[Information for taking refuge]

- -Degree of difficulty of taking refuge
- -Distribution of time required for taking refuge (Fig. 9)

[Other information]

- -Shelters, flood fighting depots, organizations for flood protection
- -important sections for flood fighting and sediment disaster prone areas, etc.

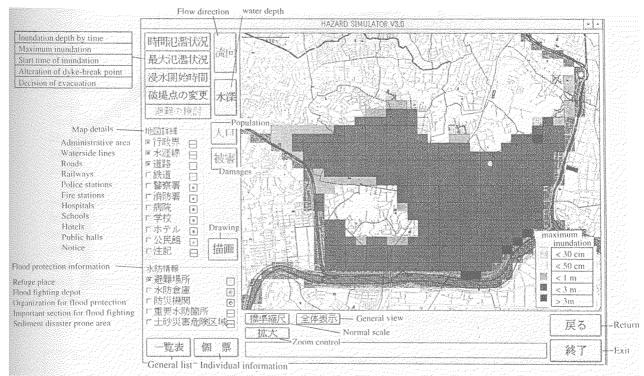


Fig. 7. Variation of inundation depth with time (at the time of maximum inundation).

Fig. 7 shows the distribution of water depth at the time of the maximum inundation (the state 1, ..., 5, 10, 20, and 30 minutes after dyke breaks at point marked "×" on the map), with the depth classified into ranks corresponding to the difficulty of evacuation. The flooding propagates moving around the hilly place on the side of the left bank of a tributary with most of the inundated areas reaching a maximum depth of 1 to 3 meters. Roads, hospitals, refuge places and agencies for flood protection can be displayed on the screen by pressing the buttons shown on the left of the screen

The "Number of People/Families Affected" and the "Amount Damaged" of Fig. 8 shows the damage that would result from flooding at a specified place with time giving the status corresponding to the time passed (the present status on display) and the status at the time of peak inundation (the maximum inundation). The table shows that about 80% of the population/families is affected by flooding, and the same percentage of total general assets is damaged.

The information is displayed using the Visual Basic for Windows, and a "Digital Map 10000 (general)" for the background picture. This system makes it possible to grasp the status of an predicted disaster, and to determine the area to be evacuated, safe refuge places/routes, action program for drainage of mundating water, and pump allocations for emergency drainage. Moreover, this system requires no specific system other than memory of 8 mega-byte or more and hard-disk memory of 120 mega-byte or more.

5. IMPROVEMENT OF EVACUATION SYSTEM-DISASTER BY TORRENTIAL RAIN IN THE SEKI RIVER BASIN⁷⁾

(1) Overview of the investigation

Heavy rain started in the evening of July 11–1995 recording a peak rainfall of 34 mm/hr totaling 200-300 mm in the Seki River basin—the heaviest raining since 1982. At 11 am on July 12, the flood overtopped (the left bank) at Tukioka area. Arai city. Niigata prefecture, and propagated at 1.3km/h.

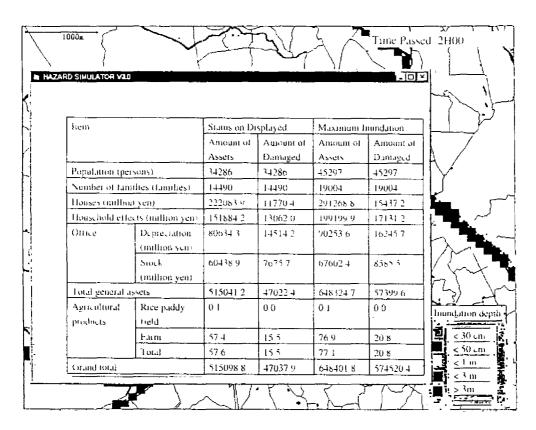


Fig. 8. Number of people/tamilies affected and amount of damage

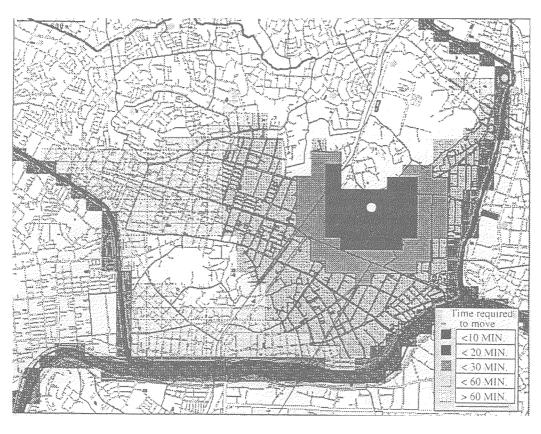


Fig. 9 Distribution of time required for evacuation Note "O" shows the refuge place

The inundation reached as far as Kijima/ Shimada area of the city (Fig. 10) Meanwhile, in the northern part of Joetsu city, inundation disaster occurred due to overtopped water from the Hokura River and the Tonome River that are tributaries of Seki River, and inner water The flooding mode was more or less similar to that of inland water The Matsumura Kasuga and Yasue areas located in the northern part of Joetsu city (indicated () in the figure) are hereafter called the Matsumura Zone, and the Tsukioka / Hiroshima areas and Kijima / Shimada areas (indicated (and and In the figure) are called the Tsukioka / Kijima Zone

The damage, as shown in Table 2, included total and partial destruction of houses and bank erosion in Arai city, and many mundated houses in Joetsu city As many as 4000 people in total took refuge from this flood disaster in both cities. We investigated the refuge

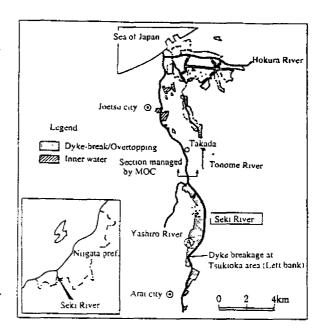


Fig 10 Location of the Seki River and Inundated Areas

Tsukioka/Hiroshima area

Matsumura/Kasuga/Yasue area

actions on site and by questionnaire, as well as the state of disaster in both cities one week and one month after the occurrence

Table 2 Status of Damage by Flooding on 7/11/95

Items	Dead Missing (persons)	Wounded (persons)	Damage by flood (houses)					Maximum
District			Total demolish	Halt demolish	Partial demolish	Inundation above floor	Inundation below floor	number of refugees (per 'i')
Joetsu city	0	2	0_	0	0	487	2,878	1 -02
Arai city	0	0	11	4	0	76	5.R	1,000
Others	1	0	0	0	0	100	· <u>: !</u> "	-
Seki River basın area	1	2	11	4	0		3,737	•
Nugata Pret	2	4	20	14	3	857	5,443	

Note The maximum number of refugees is the number at \$20 to 9.05 on July 14 in Arai city and July 12 in Joetsu city

(2) Behavior pattern in evacuation

Questions were asked as to the time before taking action for refuge | i.e. "the time received refuge order , and "time start to think about refuge". The distribution of the time (i) from "time order was given" to "the time to have left the house" showed that while about sixty percent were $0 \le t \le 40$ min in the Tsukioka/Kijima Zone. More than one quarter of the total population fall in the range of $t \ge 2$ hr in the Matsumura Zone — This can be explained that the quicker response in the former was due to the issuing of refuge recommendation in the upper stream area of Arai city, before the same was done in Tsukioka

(3) Time for deciding to evacuate

We investigated whether or not action for refuge was taken promptly by the time for deciding refuge. Fig. 12 shows that those who knew the location of the designated refuge place prior to the flood disaster took a long time to decide to evacuate, with some taking as long as two hours.

The relationship between evacuation decision time and with or without a handicapped person in the family was studied defining the age of 70 years old and above and 5 years and below as handicapped persons. As Fig. 13 shows, although those with a handicapped person in the family tended to take earlier action due to the handicapped person, at the same time there were those who

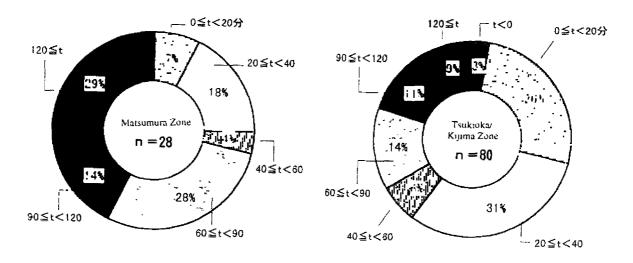


Fig. 11. Time Elapsed from Receiving Evacuation Order till Leaving House

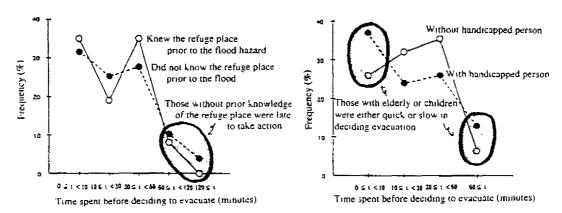
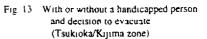


Fig. 12 Knowledge of Designated Refuge Place and the Decision to Evacuate (all areas)

Note: Time for deciding to evacuate = Time of decision for refuge - Time beginning to consider evacuation.



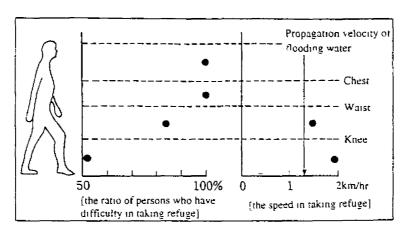


Fig. 14. The difficulty and the speed in taking retuge

were late in making decision because of the handicapped party

(4) Speed of taking refuge

In the Matsumura Zone, many of the residents took refuge on foot in the water. The inundation depth, distance and degree of difficulty in walking were investigated. The difficulty and the speed in taking refuge are shown in Fig. 14. The result shows that about half of the people had some difficulty in water up to their knees, and the difficulty became much greater for the majority of people with water up to the waist or above. The speed was about 2 km/hr with water below the knee and 1.5 km/hr for water between knee and waist.

(5) Improvement of evacuation system

Learning from this flood disaster, measures for improving evacuation action in the future were studied with hazard maps and so forth.

The improvement measures listed below including some items not discussed so far

- -Designated refuge places should be made known to each family. Also, the "Map of Designated Refuge Places' should be distributed to those who guide refugees when a flood occurs
- -Evacuation order information should be widely given to people in areas not subject to evacuation, in the form of "Refuge News"
- -The locations of handicapped residents must be mapped, and these people be given priority in providing information at the time of flood.
- -Guidelines on refuge actions must be made very clear; refuge speed (walking) is 1.5 2 km/hr; to evacuate before inundation depth reaches the knee, not to use a car once inundation begins

More detailed risk management measures in case of flooding are introduced in Document 8) with some examples, such as "Information gathering and communication", "know-how of taking refuge", "actions and first-aid emergency measure—when a person falls into a river or a waterway", "actions in case of inundation in an underground shopping center or subway", "actions when a car is submerged in water" and "relief measures after flood disaster".

6. CONCLUSION

This report explained the inundated water draining effect of a river network as a floodplain management measure. It was found that a high density river network, if it meets certain requirements, helps to drain inundated water that has flooded not only by overtopping but also by dyke breaks. The use of a hazard simulator may make it possible to predict the flood disaster from a broken dyke at almost any place on real-time, allowing prompt, timely and appropriate refuge action

The researches on trees for flood disaster prevention and floodplain pumps and sluices for controlling flooding water to be carried out in the near future

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