disaster participation activities among local residents, government, and NGOs.

(5) Issues of span of time

The bottleneck of disaster risk communication needs to be examined not only from the viewpoint of agents or organizational structure, but also from the temporal aspect, that is, span of time. This viewpoint is sometimes easily omitted, but is in fact very important, considering the disaster management cycle. There are two stages to be focused on along the time axis as shown in **Fig. 12**. Here, "Time 1" denotes the period from the moment at which a hazard is observed to happen to the moment at which the residents manage to find a safe place. "Time 2" denotes the long period until a hazard happens again. Katada et al. (2003) noted that for local residents, evacuation and action to protect household goods against inundation arise from the recognition that it is a time of calamity. And these actions have a tendency to be suspended until the recognition becomes certain. This process of recognition based on gathering disaster information corresponds to "Time 1" here. For floods, "Time 1" is very limited, especially for flash floods. The decision to evacuate must be made within a limited span of time. But a flood sometimes comes very quickly, and people have no time to respond. From this viewpoint, "Time 1" can be regarded as a special kind of bottleneck in disaster risk communication. In addition, it is unreasonable to regard "Time 2" as unlimited. So, in normal times, residents, governments, and NGOs should hurry, work together, and strengthen participatory risk communication among them. Otherwise, when disaster strikes, early warning will be found not to work. Okada and Matsuda (2005) proposed a risk communication strategy for community-based disaster preparedness. Without this successful communication process in routine life, it is difficult to achieve the goal of eliminating various bottlenecks in disaster risk communication in the process of early warning and evacuation.

6.2 Limiting factors for overall policy assessment

If the above basic proposals are examined in the context of concrete communities, some limiting factors related to localities will be found. This paper has shown this only in the limited contexts of the study areas selected. Moreover for overall policy assessment, there are many other factors to be examined such as economic costs, aging society, fewer young people in rural areas, interest conflict between different social groups, land use policy, etc. They can appear at different levels in the pagoda model. These factors will adversely affect an effective solution to various disaster risk communication bottlenecks being found. If various disaster risk communication bottlenecks are likened to the leaves of a tree, these limiting factors would then be the roots. How to eliminate them is the task not only of disaster prevention managers, but also of regional development planners. This leads us to our claim that a more integrated disaster risk management is needed.

7. CONCLUSIONS

The various bottlenecks of disaster risk communication are significant problems in disaster early warning and quick response. In this paper, a systematic method of formalizing and analyzing these bottlenecks is proposed. For this purpose, several conceptual models are presented. The C-E-D model can be used to analyze bottlenecks of information processing within one agent. Its application can be extended to analyze inter-agent information problems among different agents and organizations. To explicitly examine information-sharing devices of the different agents involved, the proposed hierarchical and sharing model can be used. The three-layer risk communication model associated with the pagoda model helps us position the level of bottlenecks in disaster risk communication. In this way, we can closely examine the whole picture of bottlenecks from the viewpoint of integrated risk management. Policy implications may also be effectively derived from this approach. Our methodological approach to proposing a framework (if further improved) will serve to systematically guide field investigations during and after a particular disaster if we intend to analyze, evaluate, and solve a diverse spectrum of integrated disaster risk management issues, particularly focusing on disaster risk communication problems.

Of course, the current study has limitations and further examination needs to be conducted. Admittedly, more extensive investigation should be carried out to follow up on the tentatively found results and implications. In the same fields as well as other fields, adaptive research should be further conducted. Continuous monitoring and verification are essential to improving the applicability of our approach. In fact, we are now conducting a similar study to systematically analyze two recent flood disasters in China. Additionally, continuing work will be performed in the same area in Japan and continuous monitoring conducted to examine the viability of the formalized knowledge and models.

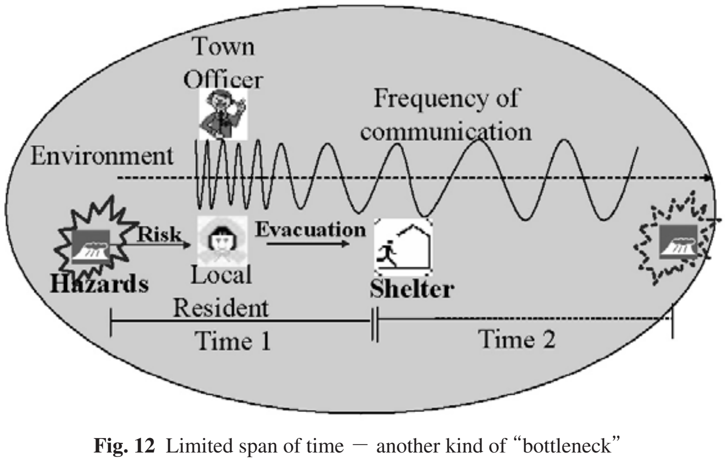


Fig. 12 Limited span of time — another kind of "bottleneck"

ACKNOWLEDGEMENTS

This study was supported by the Japanese Ministry of Education, Culture, Sports, Science and Technology 21st COE Program, awarded to the DPRI, Kyoto University. We would like to thank Dr. Yukiko Takeuchi and students of the Research Center for Disaster Reduction Systems, Disaster Prevention Research Institute, Kyoto University for their kind advice and help.

REFERENCES

Cabinet Office Government of Japan, 2005. The Loss of Typhoon No. 14 Disaster, (Report No. 28), URL: http://www.bousai.go.jp/

Hiroi, O., Nakamura, I., Tanaka, A., Fukuda, M., Nakamori, H., Sekiya, N., and Kurosawa, C., 2005. The Problem of Information Dissemination and Inhabitants Behaviors of Local Severe Rain in Niigata and Fukushima, 2004 (in Japanese), Interfaculty Initiative in Information Studies, Graduate School of Interdisciplinary Information Studies, The University of Kyoto.

Katada, T., Oikawa, Y. and Kodama, M., 2003. Analysis on time series changes of gathering and consciousness in process of typhoon approach (in Japanese), *Proceedings of River Engineering*, Japan Society of Civil Engineers, Vol. 9, pp. 293-298.

Kyoto Shinbun, Special Reports about Typhoon No. 23, 2004, URL: http://www.kyoto-np.co.jp/

Ministry of Land, Infrastructure and Transport Kinki Regional Development Bureau, 2004. Quick report of Disaster of Typhoon No. 23 (in Japanese), URL: http://www.kkr.mlit.go.jp/.

Miyazaki NichiShinbun, Special Reports about Typhoon No. 14, 2005, URL: http://www.the-miyanichi.co.jp/.

Okada, N., 2004. Urban Diagnosis and Integrated Disaster Risk Management, *Journal of Natural Disaster Science*, Vol. 26, No. 2, pp. 49-54.

Okada, N., 2005. Toward the Making of a Social System Resisting Disasters (in Japanese), *Rebuilding Maintenance and Management*, No. 147, pp. 11-16.

Okada, N. and Matsuda, Y., 2005. Risk Communication Strategy for Community Based Disaster Preparedness Viewed as Multilateral Knowledge Development, IEEE International Conference on Systems, Man and Cybernetics, CD-ROM.

Takeuchi, Y., 2006. Residents' Recognition about Rainfall and Evacuation Action in Flood Disaster － Case of Niigata, Fukui Heavy Rainfall and Typhoon No. 23 in 2004, *Natural Disaster Research Report*, National Research Institute for Earth Science and Disaster Prevention, Vol. 40, pp. 103-110.

Ushiyama, M., 2005. Characteristics of Human Damage by Typhoon No. 0423 from October 20 to 21, 2004 (in Japanese), *Journal of Japan Society for Natural Disaster Science*, Vol. 24, No. 3, pp. 257-265.

Yoshida, T., 1990. Jikososhikisei no johokagaku (in Japanese), (Information Science of Self-organization), Shinyosha, Tokyo.