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Will Mail-Based Disaster Information Systems Work Well?: A Case Study in Japan

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Abstract. Japan's recent disaster response management planning efforts have focused on non-structural measures. Many local governments often disseminate evacuation information through mail-based disaster information systems. Local governments make evacuation announcements based on their best judgment, and after that, they disseminate these announcements further using e-mails. However, there are no format of mail-based disaster information systems, and it has proven difficult to disseminate the appropriate evacuation information at the right time. Further, there are no current studies focused on developing a more suitable and effective management of mail-based disaster information system. We intend to analyze problems associated with current disaster information systems?with the objective of being able to recommend improvements?by focusing on actual evacuation information dissemination processes of mail-based disaster information systems. We begin with a survey of the actual content and timing of text messages issued by local governments. In this way, we are able to identify differences between text messages and time delays in the dissemination of evacuation information by local governments. Our case study is based on a survey of the evacuation information dissemination processes used in the case of Typhoon Man-yi (2013).

Keywords. disaster response, evacuation information, dissemination processes, e-mail

Introduction

Japan's recent disaster response management planning efforts have focused on non-structural measures. Many local governments often disseminate evacuation information through mail-based disaster information systems, and local governments are responsible for helping residents decide whether to evacuate [1]. The communication of evacuation information is a stepwise process, made up of phases. These phases are implemented according to the severity of the disaster; specifically, local governments implement different phases as needed, to keep residents informed of the severity and potential dangers of the unfolding disaster. As depicted in Figure 1, there are three phases: first, dissemi-

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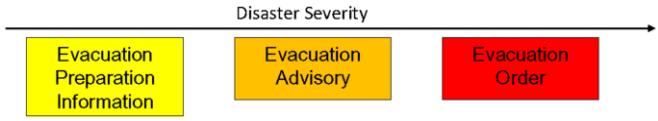

Figure 1. Evacuation information phase

nate evacuation preparation information; second, issue an evacuation advisory; and third, issue an evacuation order. Many local governments issue their evacuation information using e-mails. Currently, many residents use mobile devices, so they can receive information wherever they are. For that reason, optimal dissemination processes have become a necessary component of disaster management measures. However, there are no guidelines outlining how a mail-based evacuation information system should operate. As a result, mail-based evacuation information systems are managed differently in each local government. To date there has not even been any discussion about what the components of an appropriate evacuation information system would be, and consequently most local governments do not manage their mail-based evacuation information systems very well.

The objective of this paper is to break down the problems associated with these information systems, so that we can understand them better, and suggest improvements. We begin by analyzing existing mail-based evacuation information dissemination processes. We survey the case of Typhoon Man-yi 2013 first. Using our survey results, we analyze the evacuation information systems that were used, focusing on the timing of dissemination and the contents of the text messages sent.

While some studies have focused on evacuation information systems, no studies have been based on surveys and analyses of actual evacuation dissemination processes. Kodama examined different evacuation information phases and found them to be effective [2]. Yabe reviewed evacuation information related to the specific characteristics of regional flooding [3], and Katada analyzed residents'intentions to acquire disaster information in the event of flooding [4]. Ohta investigated a heavy rainfall disaster using non mail-based information that had been provided by local governments [5].

In the next section, we summarize our survey of existing mail-based evacuation information dissemination processes. Section 2 explains how we analyzed these processes by focusing on the timing of the dissemination and the contents of the text messages sent. Section 3 suggests improvements to the mail-based evacuation information systems. Finally, Section 4 concludes this paper with suggestions for future research.

1. Survey Overview

We surveyed the case of Typhoon Man-yi that formed on September 13, 2013, and struck Japan on September 16 (see Figure 2). Several regions suffered serious damage from this typhoon. It resulted in 6 deaths, 1 missing person, and the destruction of 11,739 residences. Kyoto Prefecture, Shiga Prefecture, and Fukui Prefecture announced heavy rain Emergency Warnings. Emergency Warnings are weather bulletins issued by the Japan Meteorological Agency (JMA) [6], to alert people to the significant likelihood of catastrophes associated with natural phenomena of extraordinary magnitude.

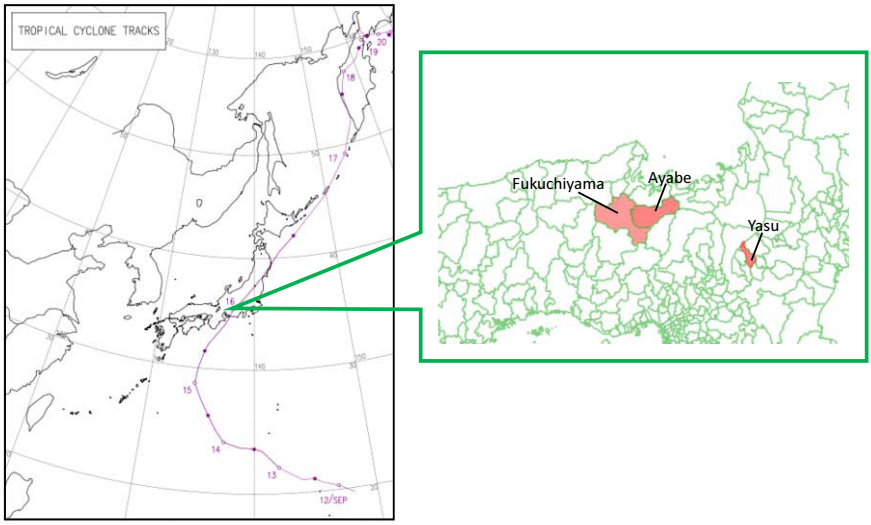

Figure 2. Tracks of Typhoon Man-yi in 2013

We collected three types of disaster response data from each of the three local governments, and studied the contents of text messages sent from Kyoto and Shiga Prefectures. The three types of data collected were: what weather information had been announced and when (the JMA announces weather information to help local governments judge whether they should issue evacuation notices [6]); what evacuation information had been issued and when; and what mailings local governments had disseminated and when.

We concluded that the local governments that had provided us with their evacuation information dissemination dates quickly and correctly were the governments most capable of disseminating evacuation information. Other local governments did not provide their dates, and did not summarize their evacuation response records as requested. Even worse, one local government tampered with its data. It was apparent that evacuation information dissemination problems existed even among otherwise capable local governments.

2. Analysis of the Evacuation Information Dissemination Processes

In this study, we analyzed evacuation information dissemination processes with a focus on their timing and message contents. Timing of the dissemination allowed us to judge whether residents obtained information quickly and so were better able to decide when to begin evacuating; message content allowed us to assess whether residents were able to assess their levels of risk accurately. By analyzing the data we had collected, we were able to document on-going problems with the dissemination processes.

2.1. Timing of Evacuation Information Dissemination

The first point to be discussed is whether local governments disseminated evacuation and weather information within suitable time frames. As depicted in Figures 3 and 4, we used the results of our survey to summarize the evacuation information dissemination processes of each local government. Weather information consisted of JMA announcements that had been used by local governments to decide whether to issue evacuation notices [7]. Evacuation announcements that had been disseminated and were subsequently cancelled were entered into the timetable, if the information had been disseminated by e-mail. Evacuation information consisted of local governments'announcements providing on weather information and the actual conditions in each region. As with the JMA announcements, local government announcements that had been subsequently cancelled were entered into the timetable if the information had been disseminated by e-mail. Mail dissemination consisted of local governments'distribution of information, mainly with regard to evacuation. The arrows in the figures reflect the paths linking disaster response activities. There are three path patterns. The blue paths represent weather information being transmitted into evacuation information, and reflect the time lapse between timing of the issuance of weather information and the issuance of corresponding evacuation notices. The black paths represent the transformation of evacuation information (whether evacuation preparation notices, advisories, or orders) to mail communication, and show the time delays between the issuance of evacuation bulletins and their dissemination by mail. The green paths represent the time between the issuance of weather information to the time this information was disseminated by mail, and they show the delays between the time the weather information was announced to the time the corresponding mailings were disseminated. The relative slopes of the different paths represent the relative time delays between the various activities; that is, as the slopes increased, the delays were greater.

2.1.1. Case 1: Fukuchiyama

Fukuchiyama is a city in Kyoto Prefecture (see Figure 2) where evacuation information dissemination followed all of the patterns described. The path slopes from receiving the weather information to issuing this information as evacuation advisories or orders were not large on average, which suggests that Fukuchiyama's evacuation dissemination processes were timely. However, some large differences were noted. For example, JMA announced a Level 3 flood forecast that triggered an evacuation advisory at 2:15 (JST) on September 16, and Fukuchiyama announced an evacuation advisory at 2:20 (JST) on the same day. In contrast, a Level 2 flood forecast that should have triggered an evacuation preparation advisory was announced at 23:50 (JST) on September 15, but the corresponding evacuation preparation advisory was not announced until 1:10 (JST) on September 16. Thus, there were lengthy delays with regard to some disaster responses. This indicates that weather information is not an absolute trigger for issuing evacuation advisories. This response was common in other cases.

The slopes of the paths from issuance of the evacuation advisory to mail dissemination of that advisory were very small, that is, there was virtually no delay between the two activities. Based on this fact, Fukuchiyama disseminated evacuation advisory mailings very quickly. Their dissemination coincided with the decision to issue the evacuation advisory.

Contrary to the path slopes describing a path from the issuance of evacuation advisories to mail dissemination, the path slopes from weather information to mail dissemination were very large. The JMA called off a heavy rain emergency warning at 9:55 (JST) on September 16, and Fukuchiyama disseminated a mailing of this information at 22:15 (JST) on the same day, 12 hours and 20 minutes later. In contrast, a heavy rain warning was called off at 19:15 (JST) on September 15, and Fukuchiyama disseminated the mailing of this information at 19:45 (JST) on the 15th. The delay in this case, was small. It is evident from these data that no mail-based information management system had been established, and this lack of consistent management practices led to problems.

2.1.2. Case 2: Ayabe

Ayabe is a city in Kyoto Prefecture (see Figure 2) that issued both evacuation preparation notices and evacuation advisories. The slopes of the paths representing the issuance of evacuation preparation notices to their dissemination by mail are small, meaning that the delays were short. However, there are some comparisons to be made with Fukuchiyama. The short delays were always of the same length?roughly 10 minutes. This tendency is characteristic of Ayabe . The delays in disseminating mail were an obvious problem, compared to the delays in issuing evacuation notices. It is not necessarily appropriate to suggest that the issuance of evacuation notices was delayed by the timing of the announcement of weather information. Issuing evacuation notices is based not only on weather information, but also on each region's actual situation. However, mailings should be disseminated without delay, following the issuance of evacuation notices. Although the delays were not great, when disaster severity is known early, delays in issuing evacuation information, notices, or advisories can lead to serious damage.

Disaster responses differ among local governments, depending on the delays between issuing evacuation preparation information, notices or advisories, and the time at which this information is disseminated by mail. Local governments have no format of mail-based evacuation information dissemination process, nor does such a process exist. Moreover, in Fukuchiyama the local government's approach to mail dissemination of weather information is inconsistent. There is no national or local government format for managing this information.

2.2. Contents of Text Messages

The following discussion regards the evacuation preparation information, notices, and advisories sent by text messaging. We analyzed the contents of the disseminated text messages for suitability. "The Guidelines for Producing a Decision and Dissemination Manual for Evacuation Advisories and Orders" [1] itemizes the information that should be provided to residents as follows:

- Time of the announcement
- Who is sending the announcement
- Who should evacuate
- Why they are being asked to evacuate
- How dangerous the situation is
- In what order the evacuation will be conducted
- When the evacuation will commence

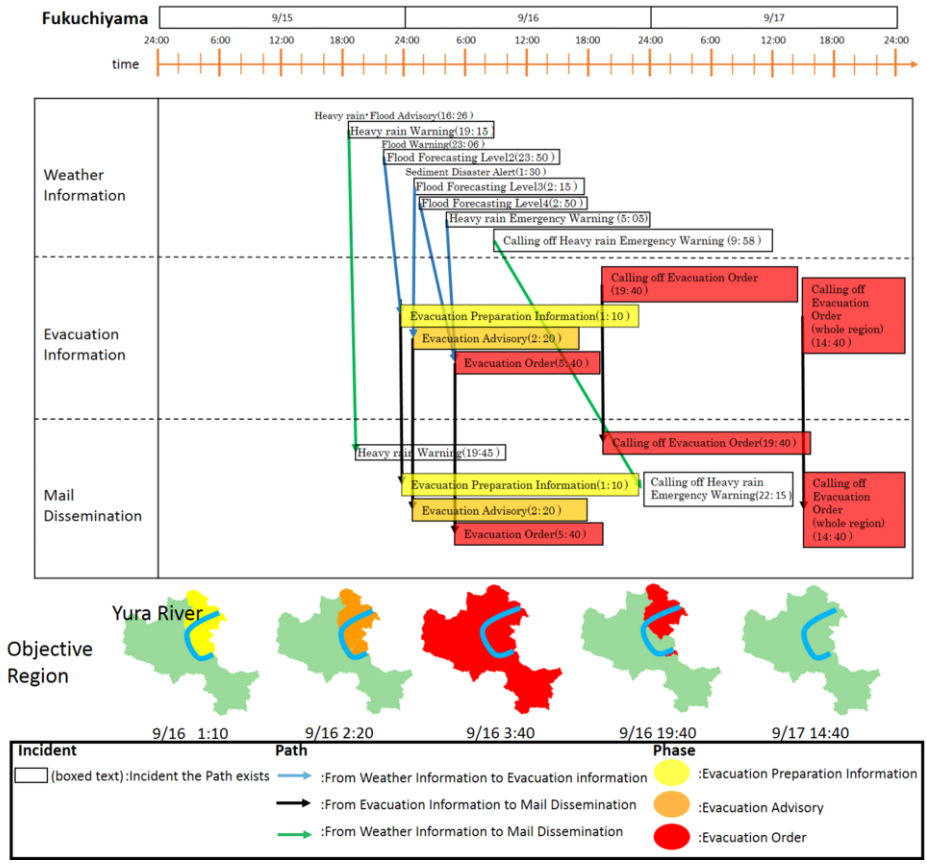

Figure 3. Timetable of Fukuchiyama

- Where the evacuation areas are located
- What the evacuation route is
- Required behavior of evacuees
- Person in charge of dissemination

In addition to this information, we consider that the following information must also be provided:

- Continued updates regarding how hazardous the situation is
- Continued updates on evacuation information as new information becomes available

These additional points are important because it is necessary to communicate how much the hazard is increasing (or decreasing), and for people to understand the meaning of the evacuation information being provided, in order to perceive the risks correctly. Especially with regard to evacuation information, many residents do not understand the different meanings inherent in each of the three evacuation information phases [7]. In Japanese, evacuation advisories are called **Hinan (evacuation), Kankoku (advisory)**, and evacua-

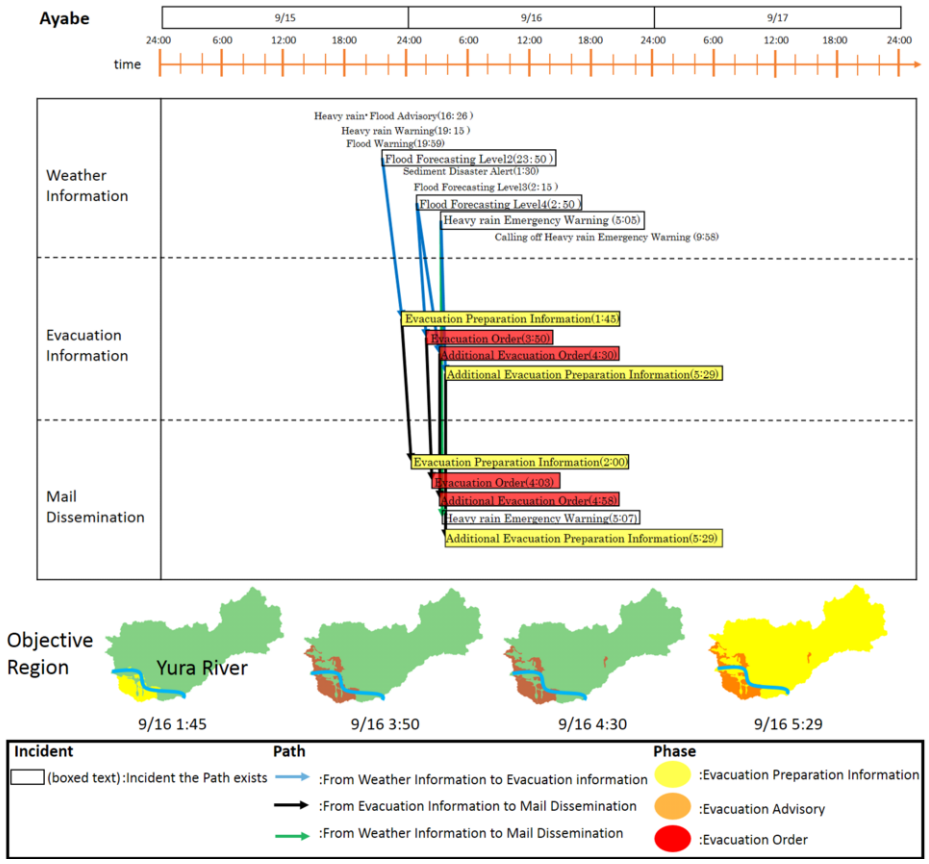

Figure 4. Timetable of Ayabe

tion orders are called **Hinan (evacuation) Shiji (order)**. Residents find **Kankoku** more compelling than **Shiji**, which is one of the reasons that residents do not understand the different evacuation information phases. However, there was nothing that explained these two matters in the data we collected.

Now, we would like to examine actual text messages. Figure 5 shows excerpts from actual text messages disseminated by local governments, i.e., Fukuchiyama and Ayabe.

2.2.1. Case 1: Fukuchiyama

Fukuchiyama disseminated all types of evacuation information. In all of its messages, the evacuation information was explained, including who should evacuate, as in the following example: *This siren announced evacuation preparation information to the Yura river valley area.* Nevertheless, apparent inconsistencies in the evacuation information were not explained. In brief, the messages providing evacuation information were not easy to understand. Moreover, it was unclear when the evacuation preparation information had been announced. “This siren” indicated that Fukuchiyama rang the siren when they announced the evacuation preparation information. Thus, the residents who had not

heard the siren did not know the exact time of the announcement. Local governments should show exactly when the siren had been sounded. Without understanding what was meant by the different types of evacuation information, residents could not respond appropriately, even after they had received explanations regarding the specific evacuation information being announced.

However, Fukuchiyama explained the risks more clearly, with its evacuation information dissemination process. For example, one evacuation advisory message stated, "*A disaster may occur.*", while on the other hand, in a subsequent message about the evacuation advisory, it was stated that "*A serious disaster may occur.*". Risks were emphasized in the evacuation order message. We concluded that these types of messages promoted accurate risk perceptions.

Additionally, hazard levels at the time were highlighted in all messages as the reasons to evacuate. For instance, "*The water level has exceeded 4m, and it may continue to rise.*" However, implications of the hazard conditions were not explained. In brief, messages mentioned the current hazard conditions, but did not mention how the conditions had changed, or what the conditions implied in terms of risk. It was difficult for residents to understand the seriousness of the risks when they were told only what the specific hazard conditions were, such as "*The water level has exceeded 4m.*" or "*The water level has exceeded 5m.*".

2.2.2. Case 2: Yasu

Yasu is a city in Shiga Prefecture (see Figure 2). Yasu disseminated evacuation preparation information, and then issued an evacuation order, which was later replaced by an evacuation advisory. In common with Fukuchiyama, the differences in hazard conditions were not explained. In addition, there were particular problems in the case of Yasu. Yasu notified residents as the situation moved from one evacuation phase to another, for example, "*The evacuation order was shifted to an evacuation advisory at 12:10.*".

Differences between different types of evacuation information were mentioned, but what the differences meant was not clarified. Therefore, without understanding the evacuation information they had received, residents could not understand the information they had been given regarding the differences between the three evacuation phases. Even further complicating matters, Yasu did not disseminate any messages regarding its evacuation order.

3. Suggested Improvements of Mail-based Systems Operation

The results of our analysis clearly show that there are a number of problems in local governments' mail-based systems operation. We would like to propose a number of improvements from two points of view, namely, the timing of the dissemination of evacuation information, and the content of the evacuation-related text messages. We show the proposal format of the mails for improvement(see Figure 6) and discussed in detail below.

3.1. Timing of Dissemination

In circumstances of disaster, the timing of evacuation information announcements and mail dissemination can have significant implications. Therefore, it is necessary to estab-

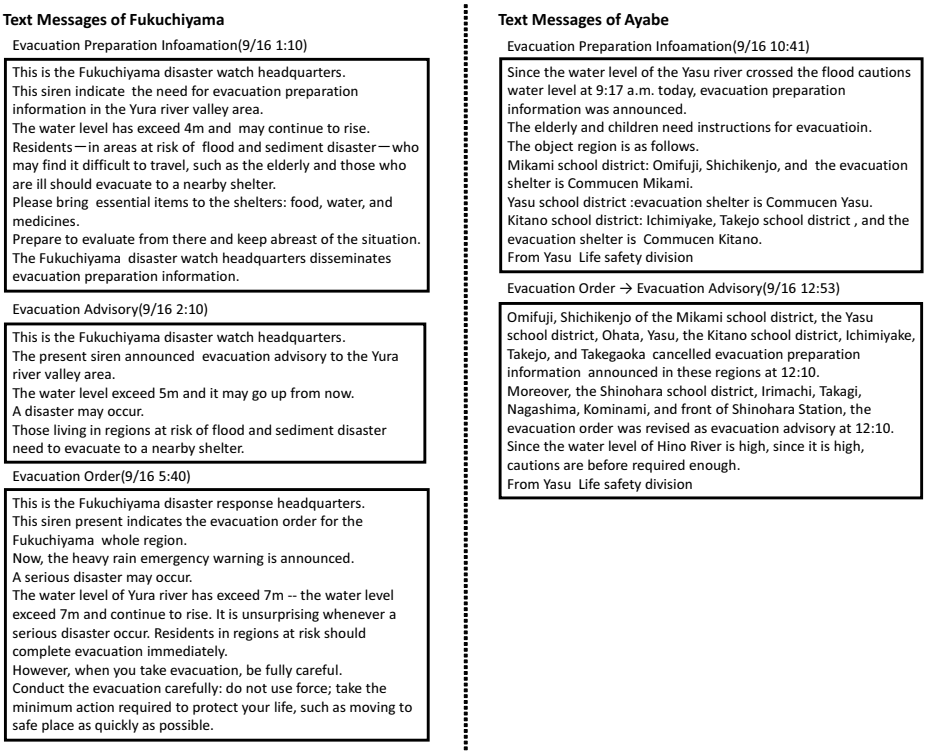

Figure 5. Examples of collected text messages

lish criteria that must be met in order to ensure the timely announcement and dissemination of evacuation information. It should be noted that relaxing the criteria for announcements would not be an effective strategy. Relaxing the criteria would lead to declining public trust in the evacuation information provided, because of an increase in the number of cases in which a serious disaster did not occur, even though evacuation information announced the possibility of a disaster. For example, one criterion for announcing evacuation preparation information occurs when a heavy rain advisory is issued, but heavy rain advisories are announced frequently, even when heavy rains do not lead to serious disasters. Therefore, in most cases using relaxed criteria, residents do not suffer any damage even though evacuation preparation information has been announced. This confusion leads residents to think that they are not in danger, even though evacuation information has been announced. Therefore, it is important not to relax the criteria too readily.

Moreover, if there are delays in mail dissemination, local governments should tell residents what the length of the delay will be, because it is possible that residents will not realize that the disseminated announcement has been delayed. In these cases, residents may make mistakes in the timing of their evacuations. For example, a message such as "announcement time 19:15; dissemination time 19:45; delay is 30 minutes" would help residents judge the timing of their evacuations because they clearly know of the delay.

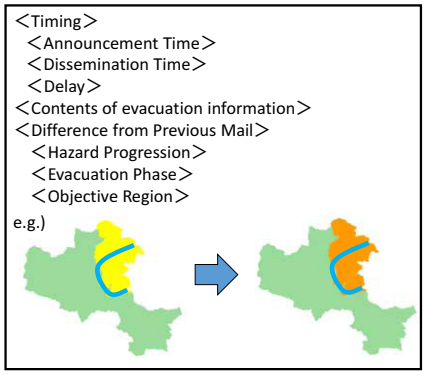

Figure 6. Proposal format

3.2. Contents of Text Messages

As mentioned above, we consider that the particularly important aspects of text message contents are information on changing conditions and what the implications of those changes are. However, in our analysis, these points were not mentioned in all messages. With regard to weather information, residents may not understand the speed at which the hazard is progressing. We propose to explain and highlight the changing hazard levels and their meanings. For example: “The water level exceeds 5m. It has risen 1m since the previous mail was disseminated. Its speed is very dangerous.” Messages like this can help residents understand the details of hazardous conditions. Similarly, concerning evacuation information, many residents may not understand the context of evacuation information messages without some explanation. We propose to provide information explaining whether evacuation phases are progressing or receding, for example, “The evacuation phase has advanced from evacuation preparation to evacuation advisory.” This additional information will help residents understand the increasing or decreasing levels of risk they face.Moreover, it is consideredthat showing objective region of evacuation information is effective.

Finally, we consider that it is important to express the risks emphatically, as in the case of Fukuchiyama, because this lets the residents know that the situation is unusual. When disasters occur, people often have mistaken perceptions because of normalcy bias [8][9]. Normalcy bias leads to an underestimation of risk, which in turn tends to cause people to consider that conditions are normal. Thus, expressing the risks emphatically will cause people to understand them better, and will help to eliminate normalcy bias [10]. For that reason, we propose to add emphatic expressions of the level of risk in messages, as does Fukuchiyama.

4. Conclusions and Future Works

In this paper, we analyzed evacuation information dissemination processes by focusing on their timing and content, using cases from Typhoon Man-yi in 2013. We clarified the problems that we had identified by analyzing our data. Moreover, we identified necessary

improvements using our analyses. Concerning the timing of evacuation information dissemination, we concluded that it is important to establish criteria for announcing and disseminating evacuation information, and to clearly explain long delays in dissemination. Furthermore, concerning the contents of text massages, we concluded that it is important to provide explanations concerning the changing weather conditions, and to clarify what the evacuation information means for the recipients, including the meanings of terms used in the message. The clarification of risk should also be improved.

In future research, we will study the effectiveness of the improvements that we have proposed, and examine the timing delays in more detail. Several factors may contribute to the delays. For instance, there is the relationship between the delay in announcing evacuation information and the evacuation information phase. The more difficult the decision to make an announcement is, the more serious the evacuation information phase becomes. Delays in making evacuation information announcements may occur as a result. It will also be necessary to perform quantitative analysis on more cases, in order to clarify the factors related to delays. Conducting a survey with local governments will be important.

Acknowledgment

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