Applications and Advantages of Hazard Maps for Sabo in Japan

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Outline of sediment-related disasters in Japan

Various natural disasters occur every year in Japan and claim people's lives and properties. In fact, 5,890 lives were lost due to natural disasters between 1967 and 2000, 54% of which were due to sediment-related disasters, excluding the Hanshin Awaji Great Earthquake in 1995[1)]. It is therefore very important to mitigate sediment-related disasters in order to reduce total disaster damages in Japan.

In Japan, sediment-related disasters are categorized into three groups, according to the characteristics of the sediment movement:
1) Debris flows
2) Steep slope failures
3) Landslides

A debris flow is where soil, stones or rocks swiftly flow downstream with the water. A steep slope failure is where a slope collapses abruptly under the influence of rainfall or an earthquake. A landslide is where a soil mass slides slowly under the influence of ground water.

On average, around 1,000 sediment-related disasters occur annually[2)], because there are geomorphological and geological vulnerabilities and harsh meteorological conditions in Japan. What are the geomorphological vulnerabilities? Hilly and mountainous areas cover 70% of the total land area of Japan[3)], and many people must live on hillsides and foothills. Why does Japan have geological vulnerabilities? The Japanese archipelago is located where the Eurasian Plate, North American Plate, Pacific Plate and Philippine Sea Plate meet. The Pacific Plate and Philippine Sea Plate are actively subducting beneath the North American Plate and Eurasian Plate. The subductions cause earthquakes and volcanic eruptions. In fact, on average, more than 1,200 earthquakes occur every year, according to a calculation based on a search of earthquake databases[4)]. Furthermore, Japan has 108 active volcanoes[5)], about 10% of the world's total.

On the other hand, what are the meteorological vulnerabilities? Japan has a monsoon climate with an annual rainfall of 1,700 mm[6)], almost twice the world average, so there is heavy precipitation during the rainy season from June to July. Several typhoons hit the mainland of Japan every year. In recent years, several downpours in excess of 100 mm/hr have often been experienced. These cause many sediment-related disasters.

History of the development of hazard maps for sabo

To mitigate sediment-related disasters, the Japanese government and prefectural governments have conducted structural and non-structural measures. This paper introduces non-structural measures, particularly hazard maps for sabo.
"Sabo" is a Japanese term which means erosion and sediment control. Therefore, hazard maps for sabo means hazard maps for sediment-related disasters.
In the 1960s, Japan experienced several major sediment-related disasters in towns around Sai

Lake (Yamanashi prefecture, 1966), Kobe-shi (Hyogo prefecture, 1967) and Kure-shi (Hiroshima prefecture, 1967), and 212 people were killed by debris flows and steep slope failures in just 2 years[7].

The Japanese government recognized the necessity of identifying sediment-related disaster-prone sites and notifying the sites to the public. Therefore, the Ministry of Construction (later reorganized into the Ministry of Land, Infrastructure and Transport) created criteria for identifying sediment-related disaster-prone sites, and then encouraged each prefectural government to identify those sites.

Each prefecture government surveyed disaster-prone sites and eventually identified:
1) Debris flow-prone streams in 1966,
2) Failure-prone slopes in 1967, and
3) Landslide-prone slopes in 1972.

At that time, sediment-related disaster-prone sites were abstracted using topographical maps on a scale from 1:10,000 to 1:25,000, and then were identified through field surveys. However, initially, the sites were identified as disaster-prone sites, such as debris flow-prone streams, failure-prone slopes and landslide-prone slopes.
After identification, sediment-related disaster-prone sites were made public as sediment-related disaster prone sites maps. However, the maps were not adequate, because it was hard to recognize actual hazard areas.
Furthermore, the maps showed disaster-prone sites for existing residential areas, but not for future residential areas. Therefore, it was difficult for residents to avoid building their houses in sediment-related hazard areas.

In the 1960s, 1970s and 1980s, urban development progressed, and particularly residential areas were developed on the hills in the vicinity of major cities because of rapid economic growth, thus increasing the number of disaster-prone areas. In 1988, the Central Disaster Prevention Council of the Japanese government issued a report on the promotion of sediment-related disaster mitigation. In the report, the CDPC stated that hazard areas should be identified and used appropriately, rather than for building houses[8].

Figure 1 shows the increase of sediment-related disaster-prone sites between the late 1970s and late 1990s.

After issuing the report, the MOC encouraged prefectural governments to create hazard maps, which they are now doing. 44% of all

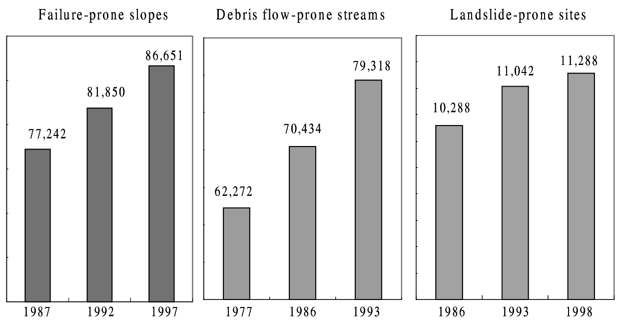

Figure 1 Increase of Sediment-related Disaster-prone Areas

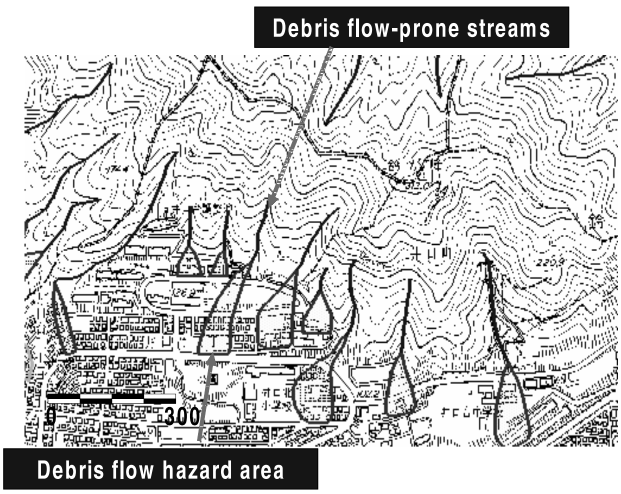

Figure 2 An Example of a Hazard Map for Sabo

municipalities which have sediment-related disaster-prone sites had made their hazard maps public as of 2002, according to a survey by the Headquarters of MLIT. **Figure 2** shows an example of the hazard maps[10] which are available on websites.

On June 29, 1999, a severe sediment-related disaster occurred in Hiroshima city and its vicinity (Hiroshima prefecture). 325 debris flows and steep slope failures occurred almost simultaneously. 24 people were killed and more than 150 houses were destroyed or damaged in newly developed residential areas on hillsides and foothills. The Japanese government was prompted by this disaster to establish a new act for designating hazard areas in order to:
1) Restrict new development for housing and other purposes,
2) Promote relocation of existing houses, and
3) Develop an early warning system[11].

The Sediment-related Disaster Prevention Act

Content of the Act[12]

The Sediment-related Disaster Prevention Act was established in 2000, and took effect in 2001, in order to restrict new development for housing and other purposes, promote relocation of existing houses, and develop early warning systems for residents within hazard areas.
The Act specified the process of designating Sediment-related Disaster Hazard Areas (Yellow Zone) and Special Hazard Areas (Red Zone). **Figure 3** shows the process of designating those areas.

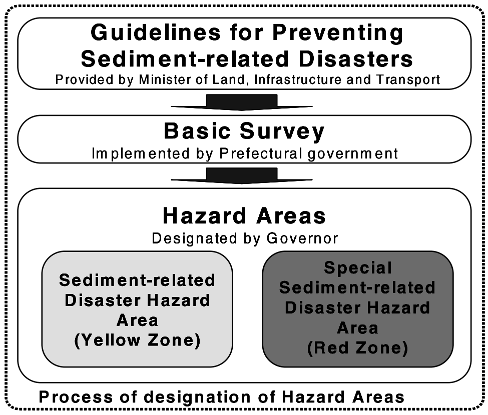

Figure 3 Process of Designation of Sediment-related Disaster Hazard Areas

Under the Act, an area prone to sediment-related disaster shall be designated as a Sediment-related Disaster Hazard Area (Yellow Zone). An area where there is a serious risk of damage to buildings and threat to residents shall be designated as a Special Sediment-related Disaster Hazard Area (Red Zone). If an area is designated as a Yellow Zone:
1) Early warning systems shall be established,
2) Steps to raise the awareness of local people about sediment-related disasters shall be taken.

If an area is designated as a Red Zone:
1) A license is required for land development for housing, etc.,
2) Building certification is required for buildings,
3) Relocation of buildings that are vulnerable to serious damage in case of a sediment-related disaster is recommended, and
4) Those who move their residence to a safe area under recommendation can receive grants.

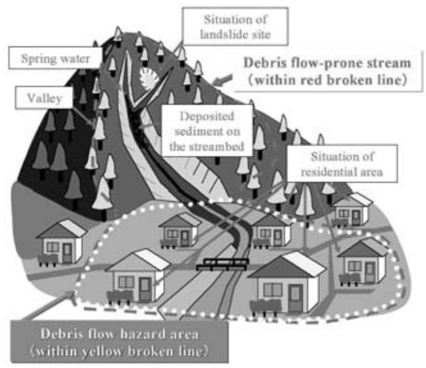

Figure 4 Schematic Diagram of Debris Flow- prone Sites

How to determine hazard areas[13)]

Debris flow-prone streams are abstracted using detailed topological maps on a scale of 1:25,000 or more. The situation of a stream, such as spring water, landslide site, deposited sediment on the streambed and residential area on a slope of 2 degrees or more, etc., is surveyed. **Figure 4** shows a diagram of a debris flow-prone stream.

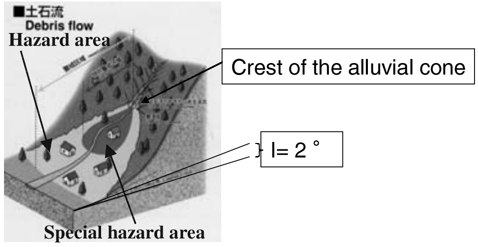

Figure 5 Designation of YZ and RZ (Debris Flow Case)

How are Yellow Zones and Red Zones determined? In case of debris flows, an area located under a stream prone to debris flow and on a slope of 2 degrees or more below the crest of the alluvial cone is determined as a Yellow Zone. An area which satisfies the following equation is determined as a Red Zone (**Figure 5**).

Fd > P2 (Fd: Fluid dynamic force, P2: Structural strength)

In case of steep slope failures, areas which are:

1) On a slope of 30 degrees or more and a slope height of 5 m or more,
2) Within 10 m horizontal distance from the top end of the slope, and
3) Within twice the slope height or 50 m, whichever is less,

are determined as a Yellow Zone.

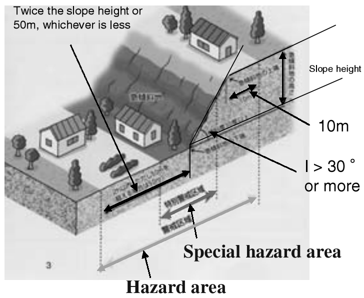

Figure 6 Designation of YZ and RZ (SSF case)

An area which satisfies the following equations is determined as a Red Zone (**Figure 6**).

Fsm > P1 (Fsm: Fluid dynamic force, P1: Structural strength against Fsm), or

Fsa > W1 (Fsa: Active earth pressure, W1: Structural strength against Fsa)

In case of landslides, areas which are:

1) Currently prone to landslide or potentially vulnerable to landslide in the future,
2) Within a distance equivalent to the length of the landslide mass from the bottom end of the landslide area or 250 m, whichever is less,

are determined as a Yellow Zone.

An area which satisfies the following equation is determined as a Red Zone (**Figure 7**).

F1 > W2 (F1: Active earth pressure, W2: Structural strength against F1)

(However, the length from the landslide mass should be 60 m at most.)

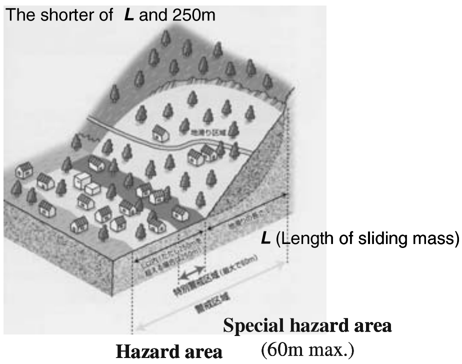

Figure 7 Designation of YZ and RZ (Landslide Case)

How to use hazard maps

Hazard maps have two functions. One is to increase people's awareness about sediment-related disasters. The other is to improve co-operation among emergency responders (**Figure 8**).

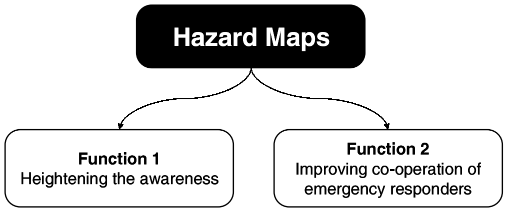

Figure 8 Functions of Hazard Maps

Regarding the former, people should be kept informed about hazard maps by every possible means, such as the internet, mail, etc., because most people do not pay attention to hazard maps during non-disaster time, and sometimes lose their copy. Some prefectural governments put hazard maps on websites, and some municipalities send direct mail to each family living within hazard areas in order to inform them that they are living in a hazard area. One good way to increase people's awareness is to fix signboards at the disaster-prone sites.

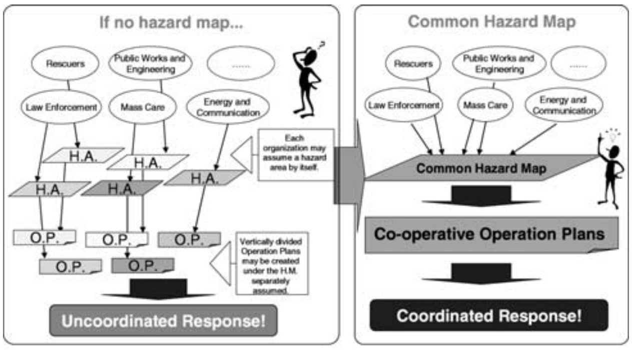

Figure 9 Necessity of Hazard Maps

On the other hand, hazard maps are also very important for organizations responsible for emergency response, because a hazard map provides a common scenario when the organizations create emergency response plans. If there are no hazard maps, each organization must identify hazard areas by itself, and so 10 organizations might identify 10 different hazard areas, resulting in an uncoordinated disaster response. If there is a common hazard map, each organization can create its own disaster response plan based on a common scenario. Such coordinated disaster response plans lead to co-operative and more effective disaster response activities (**Figure 9**).

Furthermore, hazard maps should be revised when the situation of disaster-prone sites, such as the situation of vegetation, volcanic eruptions, big earthquakes, wildfires, etc., have changed and also disaster response plans should be revised in order to respond to the disaster quickly and effectively.

Summary

- Hazard maps should be created as early as possible for all sediment-related disaster-prone sites.
- If possible, the hazard maps should be created under the law in order to restrict the development of housing, etc. within hazard areas.
- People should be kept informed about hazard areas by every possible means.
- Hazard maps are necessary to respond effectively to disasters.
- Hazard maps should be revised when the situation of disaster-prone sites has changed.
- The information about hazard maps should be shared with every organization responsible for emergency management in order to create co-operative disaster operation plans.

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