Non-structural Measures
– Designation of Sediment Disaster Alert Areas, Soil Water Index, Warning and Evacuation systems –

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Total Number of Sediment-related Disaster Prone Sites by Prefecture

Debris flow prone site, etc.: published in 2002
Landslide prone site, etc.: published in 2000
Steep slope failure prone site, etc.: published in 2002

Total number of sediment disaster prone sites

525,307 sites throughout Japan

Steep slope failure prone site, etc.
Landslide prone site, etc.
Debris flow prone mountain stream, etc.

The graph is made from data on website of the Sabo Department (http://www.mlit.go.jp/river/sabo/link20.htm)
Structural-measures alone are not sufficient

Every year

Sediment-related disasters occur somewhere and have a great impact on our lives.
The number of sites prone to sediment-related disasters increase.

Implementation of structural measures would require a great amount of time and costs.

Because
Development of new residential areas progresses

It is important to improve non-structural measures in addition to structural measures.
☆ Identify the areas with a high possibility of sediment disaster
★ Develop the warning and evacuation systems
☆ Restriction on new housing development in at-risk areas

Source: Website of Sabo department, MLIT
http://www.mlit.go.jp/river/sabo/sinpoupdf/gaiyou-06.pdf
The Sediment Disasters Prevention Act* aims to promote non-structural measures in the areas prone to sediment disasters in order to protect the lives of the people from sediment disasters. The non-structural measures include provision of information on the areas prone to sediment disasters, development of the warning and evacuation systems, restriction on new housing development, etc., and promotion of moving the existing houses to a new site.

Formulation of the Basic Guidelines for Sediment Disasters Prevention Measures
(Ministry of Land, Infrastructure, Transport and Tourism)
- Basic matters related to the measures for sediment disaster prevention
- Guidelines for basic surveys
- Policies for designating the sediment disaster special alert areas, etc.

Implementation of basic surveys [Prefectures]
- Surveys on designation of sediment disaster alerts area and sediment disaster special alert area, etc.

Designation of sediment disaster alert areas [Prefectural Governors]
(Areas with potential to be hit by a sediment disaster)
- Information provision development of the warning and evacuation systems

Designation of sediment disaster special alert areas [Prefectural Governors]
(Areas with potential to incur serious damage from a sediment disaster)
- Approval system for specific development activities
  - Targets: Housing land sales, development activities for social welfare facilities, etc.
- Structural control for buildings (Buildings outside the city planning area are also subject to building certification)
- Recommendation of moving the buildings with potential to incur great damage from a sediment disaster

Implementation of basic survey
Survey on geographic and geological features, and the state of land use in the areas, such as mountain streams and slopes, with potential to incur serious damage from sediment disasters

Designation of areas
Areas prone to sediment disasters are identified based on the basic survey

<Warning and evacuation systems>
- Regional Disaster Prevention Plan (Disaster Countermeasures Basic Act)

<Structural control for buildings>
- Setting the structural standards for buildings with living space (Building Standards Act)

<Support for moving>
- Loans of the Housing Loan Corporation

Source: Website of Sabo department, MLIT
http://www.mlit.go.jp/river/sabo/sinpoupdf/gaiyou-06.pdf
In the Sediment Disaster (Special) Alert Areas

**Sediment disaster alert area**

It is an area with the potential to harm the lives or bodies of the residents in the case of steep slope failure, etc. Countermeasures include the provision of information on the risks and development of the warning and evacuation system.

**Sediment disaster special alert area**

It is an area with the potential to incur damage on the buildings and to inflict serious harm on the lives or bodies of the residents, etc. in the case of steep slope failure, etc. Countermeasures include the approval system for specific development activities and structural control for buildings.

In the sediment disaster alert area...

- Development of the warning and evacuation system
- The warning and evacuation system is developed to facilitate the disaster information transmission and evacuation to protect the lives of the people from sediment disasters. [Municipal governments]

Additionally, in the sediment disaster special alert area...

- Approval system for specific development activities
- Development activities, such as housing sales and facilities for persons who need assistance during a disaster, shall be approved as long as they are in line with the standards. [Prefectural governments]

- Structural control for buildings
- Building certification shall be issued to buildings with living space to confirm that the structure of the building is safe against potentially affecting impact. [Local authorities over constructions]

- Recommendation for moving of buildings
- Recommendation for moving is issued to the buildings with risk of incurring serious damage. [Prefectural governments]

Source: Website of Sabo department, MLIT
http://www.mlit.go.jp/river/sabo/sinpoupdf/gaiyou-06.pdf
Imminent risk of a large-scale sediment disaster

**Flood/debris flow caused by river blockage (landslide dam)**
- When the height of a river blockage is over 20m
- When approximately more than 10 houses are likely to incur damage

**Debris flow caused by volcanic eruption**
- When the slope of the river is over 10° and 50% of the area is covered with ash at a depth of over 1cm
- When approximately more than 10 houses are likely to incur damage

**Landslide**
- When there are cracks and the cracks are expanding in the ground or buildings, etc. due to a landslide
- When approximately more than 10 houses are likely to incur damage

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Based on the emergency survey, MLIT or the prefectural government shall notify the mayors of relevant municipalities and provide the general public with information (emergency information on sediment disaster) about the areas/time likely to be affected.
What is an emergency survey?
Emergency surveys on river blockage (landslide dams), debris flow caused by volcanic eruption, or dam flooding shall be conducted by the national government, and those on landslides are carried out by the prefectural governments.

Survey image on the landslide dam

The water level observation by dropping type water level meter

Measurement of landslide dam from helicopter

Measurement of peripheral landslide dam by laser measurement

Natural dam appeared in Kumano district, Wakayama Pref.

Emergency field survey
Designation of sediment disaster alert areas

The graph is made from data on website of Sabo department, MLIT (http://www.mlit.go.jp/mizukokudo/sabo/index.html) as of Aug. 31, 2015

Designation of sediment disaster alert areas
404,439 sites
(of which 245,096 sites are the special alert areas)

Source: Website of Yamaguchi Pref.
Heavy rain warning: Treated as evacuation preparation information
Warning information on sediment disaster: Information supporting the decision of evacuation recommendation
Weather Hazard Information Release and Rainfall Time-Series

Rainfall Case of Hofu City, Yamaguchi Prefecture (12 p.m. of July 20 to 12 a.m. of July 22 2009)

Information about a Heavy Rain in a Short Period

- Released 8:50
- Released 11:49
- Switched 6:40
- Released 4:18
- Released 6:26
- Canceled 5:17
- Released 8:50
- Released 1:48
- Switched 6:40

Continued till 8:15 of July 22

Switched to Advisory at 8:22 a.m. of July 22.
The Advisory continued till 5:30 p.m. of July 22.

Continued till 8:22 of July 22

Switched at 9:56

14 people in total died from the sediment disaster in Hofu city including 7 residents of a special elderly nursing home who were killed by debris flow.

Average Monthly Rainfall in July 287.4mm
Sediment disaster alert

- Specification of municipalities with a high risk of sediment disasters
- Notice issued jointly by the prefectural Sabo department and the meteorological observatory

Objectives

- Information supporting municipal mayors for making a decision on the Evacuation Recommendation
- Also useful for citizens in deciding voluntary evacuation
[Japan Meteorological Agency (JMA)]

Upon announcement/notification of heavy rain warning or heavy rain emergency warning in accordance with Article 13 and Article 15 of the Meteorological Service Act, JMA shall develop and issue a document to explain the heavy rain warning or heavy rain emergency warning as a part of meteorological information pursuant to Article 11 of the Meteorological Service Act.

[Prefectural Government]

- A prefectural government shall clearly and specifically prescribe the objectives of warning information on sediment disaster and joint issuance with JMA in the regional emergency preparedness plan based on Article 40 of the Disaster Countermeasures Basic Act.
- When a heavy rain warning is issued, a prefectural government shall notify the municipal governments, for example, about the occurrence of sediment disaster as an “impact of anticipated disasters and countermeasures to be taken” in accordance with the provisions of laws and regulations and the regional emergency preparedness plan, in pursuant with Article 55 of the Disaster Countermeasures Basic Act.
Article 60 of the Disaster Countermeasure Basic Act

In the interest of protecting life and limb from disaster or of preventing the spread of a disaster when it has occurred or is believed imminent, the mayor of the city or town or the head of the village may, when deemed necessary, make recommendations to the local residents, temporary residents and others of an area concerned to evacuate, or may, when deemed urgent, give instructions to these persons to evacuate for their safety.
### Phased Announcement of Warning Information on Sediment Disaster

#### Reference line of heavy rain warning

- When it is expected to exceed the risk level in 2-3 hours

#### Reference line of heavy rain advisory

- Reference line of announcement of warning information on sediment disaster

#### Heavy rain warning (sediment disaster):

The soil water index criteria for heavy rain advisory is set to a value that would statistically appear **roughly one hour earlier before the soil precipitation criteria for heavy rain warning**, and the heavy rain warning is announced 2-6 hours before exceeding the set value.

#### Heavy rain advisory:

The soil water index criteria for heavy rain advisory is set to a value that would statistically appear roughly one hour earlier before the soil precipitation criteria for heavy rain warning, and the heavy rain advisory is announced 2-6 hours before exceeding the set value.

#### Warning information on sediment disaster:

Considering the time necessary for the evacuation of persons needing assistance, the value of soil index criteria for heavy rain warning is set to be a value that would statistically appear roughly one hour before the warning criteria for sediment disaster, and the heavy rain warning is announced 2-6 hours before exceeding the set value.

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**Announcement of heavy rain warning (sediment disaster)**
- Evacuation preparation information
- Evacuation of persons requiring assistance during a disaster

**Announcement of heavy rain advisory**
- Stand by of disaster prevention teams
- Advisory for small scale sediment disaster

**Announcement of warming information on sediment disaster**
- Voluntary evacuation

**Current state**
- Area with immediate risk of sediment disaster

**Prediction (2-3 hours later)**
- 60-min accumulative rainfall
- Soil water index

**Announcement of heavy rain warning (sediment disaster)**
- Voluntary evacuation

**Announcement of heavy rain advisory**
- Evacuation preparation information

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*The time frame is decided by each prefecture*
Setting up Standards

Lower limit (specific soil precipitation index)
Set to avoid frequent forecast errors: for example, evening shower without preceding rainfall.

• No rainfall
  Soil water index and the maximum value of the total rainfall during the past 60 minutes in the case of non-occurrence of targeted sediment disaster.

• Rainfall
  Soil precipitation index and the value of the total rainfall during the past 60 minutes in the case of occurrence of targeted sediment disaster.

CL is set around the upper limit of the conditions where a targeted sediment disaster does not occur.

Source: “Method of Setting Precipitation Standards for Sediment Disaster Warning and Evacuation in Collaboration of the Sabo Department, River Bureau, MLIT and the Forecast Department of JMA” (June 2005, the Sabo Department, River Bureau, MLIT/ the Forecast Department of JMA/the National Institute for Land and Infrastructure Management, MLIT)

Source: Document of the “Committee on Improvement of Meteorological Information for Disaster Prevention” (1st meeting)
What is Soil Water Index? (1)

An index obtained by a “tank model” method to show how much water from rainfall is retained in the soil.

Calculated by dividing the ground surface into 5 square km based on the analyzed precipitation

※ “Analyzed Precipitation” is obtained from the precipitation distribution analysis by combining radar rain gauge and ground rain gauge, such as AMeDAS. It allows to understand localized heavy rainfall, which cannot be monitored by rain gauges.
Monitoring of standards

Short-term rainfall prediction system

Warning determination by using the soil precipitation index on the hour every hour for up to three hours
Parameters of soil water index

Table 5. The synthetic parameters classified by geological features.

<table>
<thead>
<tr>
<th>Geological feature of basin</th>
<th>L₁ (mm)</th>
<th>L₂ (mm)</th>
<th>L₃ (mm)</th>
<th>L₄ (mm)</th>
<th>F₁ (hr⁻¹)</th>
<th>F₂ (hr⁻¹)</th>
<th>F₃ (hr⁻¹)</th>
<th>R₁ (hr⁻¹)</th>
<th>R₂ (hr⁻¹)</th>
<th>R₃ (hr⁻¹)</th>
<th>R₄ (hr⁻¹)</th>
<th>TL (hr)</th>
<th>ω (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volcanic rock</td>
<td>30–40</td>
<td>60–75</td>
<td>15</td>
<td>15</td>
<td>0.12</td>
<td>0.08</td>
<td>0.01</td>
<td>0.10</td>
<td>0.15</td>
<td>0.05</td>
<td>0.01</td>
<td>1</td>
<td>4.0</td>
</tr>
<tr>
<td>Granite</td>
<td>15</td>
<td>60</td>
<td>15</td>
<td>15</td>
<td>0.12</td>
<td>0.05</td>
<td>0.01</td>
<td>0.10</td>
<td>0.15</td>
<td>0.05</td>
<td>0.01</td>
<td>1</td>
<td>4.0</td>
</tr>
<tr>
<td>Palaeozoic</td>
<td>30</td>
<td>75</td>
<td>5</td>
<td>15</td>
<td>0.12</td>
<td>0.04</td>
<td>0.01</td>
<td>0.10</td>
<td>0.15</td>
<td>0.05</td>
<td>0.01</td>
<td>1</td>
<td>4.0</td>
</tr>
<tr>
<td>Tertiary &amp; Quaternary</td>
<td>15</td>
<td>40</td>
<td>5</td>
<td>15</td>
<td>0.12</td>
<td>0.04</td>
<td>0.01</td>
<td>0.10</td>
<td>0.15</td>
<td>0.05</td>
<td>0.01</td>
<td>2</td>
<td>4.0</td>
</tr>
</tbody>
</table>

* Welded tuff


No significant difference is found in the order of records, regardless of the parameters used (figure omitted); however, JMA obtains the index using the parameter of granite, which is the most susceptible to cracks.
Sediment disasters (debris flow/slope failure, etc.) caused by heavy rainfall are likely to occur when the amount of water contained in the soil is high and may be affected by the rainfall of several days.

Soil water index is used to announce the criteria of CL(sediment disaster alert) and heavy rain warning/advisory as a new index to indicate the risk of sediment disasters.
1. Does not specify site/time/scale of individual disaster

2. Targeted disaster

- Debris flow
- Intensive collapse of steep slope

※ Sediment disaster is technically difficult to predict from rainfall. Unable to call for a warning against (deep-seated slope failure, collapse of the mountain body, landslide, etc.)

source: website of Sabo department, MLIT
http://www.mlit.go.jp/river/sabo/index.html
Case of Announcement of Sediment Disaster Alert

- **Areas under warning**: Indicates municipalities expected to exceed predetermined warning criteria. The municipalities added to the warning list are indicated with * at the end of their name.
- **Areas where warning has been lifted**: Indicates municipalities meeting the preset criteria for lifting.
- **Warning statement**: Describes the weather outline and measures to be taken by residents, etc.
- **Information number**: The initial issue for a series of rainfall is named no.1 and a serial number is assigned to each issue until the warning cancellation.
- **Date of issuance**
- **Name of issuer**
- **Supplementary figures**: Indicates the target area of warning and area where the warning has been lifted.
- **Contact**: Document of the “Committee on Sediment Disaster Warning” (1st meeting)
Transmission of Sediment Disaster Alert

Japan Meteorological Agency / meteorological observatory

Joint statement

Making sediment disaster alert

Broadcast station

Disaster prevention agencies

Prefectures

municipalities

Residents

Data broadcast

Multimedia broadcast

TV, radio, etc.

Mobile phones

PCs

Websites

Community wireless system

Community FM station

Cable TV

Residents

Websites

Community wireless system

Community FM station

Cable TV

Residents
Prefectures are displayed where warning information on sediment disaster has been issued.

Grid information for the judgment on sediment disaster warning

The status of the excess (prediction) of the issuance level for heavy rain advisory, heavy rain warning (sediment disaster) and warning information on sediment disaster is shown by the grid of 5km squares.
Supplementary Information by Prefectural Governments

Mail service by Tottori Pref.

Automatic mail services are used to deliver information on the areas with high risks which are identified by the Sediment Disaster Warning Assessment Grid* in “Northern Tottori-shi,” to which warning information on sediment disaster has been issued.

Sabo department, Ishkawa Pref.  SABO-Ai

In addition to dynamic information created by the JMA, such as analyzed precipitation and the Sediment Disaster Warning Assessment Grid,* static information is also displayed, including information on sediment disaster prone areas and evaluation sites.

http://sabo.pref.ishikawa.jp/sabo-i/

※Sediment Disaster Warning Decision Grid: Sediment disaster risk is assessed based on the current precipitation and two-hour prediction in the grid of 5 square km.

Source: press release by Tottori Pref. on Sep. 13, 2011

Document of “Committee on Improvement of Meteorological Information for Disaster Prevention” (1st meeting)
As the climate change continues, the sediment-related disasters will increase more in the future.

**Characteristics of sediment-related disasters**

- Caused by concentrated rainfall over narrow areas for a short duration.
- Occur shortly after rainfall.

**Challenge**

- Monitoring of rainfall of such nature is difficult by national observation system even in developed countries.
- National warning system is not always quick enough to issue warnings timely even in developed countries due to uncertainties involved.

**Community-Based Early Warning System (CBEWS)**

→ Evacuation is necessary to be performed by its own efforts not totally rely only on the government.
Feature and Development Goals of CBEWS

Feature of CBEWS

Utilization of local legend, past experience and the five senses

It is difficult to quantify and objectify with the five senses, and difficult to accumulate experiences.

Need some objectivity.

Development of equipment for the community and individuals

Development goals

1. Easily available and low cost
2. Simple structure and assembled by anyone
3. Easily be modified and improved according to the local conditions
4. Created locally
5. Performed safely from indoors
Development of Simple Rainfall Gage for Monitoring & Warning System

Simple Rainfall Gage for Monitoring & Warning System

Once the accumulated rain level exceeds predetermined levels, the buzzer starts sounding. This function is useful for early warning for sediment-related disasters caused by concentrated heavy rains which may occur all of a sudden even in the midnight. The rainfall gage consists of rain gage installed at an appropriate location outside the observer’s house and a monitor placed inside the house, being connected using a 1-core or 6-core cable.

It uses the same principle as the water level indicator, by arranging a sensing pin to the inside of the reservoir bottle and alarm being sounded when it is submerged in water.

Simple monitor and buzzer

Reservoir bottle can also be set outdoors.
Development and improvement of water gauge

Original gauge developed in the Caribbean in early 2000s. Dr. Opadeyi, West Indies University of Trinidad & Tobago, assembling the rain gauge in his workshop.

Ceramics cylinder → Polyethylene bottle for easy availability
Conduit pipe → Cable for the longer connection between rain receiver and monitor

Bottle: Polyvinyl → PET bottle
Sensor: “Fixed” to inner side of the bottle
   → “Removable” from the bottle, for easy assembly and repair.
Sensing terminal: Bolt
   → Blade, for the better electric conductivity
Development and improvement of water gauge

Small buzzer
\[\rightarrow\]
Loud buzzer

One point sensor only for “evacuation” can be an option.
Advantages:
- Simple operation
- Simple assembling
- Cheap cost
Manufacture of monitoring alarm section

Sets

A hole is opened in the storage box (lunch box)

A switch and such is attached to the lid of the lunch box

Sets

Soldered

Cautiously by looking at the sample

Completed monitor alarm section
Manufacture of Rain Gauge

Parts
Substitute photos taken in Japan because I forgot to take them

Processing of the water receiving part
Processing of the water receiving part

Processing of the wide-mouth bottle
Completed rainfall monitoring alarm system
Installation of rain gauge

Rain gauge set to be installed

Connecting the cable

Connection of indoor surveillance equipment

Rain gauge installed on the roof
ご清聴ありがとうございました
Thank you very much for your attention!