Cause of Human Damage by Typhoon No.0423 from October 20 to 21, 2004.

Motoyuki USHIYAMA
Iwate Prefectural University

***ABSTRACT*:** A heavy rainfall caused by the typhoon No.0423 (Tokage) and a stationary front occurred in Western Japan from October 20 to 21, 2004. In this heavy rainfall, 96 persons were killed and serious social capital damage was happened (GLIDE: TC-2004-000109-JPN). It is the highest human damage by heavy rainfall in Japan after the "Heavy rainfall on July 1983" (death persons: 117). 32 people were killed by flood. This is the largest number of death by flood since the Nagasaki heavy rainfall disaster in July 1982. And 3/4 of them died while driving or walking out of their resident area. It is difficult to transmit of disaster prevention information such as flood forecast to them on actual forecasting and warning system. 28 persons were killed by sediment disaster and almost of them died in their houses. It is possible that the actual disaster information could mitigate this type victim. 20 persons slipped down to small irrigation canal or river and died. Almost of them were the aged and on patrol to their farmland. In this study, this type cause of death was called "Active accident". It is difficult to mitigate this type victim because they had accessed to dangerous area of their own free will. If actual disaster information such as precipitation, flood forecast and hazard map had used and understood completely, it had been possible that 35 victims had mitigated.

KEYWORDS: Typhoon No.0423, heavy rainfall disaster, flood disaster, sediment disaster, disaster prevention information.

1. INTRODUCTION

The heavy rainfall and strong winds of Typhoon No. 0423 (TOKAGE) caused widespread damage and numerous deaths on the Japanese archipelago from October 20 to 21(Figs. 1, 2). In addition, there was an active stationary front north of the typhoon, accompanied by heavy rainfall. The highest 1-hour precipitation in the last 25 years was recorded at one observatory, and the highest 24-hour precipitation in the last 25 years was recorded at 30 observatories based on the data of the Japan Meteorological Agency. The typhoon and stationary front caused record damage (GLIDE: TC-2004-000109-JPN). In western Japan, ninety-six persons were killed, 11,839 houses damaged, and 62,528 houses flooded (FDMA, 2004a). This amount of damage was the worst in the past 10 years. The number of human deaths in particular was the highest recorded since the "Sanin heavy rainfall in 1983", which had a death toll of 117.

In the years prior to the typhoon No.0423, there were fewer deaths caused by heavy rainfall in Japan, with the average number of deaths caused by storms or typhoons 76 persons per year (FDMA, 2004b). There are several characteristics to the human damage caused more recently by heavy rainfall in Japan. First, the major cause of death by heavy rainfall was due to sediment disaster, which is defined as death by debris flow, slope failure, or landslide, and few people were killed by floods. The

Cabinet Office (2003) estimated that the number of deaths by sediment disaster was about 50 percent of the whole. Second, in recent serious heavy rainfall disaster events, the deaths occurred within a narrow area. The heavy rainfall disaster in Minamata in 2003 (19 persons dead) and the heavy rainfall disaster in Izumi on 1997 (21 persons dead) are typical examples. In these events, the deaths occurred in only a few municipalities. Third, most of those who died were elderly. In this study, this type of disaster will be called a "local type heavy rainfall disaster."

Typhoon No.0423, however, had different features from those listed above. First, the number of deaths was very high. The annual average number of deaths in the past 10 years was exceeded in only this one event. Second, persons died over a wide area. Third, many persons were killed not by sediment disaster but by floods, and fourth, elderly people were not the only people killed.

Analyzing the causes of death in a natural disaster is important for disaster prevention efforts. There have been several studies on the causes of death during earthquakes (Japan's National Land Agency, 2000, Kobayashi, 1981). There have also been several studies on the human damage caused by the "Nagasaki heavy rainfall"(Matsui et al., 1984). However, since those studies were published, little attention has been paid to the causes of death by heavy rainfall disasters. It is likely that the reason for this lack is that no events have occurred since the Nagasaki event in which many people were killed.

The purposes of this study are:

1) To analyze the characteristics of the human damage caused by typhoon No.0423.

2) To gather disaster prevention information, and to propose ways in which human damage can be decreased.

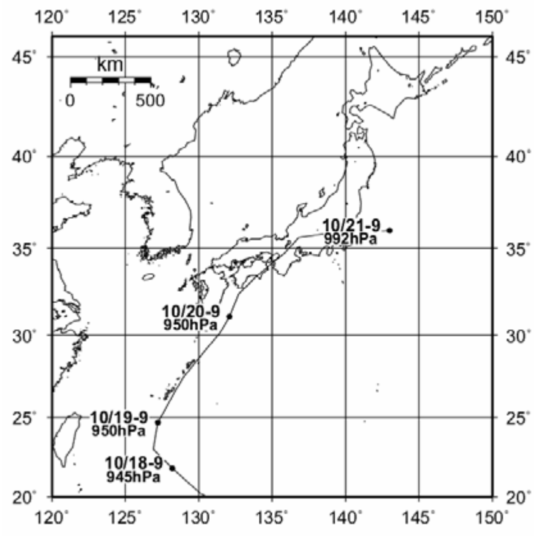

Fig. 1 The route of typhoon No.0423

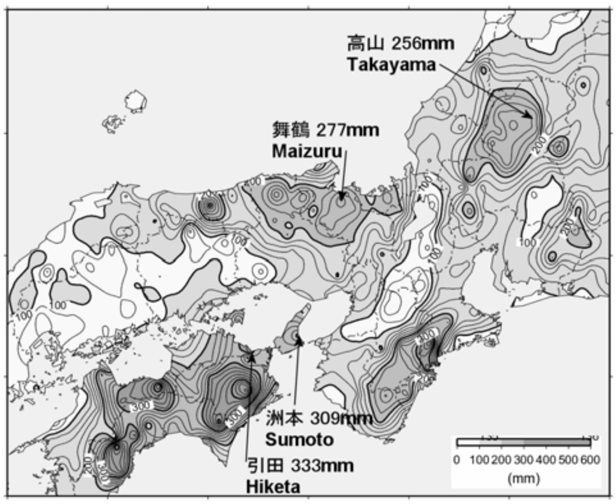

Fig. 2 24-hour precipitation distribution map at 24:00, October 20, 2004

2. METHODOLOGY

The FDMA examined an outline of the human damage] (2004a). Generally, disaster statistic values change with time. From the FDMA study, the value on November 29, 2004 was used. The total number of deaths was 96 persons in 18 prefectures. The number for every prefecture was as follows: Chiba; 2, Kanagawa; 1, Gifu; 8, Aichi; 1, Shiga; 1, Kyoto; 15, Oosaka; 1, Hyogo; 26, Wakayama; 1, Tottori; 1, Okayama; 7, Tokushima; 3, Kagawa; 11, Ehime; 5, Kouchi; 8, Nagasaki; 1, Ooita; 1, Miyazaki; 2. Detailed information on the dead was collected from the web pages of the prefectural offices, municipality offices, national newspapers, local newspapers and others.

A field survey and interview survey were performed in areas that had been seriously damaged. Toyooka city in Hyogo prefecture, Maizuru city, Miyazu City, and Ooe town in Kyoto prefecture were researched on October 24 and 25. Sumoto city, Tsuna town and Ichinomiya town in Hyogo prefecture, and Sanuki city and Higashi-Kagawa city in Kagawa prefecture were researched on November 8 and 9. In addition, the questionnaire survey was sent to seriously damaged municipality offices. Twelve questionnaires were mailed, and 5 municipalities completed them.

3. RESULTS

3.1 Identification of the location of the dead

Rough addresses of the places where the dead were found were identified based on the data gathered and the field survey. This address data was converted into latitude and longitude data by use of the "Free Address Geocoding service for CSV formatted file on WWW" (Center for Spatial Information Science, University of Tokyo, 2001).

Fig. 3 shows the distribution of deaths caused by the typhoon based on the latitude and longitude data. The total number of deaths was 96 persons, as stated previously, and the dead were found in 78 places in 60 municipalities. The largest number of deaths was in the area of Uno, in Tamano city, Okayama prefecture, where 5 persons were killed by sediment disaster. At Murotosaki-cho, Muroto city, Kochi prefecture, 3 persons were killed by high waves. In the other localities, one or two persons were killed. Thus, the present disaster event cannot rightly be called a "local type heavy rainfall disaster" but rather a "wide area type heavy rainfall disaster". Some events known as serious heavy rainfall disasters, such as the "Sainin heavy rainfall in 1983" (117 dead) and the "Nagasaki heavy rainfall in 1982" (299 dead) were also considered "local type heavy rainfall disasters". It is likely that a serious "wide area type heavy rainfall disaster" has not occurred since the "heavy rainfall disaster caused by typhoon No.17 in 1976" (169 dead).

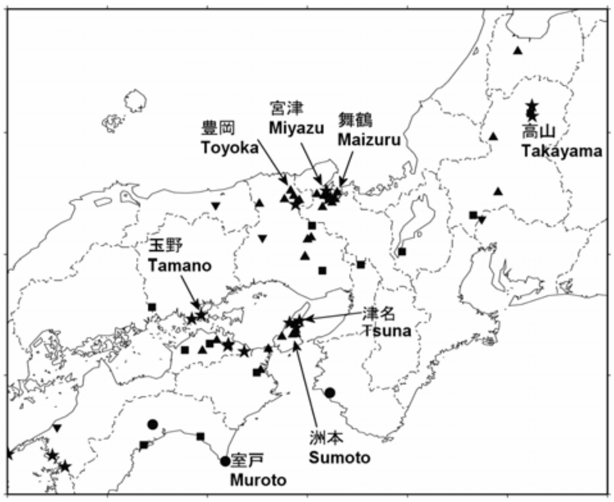

Fig. 3 Distribution map of deaths
▲: Floods, ★: Sediment disaster, ●: High waves, ▼: Strong winds, ■: Active accident

3.2 Classification of causes of death

A method for classifying the deaths caused by heavy rainfall disasters has not been established in Japan. In the "Japan Statistical Yearbook", printed by the Ministry of Internal Affairs and Communications, deaths by natural disaster are classified into "typhoon", "storm", "strong winds", "high tide", "earthquakes", "volcanoes" and "tsunamis". However, there are several problems with this classification. One is that it is not clear what the difference is between a "typhoon" and a "storm". Classifying by hazards, such as a flood or sediment disaster, is needed. In addition, in the deaths that occurred in the most recent heavy rainfall disaster in Japan, some people were killed due to careless behavior. A classification that takes this into account was also needed. Therefore, in this study, we made the following classifications:

1) "High waves": death by sea waves along the coast, e.g. , death caused when the person was inside a house destroyed by high waves, or death caused by being struck by a wave during work or when visiting an area.
2) "Strong winds": death related to strong winds, e.g. , person who died because of being blown off a roof by strong winds, or being crushed by a tree felled by strong winds.
3) "Active accident": persons who died because they approached the dangerous area instead of evacuating, or persons who died after falling into an irrigation canal while patrolling a paddy field or irrigation canal.
4) "Flood": death by flood flow or inundation, e.g. , drowning in their house, or being carried away by floods while driving a car or walking.
5) "Sediment disaster": death by debris flow, slope failure and landslide.

"Active accident" is the classification that is original to this study. This classification was defined in order to distinguish it from "floods". Passive victims may be considered to be those persons who, for example, stayed indoors, not realizing that their houses would be flooded and that they would drown. Moreover, people who drowned while driving their car or walking were attempting to run away from the danger, and can also be considered "passive" victims. On the other hand, generally persons who died after falling into an irrigation canal while patrolling a paddy field or other area can be classified as "flood victims". As we have seen, there are not few such victims recently. They must have known that a swollen irrigation canal could be dangerous, but still went to the dangerous area and died. They are thus, so to speak, "active victims." Of course, there are various reasons for their behavior, but the behavior of "passive victims" and "active victims" can be considered to differ. Therefore, methods for preventing human damage must also differ. For these reasons, the classification "active accident" was made.

Fig. 4 shows the classification of causes of death from the disaster. Thirty-two persons died by "flood", and 20 by "active accident". Deaths by "active accident" were included in the deaths caused by flood disaster in ordinal disaster statistics. Thus, in ordinal disaster statistics, the death toll by flood would be considered 52. The numbers of deaths by flood were far fewer in the latest disaster in Japan. However, in this typhoon, the number of deaths by flood was higher than that by sediment disaster. In Hyogo prefecture, which suffered the worst damage, 15 of 26 deaths were by flood. Even in Kyoto prefecture, 10 of 15 deaths were caused by flood. Table 1 lists the events since the 1980s in which the number of deaths was 50 persons or more, for comparison with the present event. As the table shows, since the 1980s, most of the deaths were caused by sediment disaster. The death toll by flood in the "Nagasaki heavy rainfall disaster in 1982" was the most serious (about 30 persons) of these events. Thus, the death toll by flood in present event is the largest since 1982. Many persons were killed by flood in the "Niigata and Fukushima heavy rainfall disasters", but the death toll by flood in the present event exceeded those numbers. Serious human damage caused by floods has not occurred for about the past 20 years. However, this was evidently a matter of luck, as the present event shows that there is a possibility that serious damage will occur from now on.

Table 1 Heavy rainfalls causing the deaths of 50 or more persons since the 1980s

Date	Cause of heavy rainfall	Death (persons)	Breakdown (persons)
1982. 7.10 - 26	Nagasaki heavy rainfall	299	Sediment disaster: 263
1982. 8. 1 - 3	Typhoon No10 and front	95	Sediment disaster: 56, Flood: 15, unknown: 24
1983. 7.20 -27	Sanin heavy rainfall	107	Sediment disaster: 91, Flood: 11
1991. 9.24 - 10.1	Typhoon No.19	62	Most of death caused by strong wind.
1993. 7.31 - 8.7	Kagoshima heavy rainfall	49	Most of death caused by sediment disaster.
2005. 7.13	Niigata and Fukushima heavy rainfall	16	Flood: 12, Active accident: 2, Sediment disaster: 2
2005.10.20 - 21	Typhoon No.23 and front	96	Flood: 32, Active accident: 20, Sediment disaster: 28

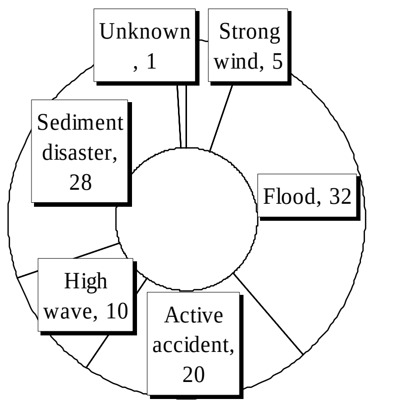

Fig. 4 The number of deaths by cause

3.3 Relationship between cause of death, age, sex and location of the dead

First, the victims were totaled according to age. Forty-one victims were under age 65 and 54 over age 65, so called elderly people. When the threshold was set at 60 years old, there were 34 persons under age 60 and 61 persons over age 60. Thus, elderly people accounted for about 60 percent of the total victims. Fig. 5 compares the death toll of the elderly in the present event with other recent serious heavy rainfall disaster events. In this figure only, "elderly people" are defined as over 60 years old in the data on the "Nagasaki heavy rainfall disaster". The death rate of the elderly in the present disaster was higher than that in the "Nagasaki heavy rainfall disaster" and "Kagoshima heavy rainfall disaster". We can say with a fair amount of certainty that the "victims were unevenly distributed among elderly people". However, it is necessary to examine this issue from another point of view.

Fig. 6 shows the relationship between cause of death and age in the present disaster event. The death rates of elderly people (over 65 years old) were higher than half in the "active accident" and "sediment disaster" classifications. However, the death rate by "flood", among non-elderly people (under 65 years old) is higher than half. Almost all of these victims were washed away by floods while driving or walking. Fig. 7 shows the relationship between the cause of death and sex. It is not clear if there is a significant difference (significance level: 5%) of sex in the "flood" and "sediment disaster" classifications. But the death rate of males by "active accident" is higher than that of females. Fig. 8 shows the relationship between the cause of death and location of the dead. Almost all of the victims who died by "sediment disaster" died indoors, and most of the victims by "flood" died outdoors.

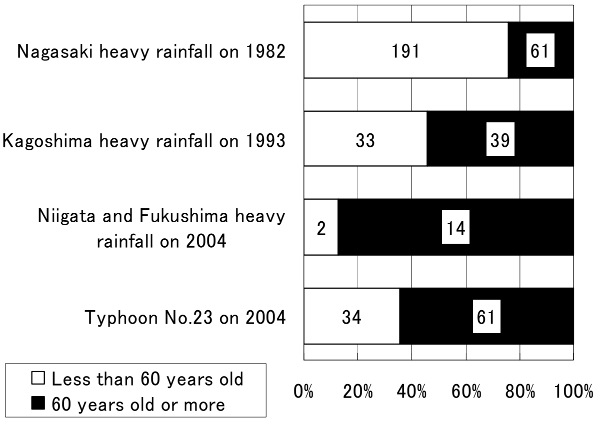

Fig. 5 The death toll of elderly and non-elderly people in the resent serious heavy rainfall disasters.

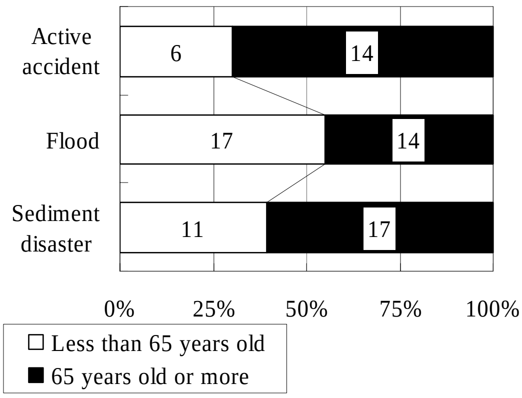

Fig. 6 The death toll by age and cause of death.

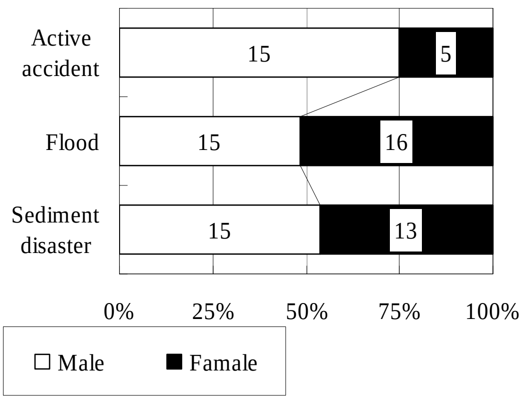

Fig. 7 The death toll by sex and the causes of death.

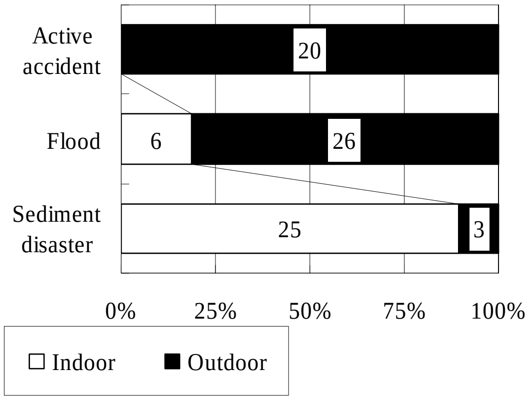

Fig. 8 The death toll by the location of the dead and causes of death.

3.4 Possibility of human damage mitigation by using disaster prevention information

In this section, it is estimated how much human damage can be mitigated when disaster prevention information, such as rainfall forecasts, real-time precipitation data, hazard maps and other tools, is used. The objects of estimation are the victims of "flood" and "sediment disaster".

First, the victims by "flood" were classified based on the location where they were killed. The locations are as follows: (1) In their home, (2) Outdoors near their home, (3) Outdoors far from their residence area. It is possible that the victims of (1) and (2) could be saved if the following necessary conditions were satisfied.

(a) By viewing a hazard map, they understood that it was dangerous near their house.
(b) The real-time precipitation or river water level information was gathered and disseminated through the Internet, radio, and by other means.
(c) The present precipitation or water level was understood to have reached dangerous levels for the region.

The information contained in (b) is disseminated now in Japan, and hazard maps of floods are released partly rivers to public by printed mater or web pages. Of course, it is not easy for the three conditions listed above to be satisfied, but it is not impossible.

However, four-fifths of the "flood" victims were type (3) victims, and it would be very difficult to save this type of victim as most were killed in a place far from their residence area during a trip by car or when walking for commuting purposes or on business and there were only a few persons who were evacuated to a shelter. Therefore, it is likely that knowledge would not be useful to them, even if they could see the hazard map for their residence area. It is not impossible to pass information gathered about real-time rainfall and river water levels by mobile phone and other methods. But it is not easy for non-experts to use this information, because most people don't know how gather information on real-time rainfall and river water levels, or how to use this information to help them remain safe. In addition, the present information on flood forecasts does not show the inundation depths inland (out of river).

Judging from the above, in the case of victims by "flood", the number of victims who could be saved by additional information was estimated at 8 persons. It was the sum of the (1) type victims (6 persons) and the (2) type victims (2 persons). All were elderly, over 65 years old. However, it was estimated that it would be difficult to save the (3) type victims, 24 persons, using this information. Seventeen of them were not elderly people. That is, people become vulnerable to disasters regardless of age when they are taking a trip. It is necessary to develop an information transmission method or system, not only using IT but all technology, to disseminate information to people.

Most of the 25 persons killed by "sediment disaster" were killed inside their homes. Although three persons were killed outdoors, two of them were killed beside their homes. That is, 27 victims were the (1) or the (2) type victims. Therefore, it is possible that the victims could have been saved if the necessary conditions (a), (b) and (c) listed above were satisfied. Judging from the above, in the case of victims by "sediment disaster", 27 persons could have been saved by obtaining information.

As we have seen, the victims who died by an "active accident" were defined as "persons who died because they approached the dangerous area by themselves instead of evacuating". They approached the dangerous area of their will. It is probable that their decision would not have been changed only by receiving disaster information. Therefore, it is unlikely that these victims could have been saved, even if all necessary conditions were in place. Refuge guidance at the time of a disaster is often considered "support to elderly people". However, 14 of the 20 victims who died from an "active accident" were elderly people. It is possible that this number cannot be reduced, even if an evacuation guiding system for elderly people is developed. It is important to provide the elderly with information and support so that they do not become victims of an "active accident".

Fig. 9 shows the conclusion of the above estimation. The thick line is a connector related to disaster prevention information. The number classified into the lower side of the connectors is 35 persons. It is possible that if the present disaster prevention information had been used, 35 persons maximum would have been saved.

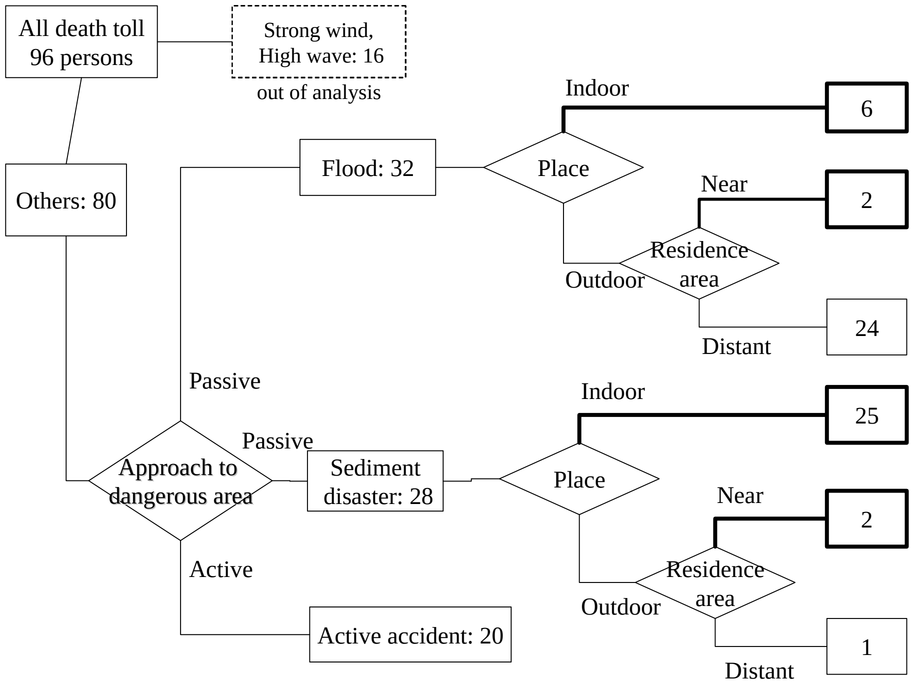

Fig. 9 Flow chart analysis of causes of death in the disaster

4. CONCLUSIONS

In this heavy rainfall disaster, 96 persons were killed, the highest death toll by heavy rainfall in Japan since the "Heavy rainfall in July 1983" (117 persons dead). Several heavy rainfall disasters occurred in 2004 in Japan, including the "Niigata and Fukushima heavy rainfall in 2004", in which 16 persons died, the "Fukui heavy rainfall disaster in 2004" (5 persons), "Typhoon No. 0416" (17 persons), "Typhoon No. 0418" (45 persons), and "Typhoon No. 0421" (27 persons). These disasters had a strong impact on the Japanese government, and several committees for heavy rainfall disaster prevention policy were formed. For example, the Ministry of Land, Infrastructure and Transport (MLIT, 2005) made the following points about the recent heavy rainfall disasters.

(1) The damage was unevenly distributed among "people vulnerable to disasters", such as the elderly and handicapped persons.

(2) Mutual help of resident community at the time of disaster became inactive.

(3) The awareness among residents of the dangers of natural disasters is decreasing.

(4) The danger of underground spaces flooding is increasing.

The above points need to be further discussed. As we have seen, one of the most important points to note about the disaster studied here is that 32 of the 96 victims were killed outdoors by floods. This was a very rare circumstance when other recent heavy rainfall disaster events are considered. They are not only elderly people, and it is also difficult to save them by mutual help, the point (2), and improvement in awareness for disaster, the point (3). Further research and analysis into the causes of death by heavy rainfall disaster would clarify the issues that need to be addressed.

NOTE

This paper is a revision of an earlier study by Ushiyama (2005, in Japanese).

REFERENCES

Cabinet Office, 2003: White Paper on Disaster Management 2003, National Printing Bureau. (in Japanese)

Japan's National Land Agency, 2000. Great Hanshin-Awaji Earthquake Research Paper, http://www.hanshin-awaji.or.jp/kyoukun/eng/.

Fire and Disaster Management Agency (FDMA), 2004a. The damage caused by typhoon No.23 in 2004, http://www.fdma.go.jp/data/010502221038234497.pdf. (in Japanese)

Fire and Disaster Management Agency (FDMA), 2004b. White Paper on Fire and Disaster Management Agency 2004, National Printing Bureau. (in Japanese)

M. Ushiyama, 2005. Characteristics of Human Damage by the Typhoon No.0423 from October 20 to 21, 2004, *Journal of Japan Society For Natural Disaster Science*, 24(3), (in print, in Japanese)

Y. Kobayashi, 1981. Causes of Fatalities in Recent Earthquakes in Japan, *Journal of Natural Disaster Science*, 3(2), 15-22.

Center for Spatial Information Science, University of Tokyo, 2001: Free Address Geocoding service for CSV formatted file on WWW, http://www.tkl.iis.u-tokyo.ac.jp/~sagara/geocode/condition.html.

Ministry of Land, Infrastructure and Transportation, 2005: The proposal about promotion of a synthetic heavy rainfall disaster prevention measure, http://www.mlit.go.jp/river/index/0418gouuteigen.pdf. (in Japanese)