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Bottleneck Analysis of Disaster Risk Communication Problems Based on Post-disaster Field Surveys

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Synopsis

In this study, based on field surveys, a methodology is proposed to systematically formalize the bottlenecks about disaster risk communication. The various bottlenecks about disaster risk communication during flood early warning and evacuation in the case studies are examined, and then be analyzed and categorized. Based on these the conceptual models are proposed to formalize them in the viewpoints of integrated risk management and the corresponding policy solutions are proposed.

Keywords: disaster risk communication, information flow, formalization

1. Introduction

Japan is one of the countries severely affected by the typhoon disasters. Sometimes the typhoon will cause huge property losses and human injuries. For reducing the life and economic losses of typhoon disasters, the important role of the effective early warning system and evacuation action is obvious. But from the practice of coping with typhoon disasters in recent years in Japan, many issues related with the dissemination of early warning information and evacuation action were found has not been well resolved yet.

In this paper these issues are examined from the viewpoint of disaster risk communication. Here the communication of “risk” in the period of disaster early warning and quick response is focused. By the examination and evaluation of the various failures or obstacles of risk communication system in the real situation and the various natural, technical and social factors as the reasons behind them, the conceptual risk communication models are proposed as a framework to analyze and formalize them. We attempt to set up a method to systemize the lessons or bottlenecks of early warning and evacuation actions under the different real contexts. It will benefit us to better understand the whole process of disaster early warning and evacuation action systematically. It is also intended that by adaptively applying this approach in future, the findings of this paper will be further monitored and verified for the same fields and /or other ones.

Case studies have been conducted for two disaster fields. One was the northern region of Kyoto prefecture which suffered heavy rainfall and flood disaster by the typhoon No.23 in Oct. 2004 (Ministry of Land, Infrastructure and Transport Kinki Regional Development Bureau, 2004). Another is the Kyushu region which suffered flood disaster by typhoon No.14 in Sep. 2005 (Cabinet Office Government of Japan, 2005). Case studies have been conducted first by analyzing data and information available on the official websites of the central and local governments, local newspapers, etc. Also field surveys were conducted by the authors. 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 (now it has been combined with the city of Fukuchiyama) in the northern Kyoto prefecture, the field survey was conducted on the day of Nov.29, 2005. For the typhoon No.14, field surveys were conducted three times in the town of Kitakata Cho and Hinokage Cho in the northern Miyazaki prefecture. The corresponding time of field survey is Nov.10 - Nov.11 (2005), Jan.12 - 13 (2006) and Dec.20 - 21(2006).

In the field surveys the questions on the following aspects were raised to the interviewees:

[1] The circumstance of information dissemination of early warning and evacuation action;

[2] The personal risk perception and evacuation behavior of the individual interviewed;

[3] Mutual role evaluation by different interviewees;

[4] The expected information from the town office in the viewpoints of the local residents.

2. Results from the field surveys

In Japan according to different degree of emergency there are three types of natural disaster warning modes disseminated from the town office to the local residents: voluntary evacuation, advice of evacuation and instruction of evacuation. Comparing with the case of Oe Cho in Typhoon No.23, in the case of Kitakata Cho in Typhoon No.14 the local residents have more experience of coping with Typhoon disasters and liable to conduct voluntary evacuation.

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

[1] Town office inundated（Source: from the interview and related reports of newspapers）. Some town offices which were assumed to serve as the 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 building of town office was inundated, and made the electric power shut down. The communication facilities failed to receive the related information from other administrative agencies. It was also not possible to send out the evacuation message to the local residents. In the case of Kitakata Cho, though the Bousaimusen system being set up on the second floor still worked, but the dissemination of evacuation instruction was delayed, because the facilities of disaster information processing system on the ground floor were inundated and can not be used to receive and analyze data.

[2] The information receiving in the part of local residents (Source: from the interview). In the case of Oe Cho, five villages were isolated by the flood or landslide. The road and electricity were cut off. In the case of Hinokage Cho similar situations happened. Three villages were isolated by the landslide. The telecommunication and electric line connecting with outside were cut off. The on-site condition had to be obtained only on foot. Under these circumstances the local residents must depended on their own knowledge and judgment to survive and evacuate. In the survey of Kitakata Cho, the complaint by some households of “forgetting put battery in” was found. In normal period, some residents put the battery out of the receiver of Bousaimusai. However in emergency period, they did not notice it. So they would not receive related disaster information via this device.

[3] The understandable of the information of “risk” (Source: from the interview). By field survey some gaps of risk perception between local residents and the staff in the town office were identified. In the town office of Kitakata Cho beside the river of Gokase, the dissemination of early warning and evacuation information from town office is conducted via Bousaimusen. The content of information is like “now the runoff from the Hoshiyama dam is xxxx ton/sec, please conduct voluntary evacuation, etc.” The Hosiyama dam is located on the upstream of the town. But from the viewpoint of the local residents, this kind of information seems too technical. Via this kind of information, it is difficult for them to judge how risky is at their home. So how extent the information affected the evacuation behavior of local residents is not the same expected by the town office. It would be more easily for the local residents to understand the risky situation by receiving the information disseminated to them like this: “Now the liquor shop has been inundated, please evacuate”. Here the liquor shop is located near their home. They are familiar with it and prefer to use it as a reference.

[4] The decision making of evacuation (Source: from the reports of newspapers and other researchers). In the case of Oe Cho, though different kinds of evacuation information disseminated from the town office, only not more than 20 percent local residents followed the

instruction of evacuation. The similar situation happened in the other flood affected region in Kyoto prefecture. In addition, through field survey local residents were found more prefer to choose the second floor of their house than the official designated schools as shelter.

In the case of Kitakata Cho, the situation was different, most local residents conducted voluntary evacuation to designated shelters. For designated shelters in eleven districts in this town, all of 217 refugees adopt voluntary evacuation. In addition, various factors were found affecting the decision making of evacuation, which can be seen from the following narrative from the interviewees:

"I am old, and should evacuate earlier".

"Even the flood enter my room, I can stay on the second floor temporarily, so I am not worry about it".

"Some valuable articles are still on the first floor, after upholding them to second floor, then I will evacuate", etc.

Usually, the evacuation instruction can not make the local residents follow instantly. They need to consider their own circumstances. There were many factors affecting their decision making.

[5] Information Exchange between organizations (Source: from reports of newspaper and other researchers). There were bottlenecks happened in this aspect. Here two examples are given. In the context of typhoon No.23, during the period of emergency, too much information, about their priority of importance, was sent out to the receiver via FAX, confused the receiver and made them spend lots of time to check. Another example in which one sightseeing bus with 37 people was trapped in the flood happened in the case of typhoon No.23. On the road to the destination at night, this bus was trapped and stopped by the flood of the Yura River. The 37 people had to spend a terrible night on the roof of the bus. From this accident, the issue which there was not effective information sharing between the traffic and river agencies can be identified.

[6] Designated refuge shelters (Source: from field surveys and reports of newspapers). In the case of Typhoon No.23, 2004 (in Oe Cho), some designated refuge shelters were complained by the local residents that were "inundated, too far away, or the door had not been open yet", etc. The similar circumstances also happened during Typhoon No.14. In Hinokage Cho, one primary school specified as official refuge shelter had not been inundated by river under its foot, but over its head a severe landslide happened. It was nearly destroyed.

For the above problems or bottlenecks, it is not enough to only list and record them in the report, but it is necessary to analyze them, to set up some kind of theory to formalize them. This kind of theory will be useful for the understanding of the complexity and variety of disaster risk communication, also for the corresponding policy making in the future.

3. Conceptual disaster risk communication agent models

Here two types of agent models are proposed about disaster risk communication in the stage of early warning and quick response: one type is a special type: communication with agent of environment. Another type is communication with other agents.

3.1 Communication with agent of environment.

Through common sense and experience from routine life, the human beings have the capability of communication with agent of environment. As the natural hazards happen, through his own observation and past experience and knowledge, some human being can make correct judgment, such as which place is in danger or which place is safe and secure. For this process from the information he observed to the action he adopt, the so-called C-E-D model can used to describe it, as shown in Fig.1. The C-E-D model is 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.

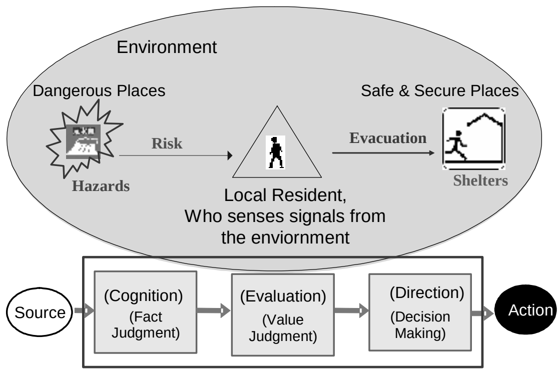

Fig. 1 Communication with agent of environment

The agent (here denotes the local resident) senses the signals from the environment and through the process of cognition, evaluation and direction, and then makes the decision. In the cognition process the agent needs to recognize the fact; and in the evaluation process the agent need to conduct the value judgment; and in the direction process, the agent makes a corresponding decision. For the evaluation which the person makes, his past experience and knowledge which learned from the routine life take an important role to evaluate how severe the condition is and when it is the time to conduct evacuation.

3.2 Communication with other agents

Comparing with the former, it is more common for the communication with agents. Here the agents would be the staff of town office or their neighborhoods, shown as Fig.2. This time the C-E-D process is still valid within each agent. The information sink of the local residents not only comes from the environment directly, but also come from other agents such as the town office. For example, the local residents receive the information, e.g. the advice of evacuation from the town office, and combine them with their own observation of the environment and decide whether or not to evacuate. Once the decision is made, they will go to the safe place, such as the official designated shelters. This kind of information flow between the town office and local residents is obviously not one-directional. Sometimes the local residents will give some useful on-site information to the town office.

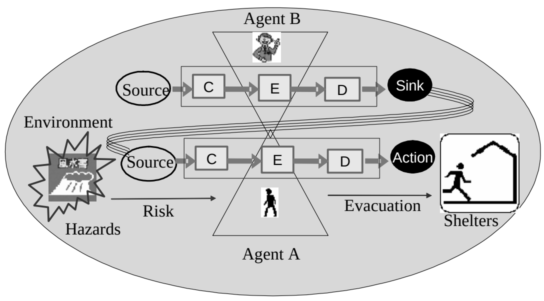

Fig. 2 Communication with other agents

3.3 Information flow between different agents

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

In order to denote these model figuratively, three basic elements are introduced here, shown as Fig.3. They are node, directed arc and loop, denote agent, information flow and information sharing respectively.

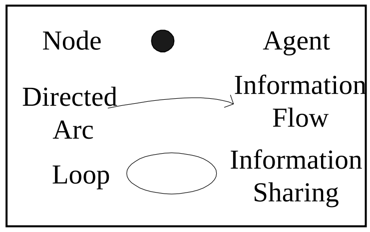

Fig. 3 Three basic elements

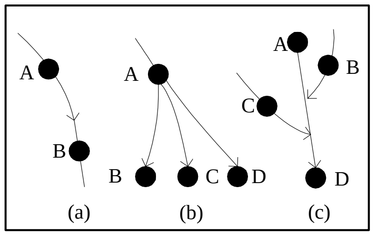

Fig. 4 Hierarchical model

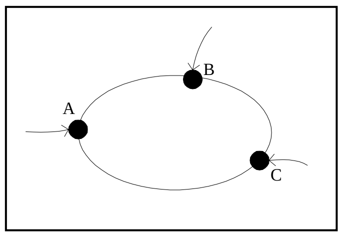

Fig. 5 Sharing model

(1) Hierarchical model

In this case the information flow is commonly one-way. Graph (a) in the Fig.4 gives its basic form. Its complex variation could be found in actual practice, as graph (b) and (c) in the Fig.4 shows. The information flows among the administrative agencies can be illustrated by these graphs. The dissemination of meteorological information from the meteorological agency to related administrative agencies is more like graph (b). The disaster related information coming from different sources received in the town office is more like graph (c).

(2) Sharing model

As Fig.5 shows, here the related agents share their information. The loop serves as an information platform. Through this platform the content of information coming from different sources are integrated and matched properly. In the context of early warning and evacuation, two types of sharing models can be identified. One would be the external dependent type. The information broadcasting system on the platform of internet can be illustrated by this type. It serves as the common platform to give the external dependent information to the public. Another would be the self-reliance type. In the context of community, the evacuation behavior of local residents can be described as this graph. The local residents mutually exchange the information they received from other media or related NGOs, and then make their own judgment.

4. Bottlenecks analysis

Here the bottlenecks mentioned in the section 2 will be analyzed by the above models.

Case 1: Town office inundated. Because of inundation, its facilities were damaged physically. It lost the capability of information receiving, and information dissemination. Its headquarter functions are paralyzed. The communication between town office & local residents was blocked. The position where bottlenecks happened can be illustrated in Fig.6 (a).

Case 2: the isolation of local community. Here three types of isolation can be identified. One type is physical isolation, which means that community is not physically accessible. The lifeline and road were shut off from outside. The second type is communicative isolation. The communication bottlenecks between residents and town office could be one-way or two-way. The one-way bottleneck is the case that even though some households can receive the information by Bousaimusen, but it was difficult for them to send information out to let the town office know that they were isolated. It can be illustrated as Fig.6 (b). The two-way bottleneck is the case that the household is totally isolated from outside. They can neither receive the information from outside, nor send out the rescue information to the outside. The third type would be the transportation and supply other lifelines isolation. In this case there was no problem about the communication of local community with outside, but transportation and lifeline supply are still not function. The food supply still depends on the outside by helicopter.

Case 3: The contents of Bousaimusen. “Now the runoff from the Hoshiyama dam is xxxx ton/sec, please conduct voluntary evacuation”, the local residents understand the meaning of this sentence ,but by it they could not evaluate the risk situation. The decision of whether or not the evacuation should begin could not be made.

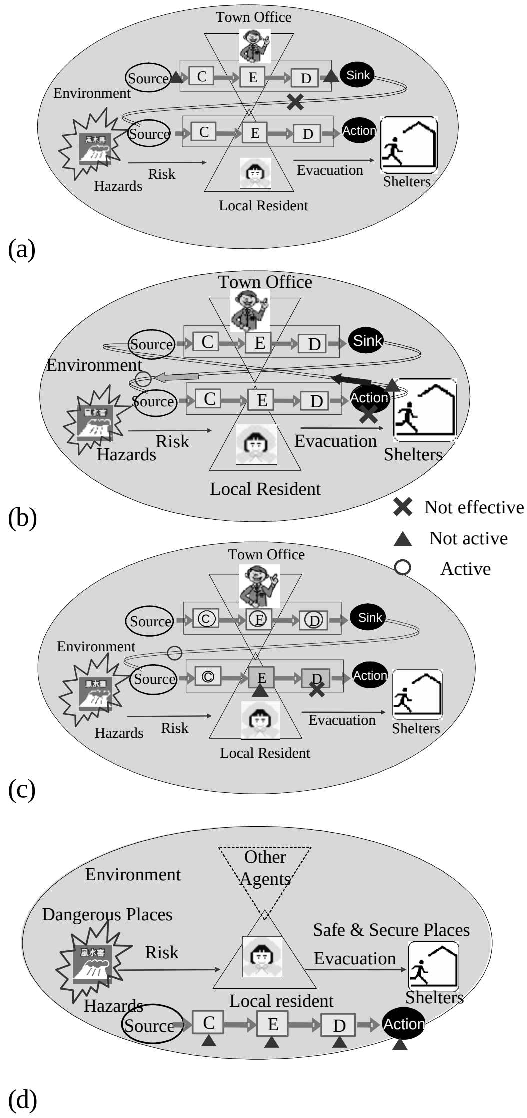

Fig. 6 Various bottlenecks of risk communication

As Fig.6 (c) shows, this time for the information process of C-E-D, the bottleneck happened in the process of “E”, so the process of “D” will not be active.

Case 4: The problem of self-judgment. Through field surveys, some local residents were found to take action more depending on their own judgment. For them the messages from the town office is only one of information source for reference. Here it should be pointed out, if this judgment comes from their past disaster suffered experience it would be some kind of reasonable. However if it only comes from self-confidence or being taken for granted, it would be dangerous. In addition, the bottlenecks could be happened in the any parts of the process of "C-E-D", as shown in the Fig.6 (d). Usually the local residents can recognize the facts through the observation. But sometimes the scope limitation of information access and individual past experience will prevent them making correct fact judgment. So the bottleneck can happen in the stage of "C".

Priority is other factor need to be pointed out. For the life of people it is needed to be evacuated to safe place, but also their properties. When they decide to adopt certain action they must make a balance between them. It is one point need to be considered not only by the local residents but also for the enterprise. In one point there is difference between flood and earthquake. For the flood, people still have some time to take response. For this case, the bottlenecks will happen in the process of "E". If their evaluation is not correct, then the wrong decision would be made inevitably.

By the way, for the disables or elder persons, they can not take action themselves. In the disaster of Typhoon No.23, among 96 persons killed, 54 persons were over 65 years old (Ushiyama, 2005). Though they would have heard the message of warning, they could not take the quick evacuation by themselves. In this situation the bottleneck can be categorized to be happening in the process of "D".

Case 5: Information exchange among agencies. As the "FAX" problem concerned, the reason of bottleneck happening would be ascribed to the one-directional information flow. For transferring message only via Fax, there is one weakness. Sometimes it will not be guaranteed the message to be received in time and understood completely by the receiver. In addition, the staff who receive a large number of FAX sheets from the related agents sometimes are not clear which one would be more important. The multiple (and no-classified) contents of the FAX made the recipients confused (Okada, 2005). For the accident of sightseeing bus, the bottleneck can be ascribed to lacking an information sharing system. To solve this problem, it is not enough only depending on the information from one or two agents.

Case 6: Designated shelters. The official specified shelters are assumed to be safe enough to one kind of disaster, but sometimes they are facing high risk of another kind of disaster. The reason of it can be ascribed to lacking of enough knowledge of the local community.

5. Formalization of Bottlenecks

5.1 Types of disaster risk communication bottlenecks

From the above analysis, for the disaster risk communication in the stage of early warning and evacuation action, two types of bottlenecks happened in the real case can be identified: one is inter-agent bottleneck; another is intra-agent bottleneck (see figure 7). Inter-agent bottlenecks happened when two agents conduct communication, and intra-agent bottleneck happens in the C-E-D process within one agent.

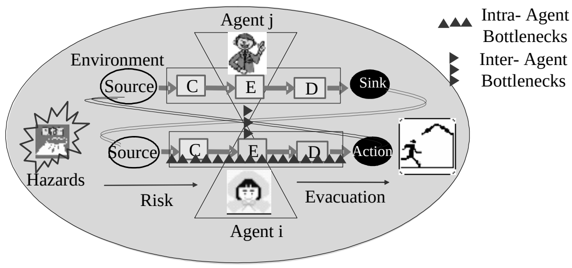

Fig. 7 Intra- and inter-agent bottlenecks

5.2 Three-layer conceptual risk communication agent model

In order to better understanding the disaster risk communication bottlenecks, from the viewpoint of integrated risk management, especially considering the agent conducted activities, here the three-layer conceptual disaster risk communication agent model is proposed, as shown in the Fig.8. From bottom to up, the first layer (OL) is organizational layer. It represents the organizational structure and framework which governs information flow among the same and/or different organizations (governmental, non-governmental and local residents in the neighborhood community). The second layer (CL) is cognitive layer. It addresses the risk perception characteristics of different cognitive agents such as local residents and government agencies. The top layer (AL) is action layer. It is concerned with actions (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 top layers correspond to the C-E-D prototype model and the first layer is considered to refer to the relevant organizational framework which provides a platform for information processing by related agents. The above three layer is based on the background of specified regional/social system. Okada (2004) set up a theoretic model (Pagoda Model) to describe it, and depicted it via a five-story vital system. The relation between the three-layer disaster risk communication agent model and Pagoda model are shown as Fig.8. They can be used together to classify the different disaster risk communication bottlenecks.

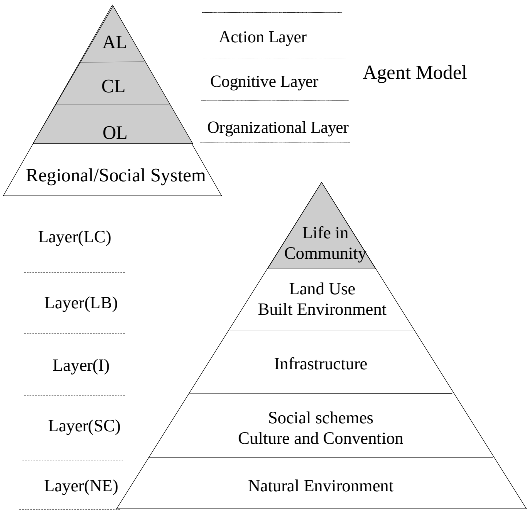

Fig. 8 Three-layer disaster risk communication agent model corresponding to "Life in Community" in the Pagoda Model by Okada

In real world, the bottlenecks of disaster risk communication would occur in different aspects. According to the theory set up in this section, the taxonomy of different bottlenecks analyzed in the section 4 can be made as Table 1.

Table 1 Bottleneck taxonomy of different cases

Issue	Inter-agent	Intra-agent	Bottlenecks happened in
Town office inundation	○		AL, Layer(I)
Village isolation	○		OL, AL, Layer(I)
Bousaimusen Content		○	CL
Self-judgment problem		○	AL,CL, Layer(SC)
(a)FAX issue	○		OL
(b)Bus accident	○		AL, OL, Layer(I)
Refuge problem	○		CL,OL, Layer(SC)

6. Policy Analyses

Next the conceptual models proposed above will be used to discuss the solutions about various risk communication bottlenecks about early warning and evacuation mentioned in chapter 4.

[1] Town office and isolated villages. 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 the flood prone area. If possible the facility of disaster prevention should be back up. For the flood vulnerable town office, relocation or setting up a temporary center in the flood season would be an alternative solution. To avoid becoming an information isolated island, the corresponding wireless or satellite communication system should be set up in remote towns or villages.

[2] Readily comprehended messages from Bousaimusen to the public. In order to let the audience understand the content of it, it is necessary to avoid including too much technical terms in the content of Bousaimusen. Concerning about the effect of it, the times of broadcast should be controlled. Also the standard of different evacuation mode should be set up.

[3] Cooperation among agencies. To solve the issue, such as FAX problem mentioned above, the mechanism of feedback is needed. Though it may not always be necessary, but it will improve the reliability of the whole system. Also it is necessary to considering set up some kind of feedback mechanism from the local residents to the town office in the early warning system. For the communication network the multi-routes are necessary. When disasters happened, some communication routes which work well in normal time will be found to be failure sometimes. So in this case some kinds of improvisatory management should be conducted. The temporary routes can be regarded as a tentative method to transfer information. This kind of temporary (and contingent) management should be scheduled in the routine disaster training program. To solve the problem of "Bus" accident, the information sharing via internet platform should be done. On this platform the related real time information coming from the different agencies can be browsed and modified, and can be utilized by other agencies.

[4] Importance of participation. For the issue of shelter, whether it is safe and danger should not be determined only by one agent, e.g. town office. The participatory risk communication among government, NGOs and local residents is necessary. After all the local residents are the victims of natural disaster. Their capability of risk perception to natural disaster should be improved under the help of government and NGOs. Their opinion and circumstances should be involved in the process of shelter designation. For the bottlenecks of "self-judgment", to overcome it depends on the disaster education through the disaster participation activity among local residents, government and NGOs.

[5] Span of time. It should be considered in the disaster risk communication. There are two time stages as shown in the Fig.9. Here the "Time 1" denotes the period from the moment the hazard is observed to occur to the moment the residents find the safe place. And "Time 2" denotes the long period until the hazards happen in the future. For the flood the "Time 1" is very limited, especially for the flash flood. The decision of evacuation should be made within the limited span of time. However sometimes in the real world the flood comes so quick and it makes people have no time to response. From this viewpoint "Time 1" can be regarded as a special kind of bottleneck for the disaster risk communication. It should be pointed out that it is unreasonable to regard "Time 2"as unlimited. So in normal time the residents, governments and NGOs should hurry up and work together, strengthen participatory risk communication among them. Otherwise when the disaster comes one day, the early warning would be found not working.

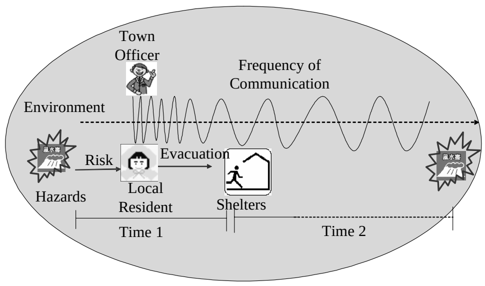

Fig. 9 Limited span of time – another kind of bottleneck

7. Conclusions

The various bottlenecks of disaster risk communication are big problems for the disaster early warning and quick response. In this paper through the examination of them via case studies, from the integrated disaster risk management viewpoint, a methodology to formalize these bottlenecks is proposed. The C-E-D model can be used to analyze the bottlenecks within one agent. The hierarchical and sharing model can be used to analyze the information flow among different agents. The three-layer risk communication agent model together with Pagoda model can be used to depict the whole picture of bottlenecks of disaster risk communication from the integrated risk management viewpoint. Based on this kind of theoretical analysis, the corresponding policy solutions are proposed.

Though the method proposed in this research is set up based on the two case studies of typhoon disaster in Japan, it was found valid and useful in the case studies which the author conducted in the two flood disasters in China. Additionally continued work will be performed in the same field areas and continuous monitoring made to examine the viability of the formalized knowledge and models.

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ポスト災害実地調査に基づく災害リスクコミュニケーション問題のボトルネック分析

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要　旨

本研究は災害現場での調査に基づいて，洪水早期警戒と避難のための災害リスクコミュニケーションについてのいろいろなボトルネックは、分析されて、分類されます。これらに基づいて，三階層システム概念モデルを踏まえた調査論の展開が有用であることを提唱した。これらの概念モデルを提案し，適用することにより、特に災害発生時の早期警戒や緊急避難に伴う教訓や政策課題を定型化するための基礎的アプローチを行った。

キーワード: 災害リスクコミュニケーション，情報の流れ，定型化