

Comprehensive Sediment Related Disaster Prevention Countermeasures in Kagoshima Prefecture

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Kagoshima prefecture is located at the southern end of Kyushu, in one of Japan's most rainy zones, with an annual average rainfall of over 2,300 mm. The majority of the prefectural land is covered with special soils, including "shirasu," which is easily collapsible volcanic ejecta. Geologic features of Kagoshima include major calderas created by large-scale volcanic eruption, or the Aira Caldera and Ata Caldera, and "shirasu" plateaus, which are formed with pyroclastic deposits that gush from the volcanoes. These special topographic and geologic features are the cause of frequent sediment related disasters, such as slope failures or debris flow which wreak havoc on the prefectural citizens almost every year. Considering these natural characteristics, the prefecture takes comprehensive disaster control measures from both structural and nonstructural perspectives, including the construction of sediment control dams and other facilities, and the provision of information concerning danger zones and disaster prevention to prefectural citizens. This paper explains the Kagoshima prefectural government's comprehensive sediment disaster control measures and describes the future efforts based on the identified problems facing our efforts.

Key words: Comprehensive Sediment Related Disaster Prevention Measure, Sediment Disaster Warning Information, Sediment Disaster Prone Area

1. OUTLINE OF KAGOSHIMA PREFECTURE

Located on the southern end of Kyushu, Kagoshima prefecture is composed of two major peninsulas, the Satsuma Peninsula and the Osumi Peninsula, which are part of the main island of Kyushu, and many isolated islands, including Tanegashima, Yakushima and Amami Archipelago. The prefecture has a vast land mass that stretches roughly 272 km from east to west and about 590 km from north to south.

Occupying a total area of roughly 9,189 km², the prefecture is the 10th largest prefecture in Japan, with the area of the islands accounting for about 27% of the total prefectural land.

The Kirishima volcanic zone crosses the central part of the prefecture from north to south. A total of 11 active volcanoes, including Mt. Kirishima, Mt. Sakurajima and Mt. Kaimon-dake, are dispersed throughout the prefecture. Due to these volcanoes, the prefecture is also endowed with many hot springs.

The prefecture is located in the moderate zone as well as the sub-tropical zone, which contributes

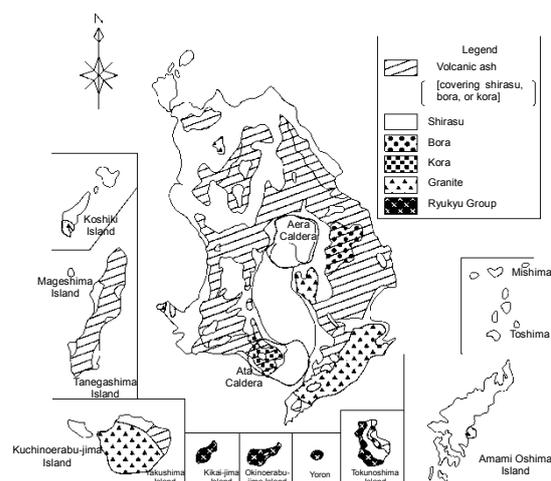


Fig. 1 Schematic diagram of special soil distribution in Kagoshima prefecture

to an exposure to complicated and diversifying meteorological conditions. As a result of the mild and rainy climate, the prefecture has an average annual temperature of 18 to 19 °C and an annual average rainfall of over 2,200 mm in the main prefectural land. The area covering the islands of Tanegashima, Yakushima and Amami has an annual temperature of 19 to 22 °C and an annual average

rainfall of over 2,300 mm, which is characteristic of the subtropical zone. The majority of rainfall is concentrated in the period from the rainy season to the typhoon season, making the prefecture one of Japan's most rainy zones.

The volcanic topography is characterized by volcanic deposits, namely volcanic ash, volcanic sand, volcanic gravel, and pumice layers. What is generally referred to as "shirasu" layers form hilly plateaus, a dominant topography of the prefecture, making the prefecture poor in flat land. The shirasu soil covers about 51% (3,430 km²) of the prefectural land, meaning the majority of the prefectural land is covered by easily collapsible special soils (Fig.1).

The prefecture also has major calderas formed by previous large-scale volcanic eruptions, including the Aira Caldera and the Ata Caldera. The former, in particular, was developed between 90,000 to 25,000 years ago, and the pyroclastic flows resulting from eruption form the shirasu plateaus. When water is permeated into the soil, it tends to fail easily. Large sediment related disasters, including slope failures and debris flows have frequently occurred in the prefecture.

Granite rocks are dominantly distributed in mountainous areas, including Shibi, Takakuma and Kimotsuki Mountains, and the Yakushima Island. Parts of the rocks are highly weathered and have become "masado" or decomposed granite soil, which is susceptible to surface failure.

2. STATUS OF SEDIMENT RELATED DISASTERS IN KAGOSHIMA PREFECTURE

Kagoshima prefecture experiences devastating sediment related disasters and suffers from serious damage almost every year because of its unique topography, which is composed of SHIRASU and other materials originating from volcanoes, its

location in typhoon paths, and its abundant rainfall, including torrential rain during the rainy season. Area of Kagoshima Prefecture is only 2.4% of the land area of Japan, however recent data indicates that the number of sediment related disasters that occurred in the area in the past 10 years accounts for about 7% of the sediment related disasters in the country, and that the average rate of disaster occurrence has increased by 1.6 times from what it was 10 years ago (Fig.2).

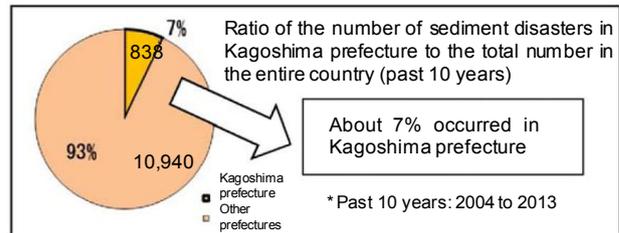


Fig. 2 Status of sediment disasters in Kagoshima prefecture (ratio of the total number of sediment disasters in Japan)

Human injury resulting from sediment related disasters in the prefecture has been reduced in these years thanks to the years of effort, which include the

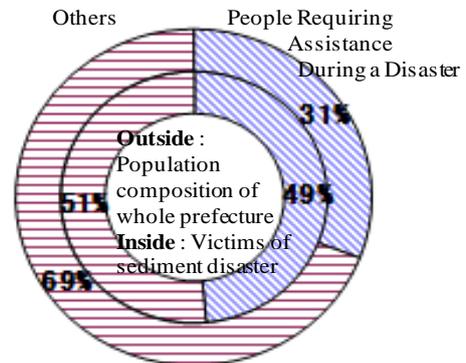


Fig. 4 Status of sediment related disaster damage in the prefecture (from 1993 to 2013)

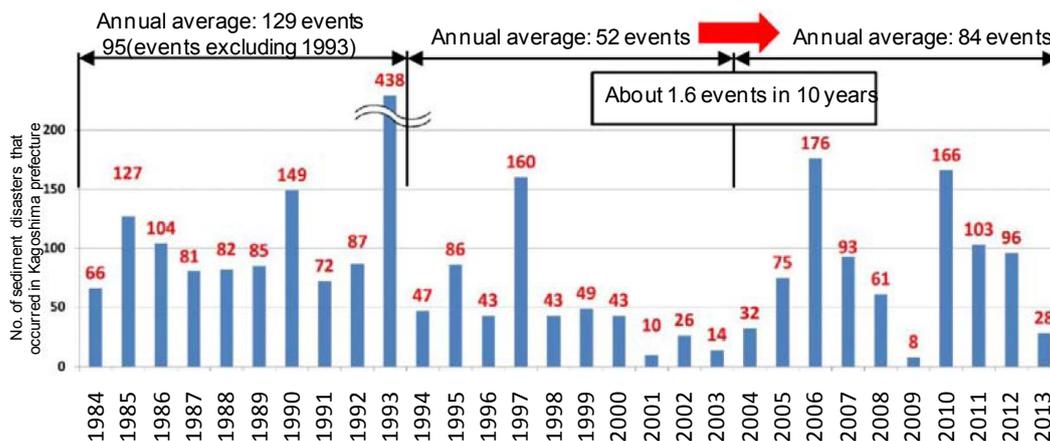


Fig. 3 Status of sediment related disasters in Kagoshima prefecture (changes in the number of disasters)

collection and diffusion of disaster information and the improvement of evacuation procedures(Fig.3). However, sediment related disasters in the prefecture account for about 80% of all natural disasters that resulted in injury to humans, which is higher than the national average, or about 40% of all such cases.

In particular, of the sediment related disaster victims in the prefecture (from 1993 to 2013), those who need help at the time of disaster, such as the elderly, account for about 49%(Fig.4). Considering such a high ratio of vulnerable people, developing sediment control measures for vulnerable segments who need help during a disaster is one of the prefecture’s critical tasks to undertake.

3. BASIC POLICY OF THE SEDIMENT CONTROL MEASURES OF KAGOSHIMA PREFECTURE

Protecting the life and assets of the prefectural citizens from sediment related disasters, maintaining the prefectural land, and promoting the creation of safe and affluent communities are priority issues for prefectural zones prone to sediment related disasters.

To this end, the prefecture is taking comprehensive sediment related disaster control actions to prevent sediment related disasters and mitigate their damage. Specifically, the prefecture conducts structural measures, including the construction of sediment control dams as well as nonstructural measures,

including the provision of information on danger spots, such as Sediment related disaster Alert Zones and disaster prevention information, such as sediment related disaster warnings, to citizens.

4. SYSTEMATIC DEVELOPMENT OF CONTROL FACILITIES

In the prefecture, there are 2,160 mountain streams in danger of debris flow that may damage five or more houses, 85 locations in danger of landslide, and 2,707 locations in danger of steep slope failure.

In addition, there is a total of about 16,200 locations that are considered in danger as they are in locations that are in danger of sediment related disaster, and have one or more, but less than five houses that should be protected, or are considered to cause danger to human life because of the planned development of residential land.

The prefectural government is actively conducting various sediment related disaster prevention activities, including, the construction of sediment control dams, landslide control facilities, and failure control works on steep slopes. Despite these efforts, there are somewhere near 5,000 locations that need attention due to there being five or more houses to protect. The current improvement ratio is only about 35% (at end of March, 2014). Considering such a low improvement ratio, further efforts are required in the future(Table 1).

The sediment control budget of the prefecture

Table 1 Improvement status of locations in danger of sediment related disasters in Kagoshima prefecture
Status of locations with the danger of sediment disaster (as of the end of 2014)

Mountain streams in danger of debris flow	Locations in danger of steep slope failure	Locations in danger of landslide	Total
a) No. of dangerous mountain streams: 4,301	a) No. of dangerous mountain locations: 11,818	a) No. of dangerous mountain locations: 85	16,204 locations
b) Mountain streams that need improvement: 2,160	b) Mountain locations that need improvement: 2,707	b) Mountain locations that need improvement: 85	4,952 locations
Of these mountain streams, facilities have been constructed for 709	Of these mountain streams, facilities have been constructed for 993	Of these mountain streams, facilities have been constructed for 24 mountain	1,726 locations
Improvement ratio: 33%	Improvement ratio: 37%	Improvement ratio: 28%	35%



Photo 1 Sediment control measure in an area that recently suffered serious damage(Landslide prevention works in Tatsugo town, Kagoshima prefecture)
(The damage caused by the landslide that occurred in 2010) (Landslide prevention work conducted to reinforce the slope)

gradually decreased after peaking at about ¥29.6 billion in 1998, and decreased to about 38% of the peak level in the 2013 budget because of dire fiscal conditions.

Under such circumstances, the prefectural government conducts facility development in a systematic manner through selection and concentration, while considering local characteristics and other factors from a mid-to long-term viewpoint.

We have intensively focused on developing sediment related disaster control facilities for “locations that recently suffered serious damage” and “locations with facilities related to the people who need help during a disaster as the subjects of protection” according to the concept of “creating a safe community” as one of the prefecture’s top priority issues(Photo 1,Photo 2). Aware of the fact that wide-area severances of the traffic network by sediment related disasters could have serious impacts on the socioeconomic activities of the prefectural citizens, we intend to focus on the development of sediment control facilities designed to protect important traffic networks, such as national highways and railroads, in the future.

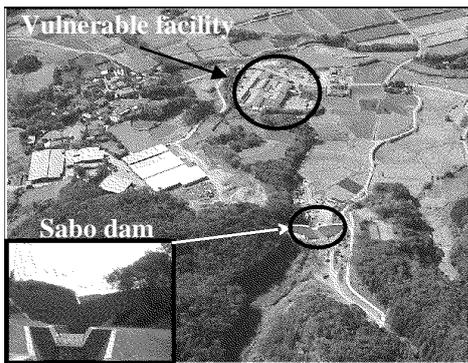


Photo 2 Sediment control facility to protect a facility related to the people who need help during a disaster (Sediment control work in Nishinoomote city, Kagoshima prefecture)

In the field of anti-volcanic measures for the prefecture, we also promote measures to deal with debris flows in active volcanoes, including the still active Mt. Sakurajima, and Mt. Shinmoe-dake of the Kirishima Mountains, which explosively erupted in January 2011 for the first time in 52 years.

With regard to Mt. Sakurajima, since the conditions are very prone to the occurrence of debris flow with the ongoing activation of volcanic activities, the national government and the prefectural government jointly construct sediment control facilities, including sediment control dams, on a systematic manner, and remove debris and stones as required to

maintain the functions of the sediment control facilities.

For Mt. Shinmoe-dake of the Kirishima Mountains, since the explosive eruption in 2011, pyroclastic fall deposits have accumulated around the crater. Since debris flow is expected in the future, sediment control dams are currently being improved or constructed.

The work currently under way for these two volcanoes, under the joint efforts of the national government and the relevant organizations, to prevent and mitigate damage includes construction of sediment control dams and the monitoring of volcanic activities with ash fall meters and debris flow monitoring cameras, in addition to the construction of sediment control dams.

5. INFORMATION ON SEDIMENT RELATED DISASTER WARNING

When the risk of a serious sediment related disaster is elevated due to heavy rain, the prefecture issues sediment related disaster warning information to the municipalities in partnership with the Kagoshima Local Meteorological Observatory(Fig.5). At the municipal level, the information is used to make judgments regarding the necessity of issuing evacuation advisories and performing disaster prevention activities, and is also used by residents to make decisions on whether to evacuate on an individual basis(Fig.6).

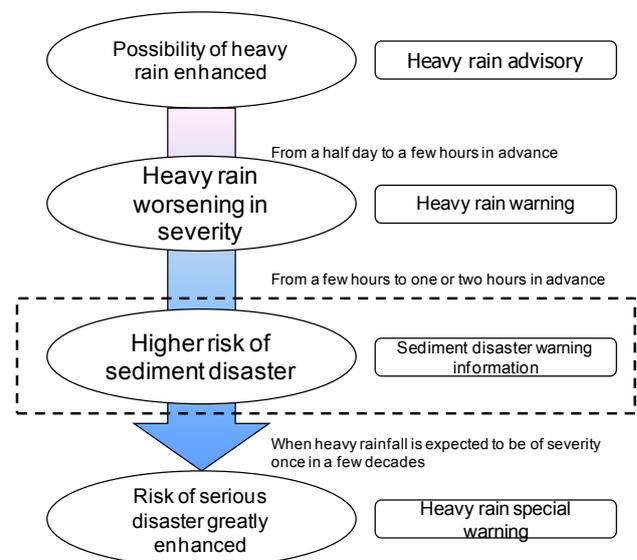


Fig. 5 Flow of weather information announcement

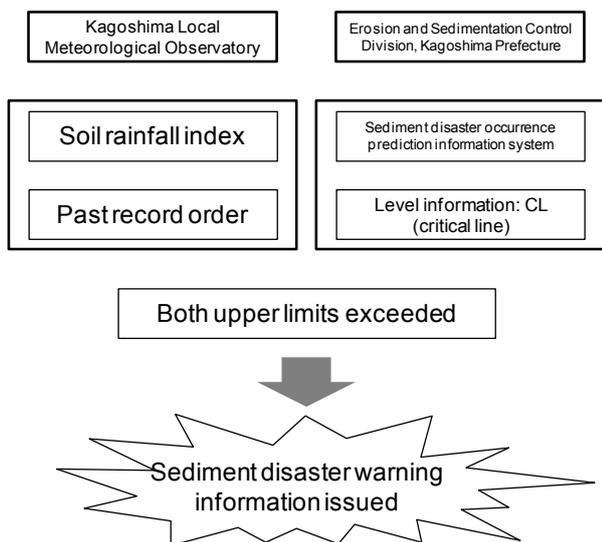


Fig. 6 Issuance standard for sediment related disaster warning information in Kagoshima prefecture

Table 2 Issuance of sediment related disaster warning information in Kagoshima prefecture

By the year	No. of times by the series of meteorological event unit		Detective rate
	No. of times	No. of disaster occurrences	
2005 (since September)	Twice	Once	50.0%
2006	12 times	6 times	50.0%
2007	10 times	5 times	50.0%
2008	10 times	7 times	70.0%
2009	4 times	Twice	50.0%
2010	11 times	5 times	45.5%
2011	10 times	8 times	80.0%
2012	11 times	9 times	81.8%
2013	5 times	3 times	60.0%
Total	75 times	46 times	61.3%

* Series of meteorological event: (Example) rainfall from (day) to (day) (month)
 * No. of disaster occurrences: No. of sediment disaster reports received or counted by the Erosion and

disaster warning information, when information is issued, it is further communicated to municipalities from the Kagoshima Local Meteorological Observatory through the prefecture's Crisis Management Bureau.

The Erosion and Sedimentation Control Division of the Public Works Department also contacts the prefecture's Local Promotion Bureau and other organs by phone to have them notify each municipality of the issued information, thereby ensuring diffusion of the information to relevant organizations and citizens(Fig.7).

Every June, the prefecture holds an information conveyance drill with the municipalities, regularly checks the procedures regarding the provision and reception of information related to sediment related disasters, such as sediment related disaster warning information, and verifies the issuance timing of evacuation instructions, so as to ensure the reinforcement of a swift and accurate information provision system.

On the part of the municipalities in the prefecture, today, only about 70% of them incorporate sediment related disaster warning information in their local disaster prevention plans as the announcement standard for evacuation instructions (as of the end of March 2014). For municipalities that have yet to designate the use of sediment related disaster alert information as the standard for the issuance of evacuation instructions, the prefectural government recommends that they make effective use of such information as the issuance standard.

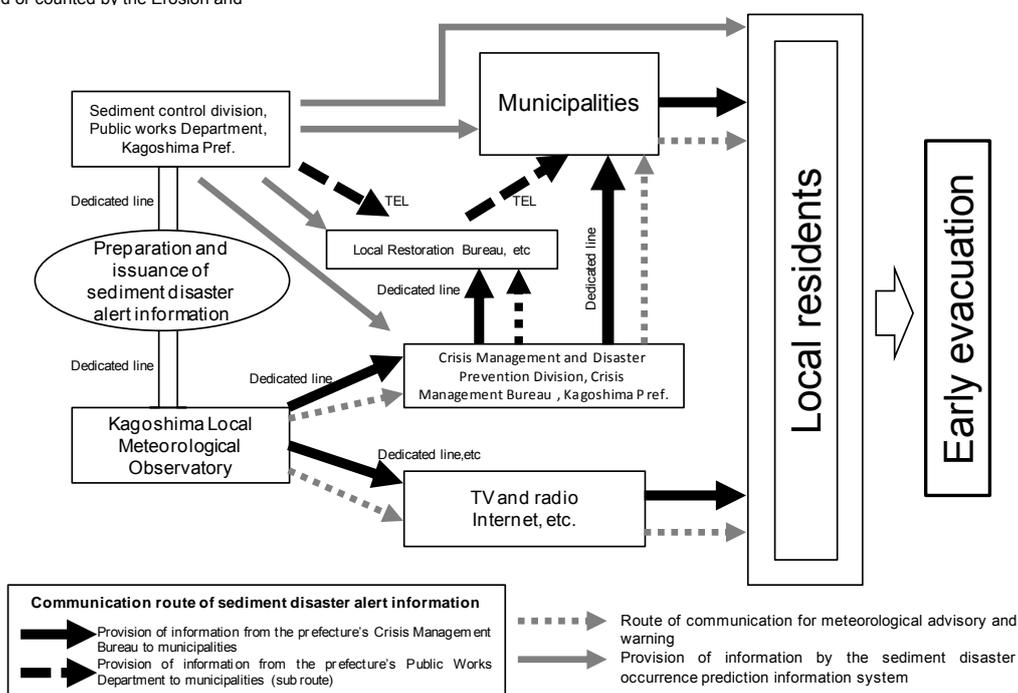
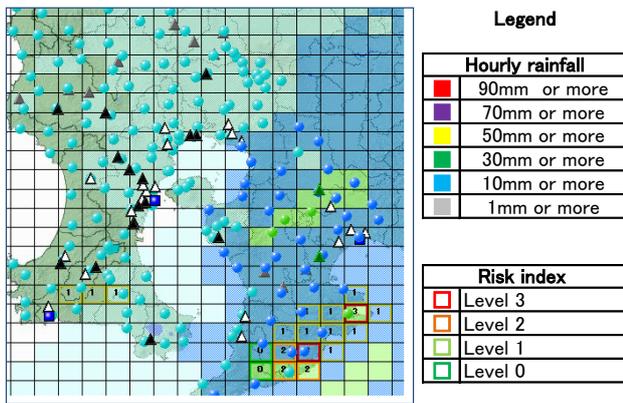


Fig.7 Communication route of sediment disaster warning information in Kagoshima prefecture



[Information by the 5 km mesh]

Fig. 8 Supplemental information for sediment related disaster warning information (provision of information by the 5 kilometer mesh)

The government has been using sediment related disaster warning information ahead of other prefectures in the country since September 2005. Critical index is based on the relationship between short-term rainfall and long-term rainfall. In roughly 8 years since the start of its use until 2013, sediment related disaster warning information was issued 75 times, and 46 sediment related disasters occurred (Detective rate 61%) when the information was issued (Table 2).

The government also started providing municipalities and citizens with supplemental information, such as information concerning rainfall in the entire prefecture or sediment related disaster danger indexes, on the prefecture's official website in April 2008. The government supports disaster control activities of municipalities by providing them with sediment related disaster danger indexes and rainfall information shown on a one-kilometer mesh map (Fig.8).

6. SEDIMENT RELATED DISASTER ALERT ZONE

The prefectural government designates Sediment related disaster Alert Zones and Sediment related disaster Special Alert Zones according to the Sediment related disasters Prevention Law effected in 2001, as part of our effort to promote nonstructural measures to protect citizens from sediment related disasters, including danger notifications for zones likely to cause sediment related disasters and the development of a warning and evacuation system.

The designation procedure of Sediment related disaster Alert Zones involves implementation of basic surveys, briefing residents, collecting comments from relevant municipal heads, and

officially designating alert zones. It takes approximately three years to complete the designation (Fig.9).

Briefing sessions for residents are held to notify them of the areas likely to suffer sediment related disasters, as determined by the basic surveys, and to help them understand the importance of the warning and evacuation system. Thus far (as of the end of March 2014), a total of 343 briefing sessions were held for some 9,000 residents.

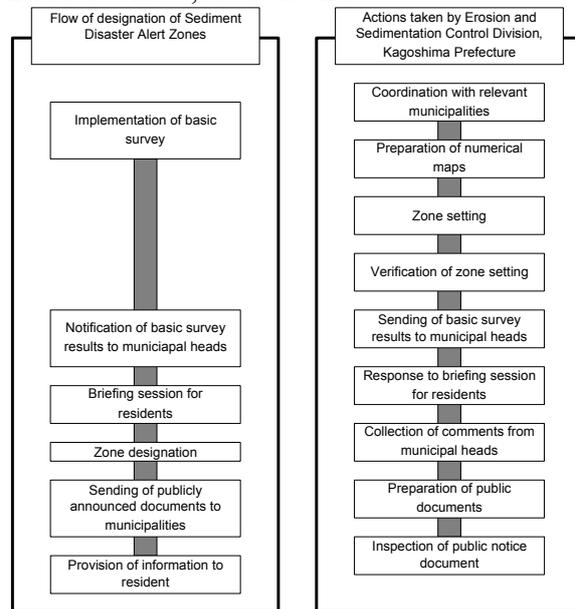


Fig. 9 Flow chart for designation of Sediment related disaster Alert Zones in Kagoshima prefecture

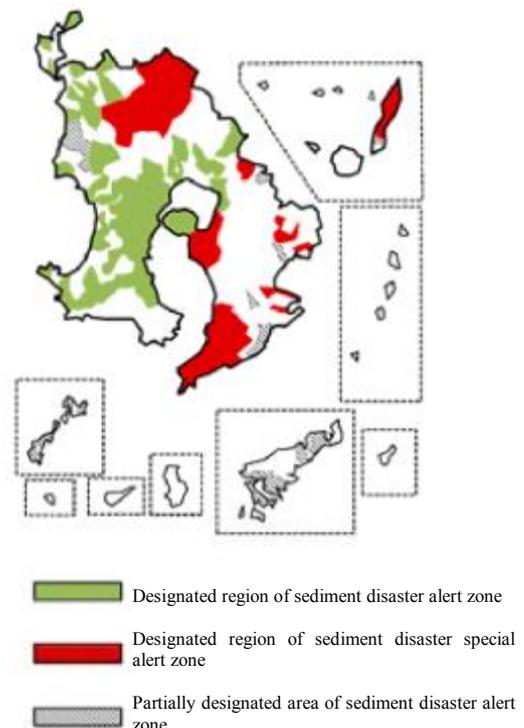


Fig. 10 Designation of Sediment related disaster Alert Zones in Kagoshima prefecture (as of the end of March 2014)

As of March 2014, 13,245 locations have been designated in 35 municipalities out of a total of 43 in the prefecture(Fig.10). We continue to work with municipalities on this designation procedure. In particular, we intend to prioritize areas that recently suffered sediment related disaster damage or areas in which facilities related to the people who need help during a disaster are located when designating areas.

For facilities related to people who need help during a disaster and are likely to suffer sediment related disasters, the prefectural government has been conducting field surveys on the location of those facilities jointly with the relevant departments since 2010 and publishing the results of such surveys. This operation started after a special elderly nursing home in Yamaguchi prefecture was damaged by debris flow in 2009.

The prefectural government notifies the relevant municipalities of the survey results. In addition, the government provides guidance and advice to the municipalities, encouraging them to stipulate the provision of sediment related disaster information to the facilities located in Sediment related disaster Alert Zones and promoting them to instruct the managers of those facilities to develop appropriate warning and evacuation systems.

Once an area is designated as a Sediment related disaster Alert Zone, the competent municipalities are required to develop a warning and evacuation system as part of their duties. With regard to the preparation of sediment related disaster hazard maps, one of the requirements of the relevant municipalities, remains in 13 municipalities (about 37%) among 35 municipalities in designated zone as the end of March, 2014(Fig.11). The prefecture continues to encourage municipalities to prepare sediment related disaster hazard maps.

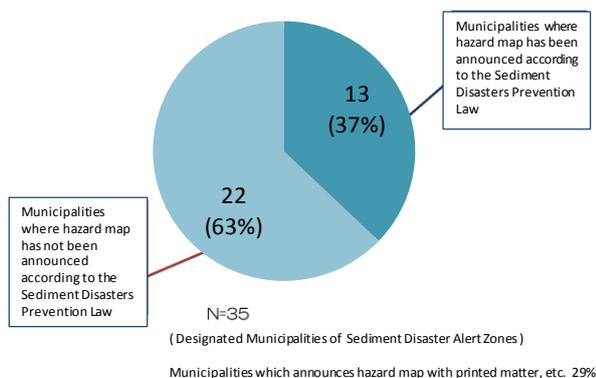


Fig. 11 Issuance of sediment related disaster hazard maps by municipalities in Kagoshima prefecture(as of the end of 2014)

7. PROMOTION OF DISASTER CONTROL EDUCATION

In order to prevent sediment related disasters and mitigate their damage, it is necessary for the prefecture to take structural measures, such as the construction of sediment control dams, and for local residents to judge and act wisely and appropriately. Therefore, it is considered important to improve disaster control education at elementary schools and junior high schools in order to help students enrich their knowledge of sediment disasters even at the adolescent stage if we want to improve the community's disaster preparedness in the future.

To this end, the prefectural government conducts delivery lectures on disaster control education at elementary schools and junior high schools in the prefecture so as to bestow the lessons learned from past experiences with large-scale disasters and the accumulated knowledge of sediment related disasters to future generations, and to help the people take swift and accurate actions for evacuation in the event of a disaster. Brochures on sediment related disasters have been prepared for this purpose and used in our delivery lectures(Kagoshima Prefecture(2010),(2014)).

The Local Promotion Bureau of each region in the prefecture visits elementary and junior high schools in their jurisdiction and holds delivery lectures every year. Lecturers use model experiments to help students understand the roles of sediment control dams, and video materials dealing with sediment related disasters so that elementary and junior high school students can easily understand the contents of the lectures(Photo 3).

Various ideas, including the issuance of a hand-made "Sediment related disaster Junior Master Certificate" to students upon completion of the lecture, are put into action in the lectures to help keep elementary and junior high school students interested in disaster prevention, and to have them take up sediment related disaster topics even at their homes.

The prefecture is determined to provide appropriate disaster control education to young students who represent the future leadership of Kagoshima, to help them deepen their understanding of sediment disasters, and eventually improve further enhancement of the people's disaster preparedness.



Photo 3 Disaster control education at an elementary school (model used in the lecture)

CONCLUSIONS

A large number of sediment disasters have occurred in Kagoshima prefecture. In these years especially, it is estimated that increases in local heavy rain or typhoons are attributable to global warming and other factors. Considering this, it is reasonable to think that the risk of sediment related disaster is

further increasing.

Last year was the 20th anniversary of the prefecture's most devastating post-war disaster caused by a series of sediment related disasters in 1993. This January marked the 100th anniversary of the Taisho Eruption of Sakurajima.

These events have increased our awareness of the lessons learned from the past calamities. In this respect, the prefecture is determined to continue comprehensive sediment control measures for the prevention of sediment related disasters and the mitigation of their damage from both structural and nonstructural aspects with the joint efforts of the people and the administration so as to realize a safe and secure prefectural land.

REFERENCES

Kagoshima prefecture (2010): Handbook of SABO.
Kagoshima prefecture (2014): Safe and reliable Native province, In order to create a Kagoshima