Non-structural Measures

– Designation of Sediment Disaster Alert Areas, Soil Water Index, Warning and Evacuation systems –

NOV. 5, 2015

National Institute for Land and Infrastructure Management,

Sabo Planning Division, Sabo Department

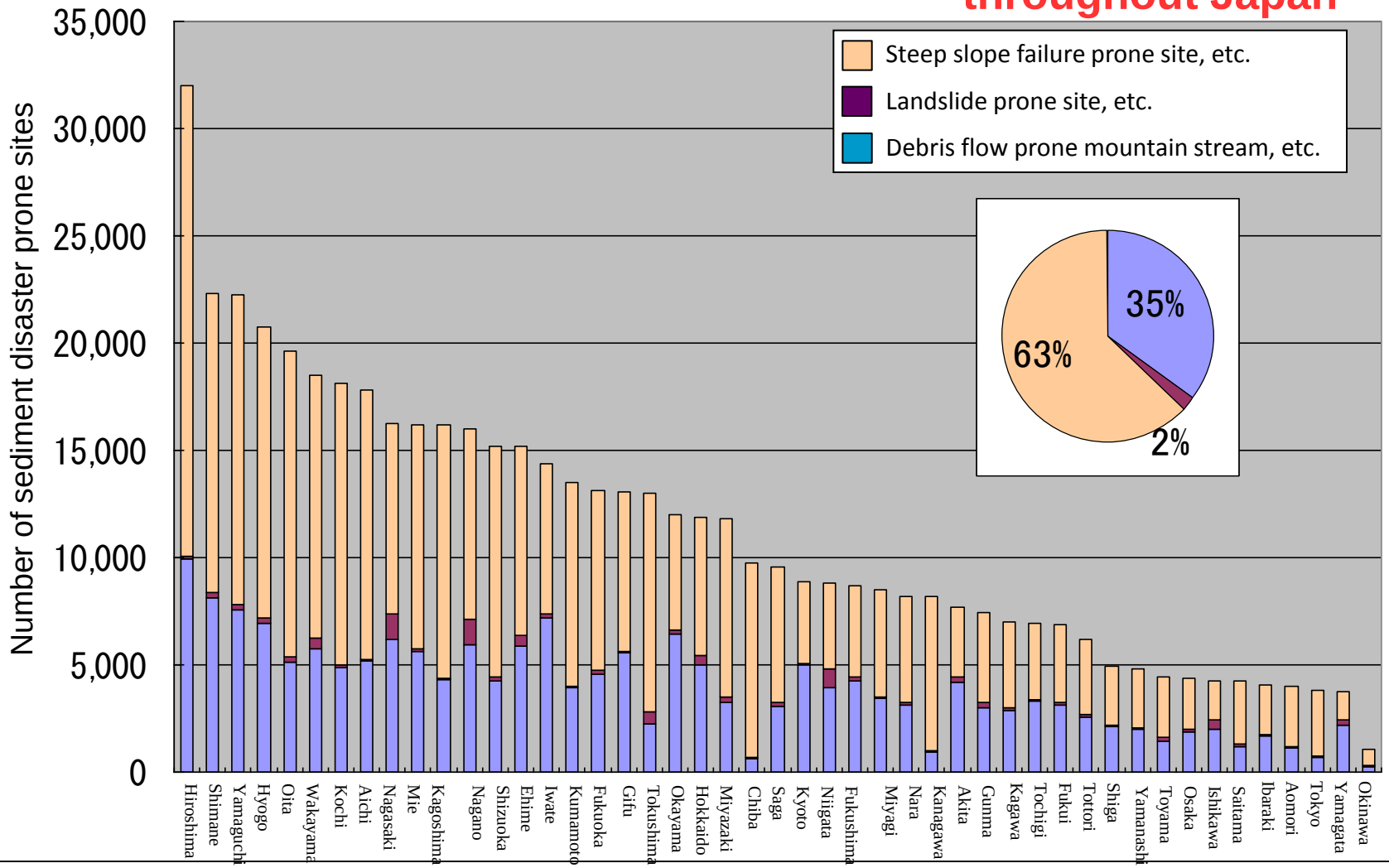
Naoki Matsumoto

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



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.

Because
Development of new residential areas progresses

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

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

Outline of the Sediment Disasters Prevention Act

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 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

Implementation of basic surveys [Prefectures]

- **Surveys on designation of sediment disaster alerts area and sediment disaster special alert area, etc.**

Designation of areas

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

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**

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

Designation of sediment disaster special alert areas [Prefectural Governors]

(Areas with potential to incur damage on buildings and inflict serious harm on local residents)

- **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**

<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

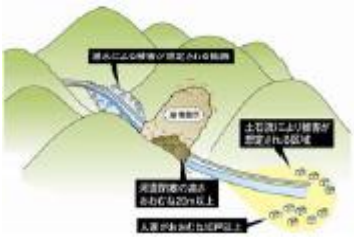
Recommendation for moving is issued to the buildings with risk of incurring serious damage. **[Prefectural governments]**

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

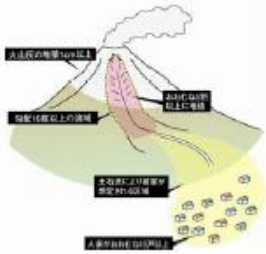
Flood/debris flow caused by river blockage(landslide dam)

- 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

Emergency Survey — MLIT

Assumption of the area/time likely to be affected by dam flooding or debris flow

Emergency Survey — Prefecture

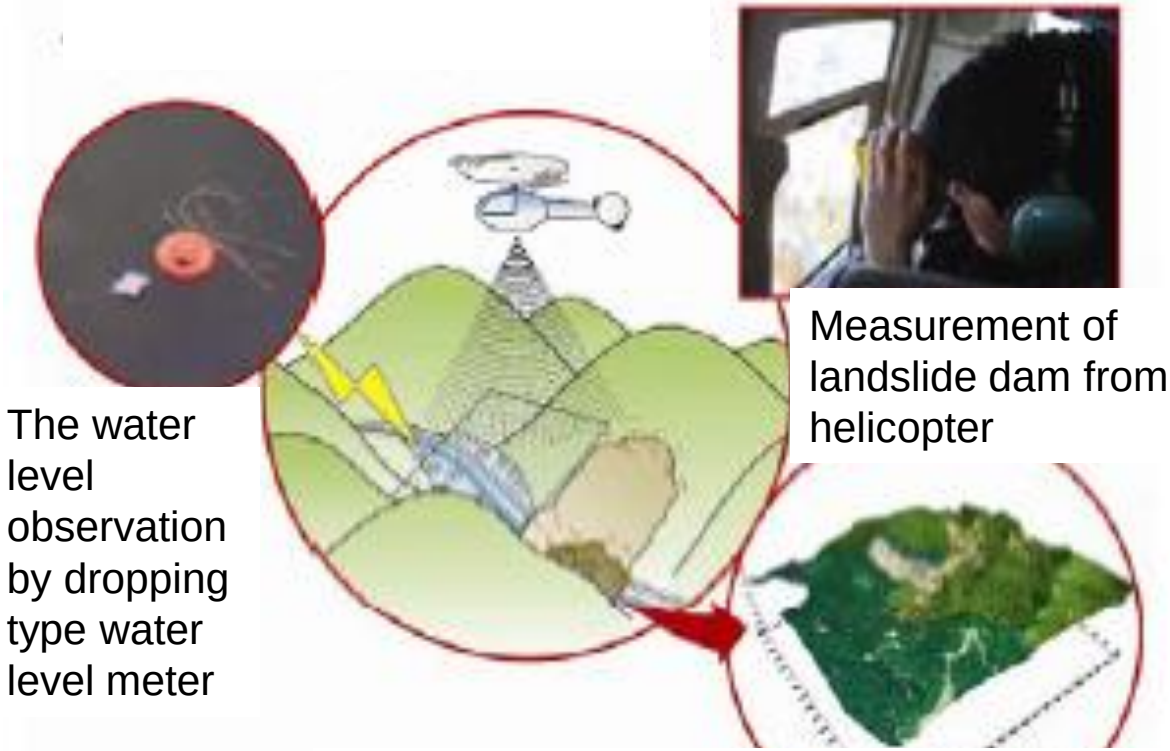
Assumption of the area/time likely to be affected by landslide

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.

Emergency surveys

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



Measurement of landslide dam from helicopter

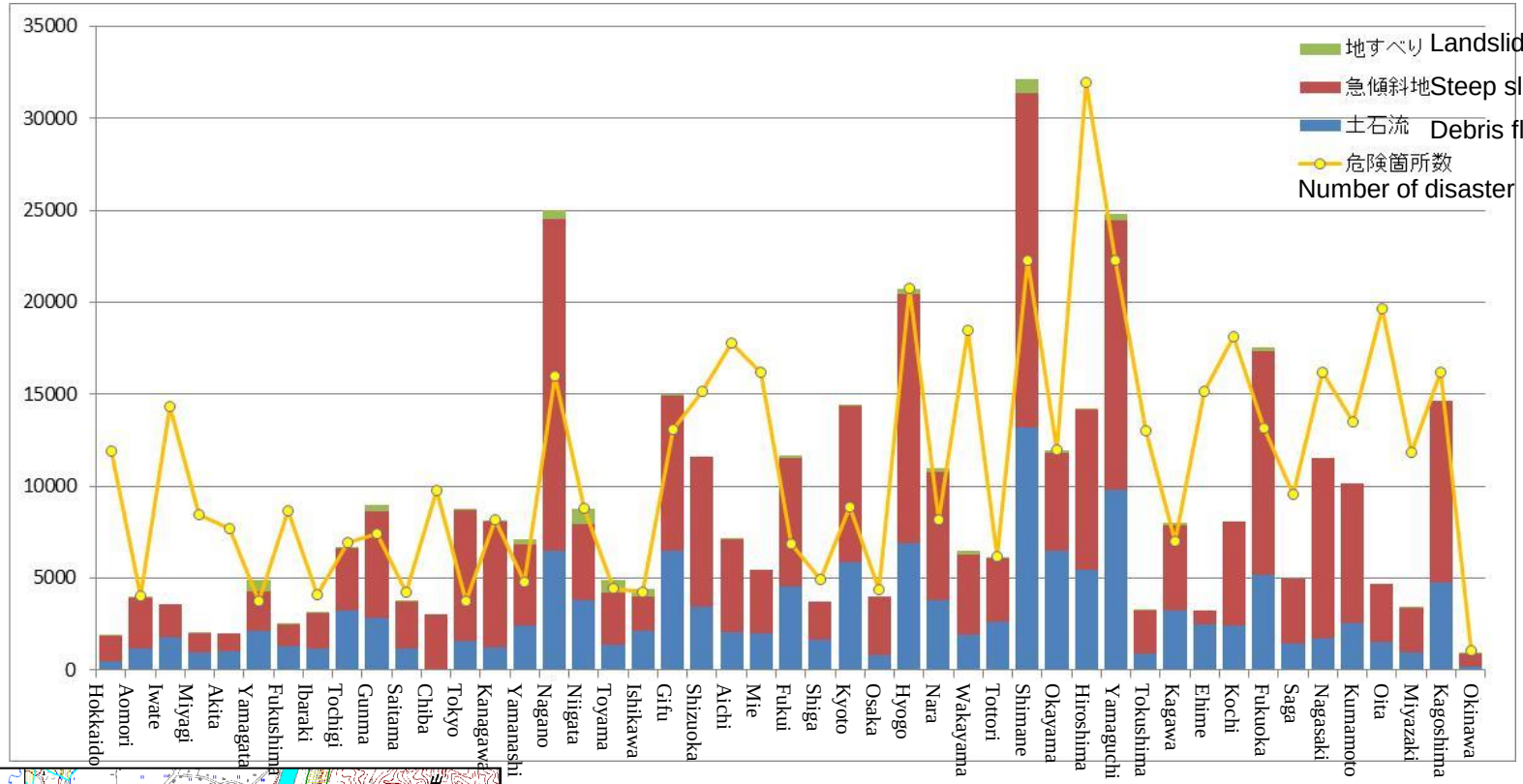
The water level observation by dropping type water level meter

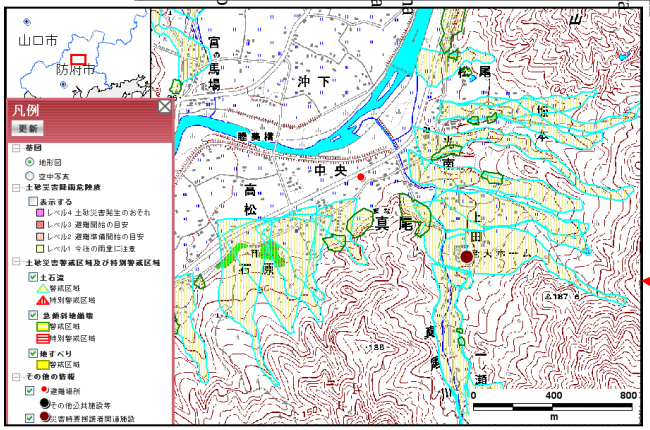
Measurement of peripheral landslide dam by laser measurement

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.
http://kikenmap.pref.yamaguchi.lg.jp/kikenmap/index.aspx

Weather Information and Disaster Prevention Response to Sediment Disasters

Heavy rainfall

Weather information from meteorological observatory

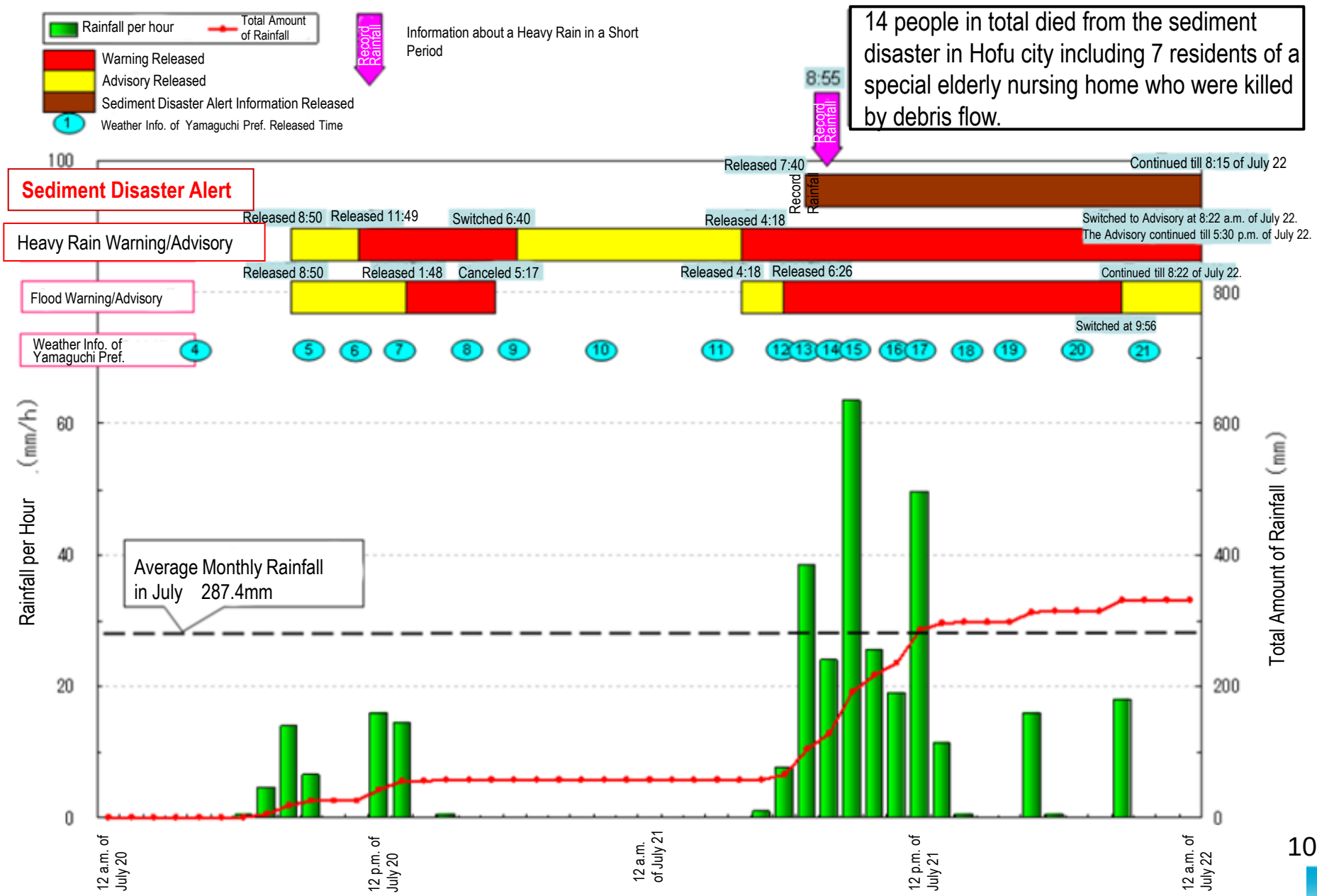
	Sediment disaster	Response by municipalities	Actions by people
About a day before Possibility of heavy rainfall increases	**Weather information on heavy rain** Issued prior to warning/advisory	Establishment of contact system for concerned officers Collection of weather information and rain conditions	Pay attention to weather information Obtain the latest weather information from TV, radio, JMA's website
From half a day to several hours before Starts raining Intensity increases	**Heavy rainfall advisory** If there is a chance of issuance of warning, an announcement to that effect is made **Weather information on heavy rain** Timely announcement of the rainfall conditions and prediction	Calling for attention (disaster management radio communications) Patrolling of dangerous areas	Check the exterior of the house, such as windows and shutters Confirmation of evacuation site Check the emergency kit 
From several hours before to 2 hours before	**Heavy rain warning (sediment disaster)** Presenting the period and amount of rainfall and matters requiring attention.	Preparation/opening of evacuation camps Issuance of information on evacuation preparations (evacuation of persons requiring assistance) where needed Establishment of emergency response system 	Prepare for evacuation Do not get close to dangerous site Notify the civil office when something unusual happens
The heavy rain intensifies further	**Weather information on heavy rain** Announcement of constantly changing rain conditions	Issuance of evacuation recommendation where needed Calling for evacuation (disaster management radio communications・PR cars, etc.)	
Concerns about extending damage	**Sediment Disaster Alert (Joint announcement of the prefecture)** Announcement in the case of further increase in the risk of sediment disaster.	Issuance of evacuation instructions where needed	Immediate evacuation

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)



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

Administrative Standing of Sediment Disaster Alert

[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.

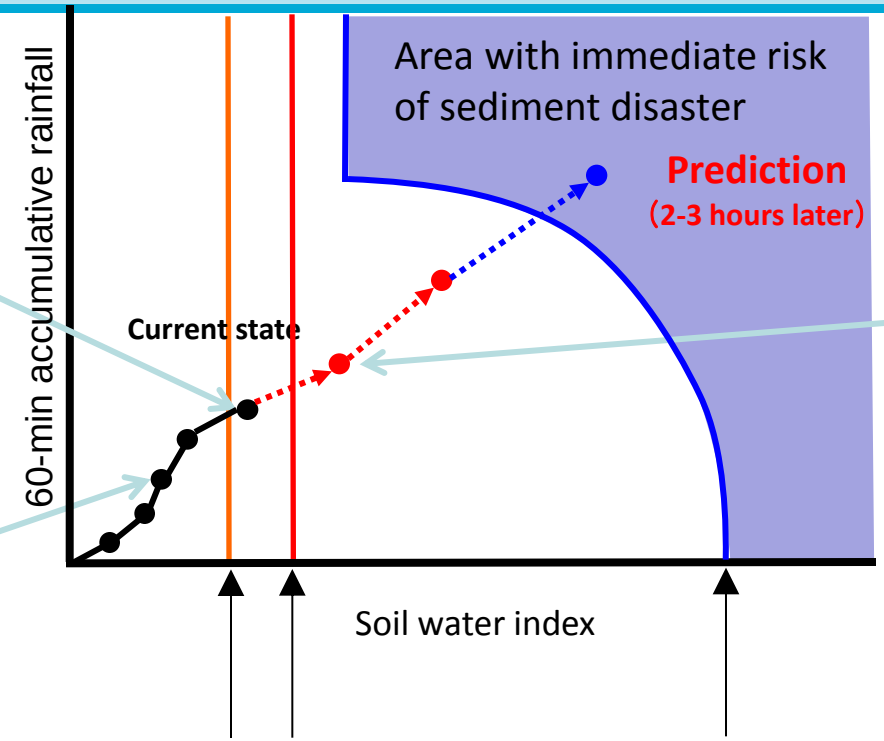
Evacuation Recommendation/Evacuation Instruction

Evacuation Recommendation/Evacuation Instruction

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



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

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

· evacuation advisory
· voluntary evacuation

Reference line of heavy rain advisory

Reference line of heavy rain warning

Reference line of announcement of warning information on sediment disaster

- **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.

- **Heavy rain warning (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.

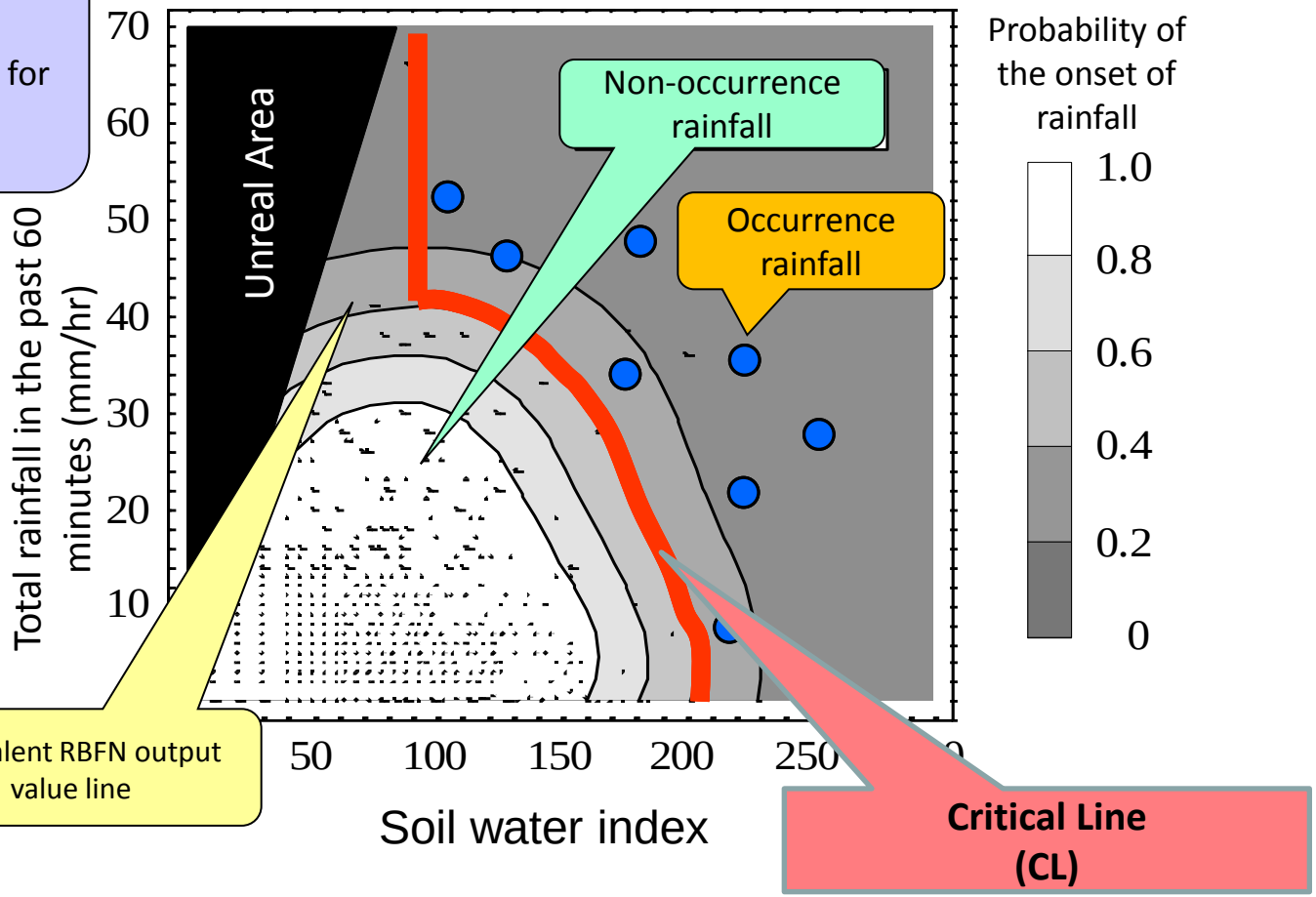
- **Warning information on sediment disaster:**
  Considering the time necessary for evacuation, the warning information on sediment disaster is issued **roughly more than two hours* before reaching the criteria of occurrence of sediment disaster**. (*The time frame is decided by each prefecture)

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.

※Targeted sediment disasters shall be determined upon consultation with prefectural and municipal governments.

Source: Document of the "Committee on Improvement of Meteorological Information for Disaster Prevention" (1st meeting)

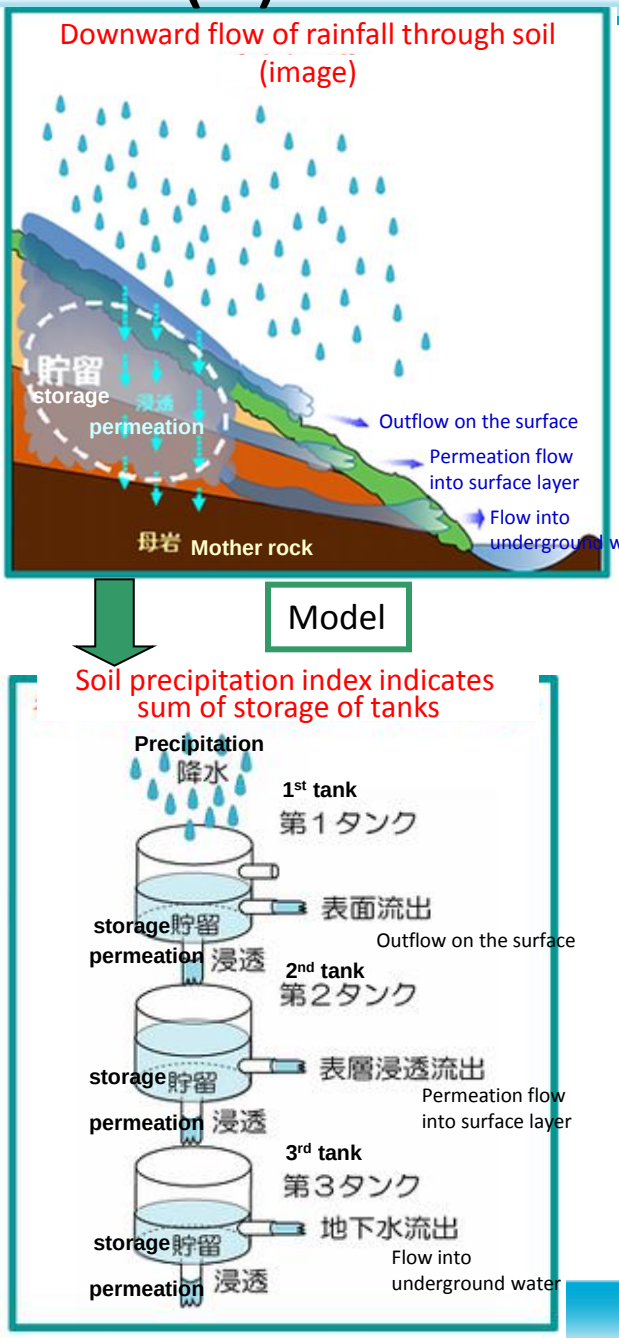
Source: "Method of Setting Precipitation Standards for Sediment Disaster Warning and Evacuation in Collaboration of the Sabo Department, River Bureau, MLIT and the Forecast Department of JMA" (June 2005, the Sabo Department, River Bureau, MLIT/ the Forecast Department of JMA/the National Institute for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

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

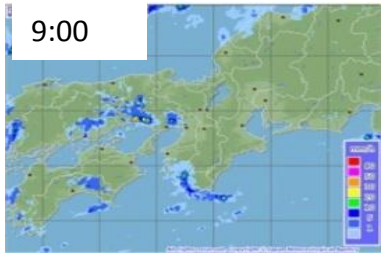
※ “Analyzed Precipitation” is obtained from the precipitation distribution analysis by combining radar rain gauge and ground rain gauge, such as AMeDAS . It allows to understand localized heavy rainfall, which cannot be monitored by rain gauges.



Monitoring of standards

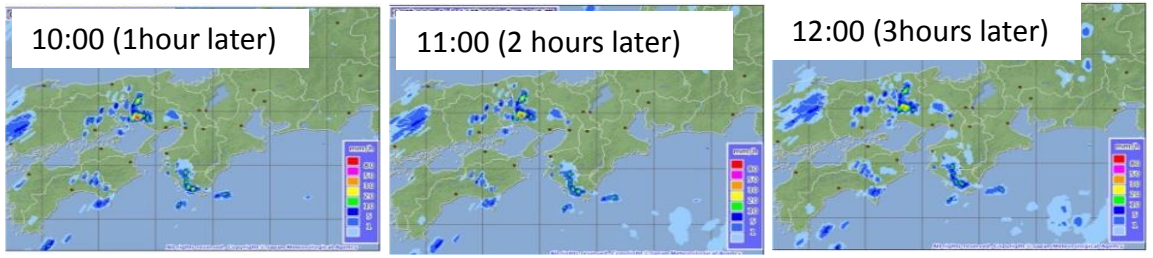
Short-term rainfall prediction system

Analyzed precipitation



+

Short-term rainfall precipitation



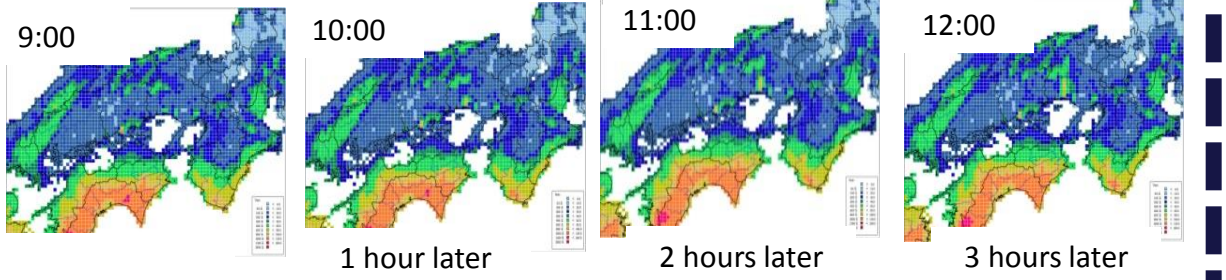
Total rainfall thus far (Analyzed Precipitation)

+

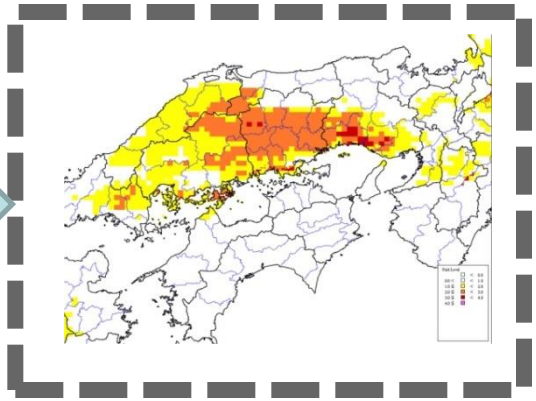
Predicted rainfall（Short-term rainfall prediction ）

Tank model

Soil precipitation index

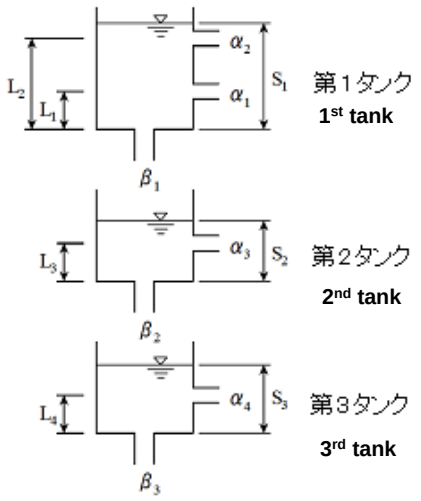


Warning determination grid



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

Parameters of soil water index



Parameters of tank model

	1st step	2nd step	3rd step
Height of outlet (mm)	$L_1=15$	$L_3=15$	$L_4=15$
	$L_2=60$		
Run-off coefficient (1/hr)	$\alpha_1=0.1$	$\alpha_3=0.05$	$\alpha_4=0.01$
	$\alpha_2=0.15$		
Permeability coefficient (1/hr)	$\beta_1=0.12$	$\beta_2=0.05$	$\beta_3=0.01$

(Ishihara & Kobatake(1979)による)

(Reference)

Formula for calculation of soil precipitation index

Formula for calculation of storage (S_i : i=1,2,3) of each tank

$S_1(t+\Delta t)=(1-\beta_1\Delta t)\cdot S_1(t)-q_1(t)\cdot\Delta t+R$

$S_2(t+\Delta t)=(1-\beta_2\Delta t)\cdot S_2(t)-q_2(t)\cdot\Delta t+\beta_1\cdot S_1(t)\cdot\Delta t$

$S_3(t+\Delta t)=(1-\beta_3\Delta t)\cdot S_3(t)-q_3(t)\cdot\Delta t+\beta_2\cdot S_2(t)\cdot\Delta t$

S_1, S_2, S_3: Storage height of each tank

β_1 , β_2 , β_3: Permeability coefficient of permeable outlet of each tank

q_1 , q_2 , q_3: Outflow amount from side outlet of each tank

Outflow amount from side outlet (qi : i=1,2,3) of each tank

$q_1(t)=\alpha_1\{S_1(t)-L_1\}+\alpha_2\{S_1(t)-L_2\}$

$q_2(t)=\alpha_3\{S_2(t)-L_3\}$

$q_3(t)=\alpha_4\{S_3(t)-L_4\}$

α_1 , α_2 , α_3 , α_4: Run-off coefficient of each outlet

L_1 , L_2 , L_3 , L_4: Height of each outlet

Table 5. The synthetic parameters classified by geological features.

Geological feature of basin	L_1 (mm)	L_2 (mm)	L_3 (mm)	L_4 (mm)	F_1 (hr^{-1})	F_2 (hr^{-1})	F_3 (hr^{-1})	R_1 (hr^{-1})	R_2 (hr^{-1})	R_3 (hr^{-1})	R_4 (hr^{-1})	TL (hr)	ω (m/sec)
Volcanic rock	30–40	60–75	15	15	0.12	0.08	0.01	0.10	0.15	0.05	0.01	1 0*	4.0
Granite	15	60	15	15	0.12	0.05	0.01	0.10	0.15	0.05	0.01	1	4.0
Palaeozoic	30	75	5	15	0.12	0.04	0.01	0.10	0.15	0.05	0.01	1	4.0
Tertiary & Quaternary	15	40	5	15	0.12	0.04	0.01	0.10	0.15	0.05	0.01	2	4.0

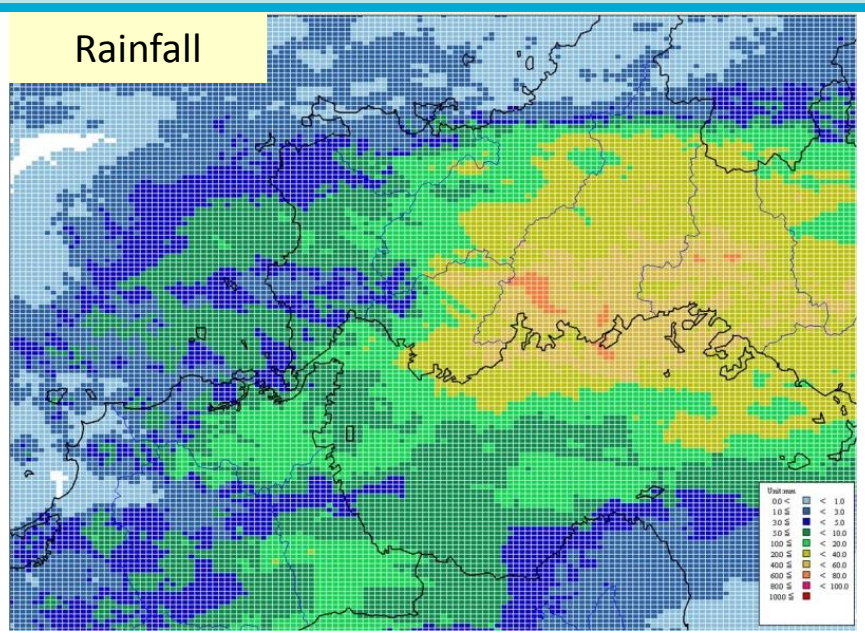
* Welded tuff

Ishihara, Y. and S. Kobatake (1979): Runoff Model for Flood Forecasting, Bull. D.P.R.I., Kyoto Univ., 29, 27-43.

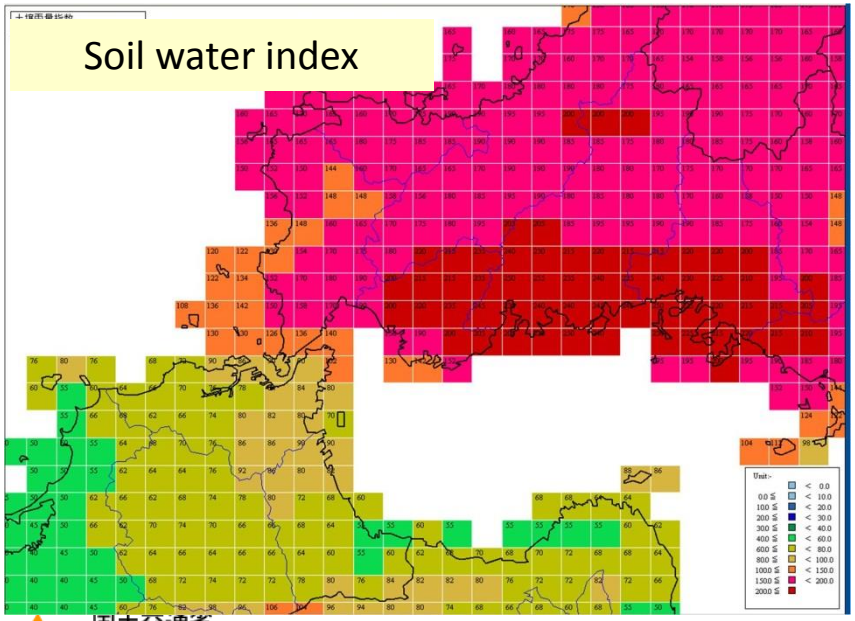
No significant difference is found in the order of records, regardless of the parameters used (figure omitted); however, JMA obtains the index using the parameter of granite, which is the most susceptible to cracks.

Why Soil Water Index?

Rainfall



Soil water index



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

source: website of Sabo department , MLIT
http://www.mlit.go.jp/river/sabo/index.html

※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.)

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.

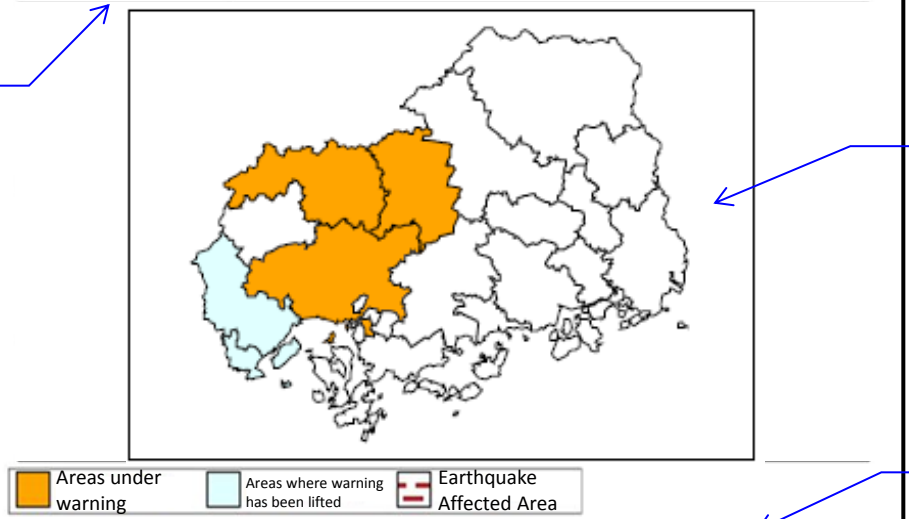
Sediment Disaster Alert of Hiroshima No. 4

5:30, August 20, 2014
Joint announcement of Hiroshima Government and
Hiroshima Local Meteorological Observatory

[Areas under warning]
Hiroshima-shi, Akitakada-shi, Kitahiroshima-machi

[Areas where warning has been lifted]
otake-shi, Hatsukaichi-shi

[Warning statement]
(Outline) Due to continuous heavy rainfall, risk of sediment disaster is increasing in the areas under warning.
(Measures to be taken) Those who live near the areas prone to sediment disasters, such as near the cliff, are encouraged to get ready for early evacuation and are asked to pay close attention to information provided by the municipal government, such as evacuation recommendation.



Contact:
03-(Disaster Prevention Section, River Department, Bureau of Construction, Tokyo Metropolitan Government)
03 (Forecast Section, Forecast Department, Japan Meteorological Agency)

■Title

■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

Makimg sediment disaster alert

Joint statement

Prefectures

Broadcast station

Data broadcast

Multimedia broadcast

TV, radio, etc.

Mobile phones PCs

Disaster prevention agencies

Websites

Residents

Community wireless system

municipalities

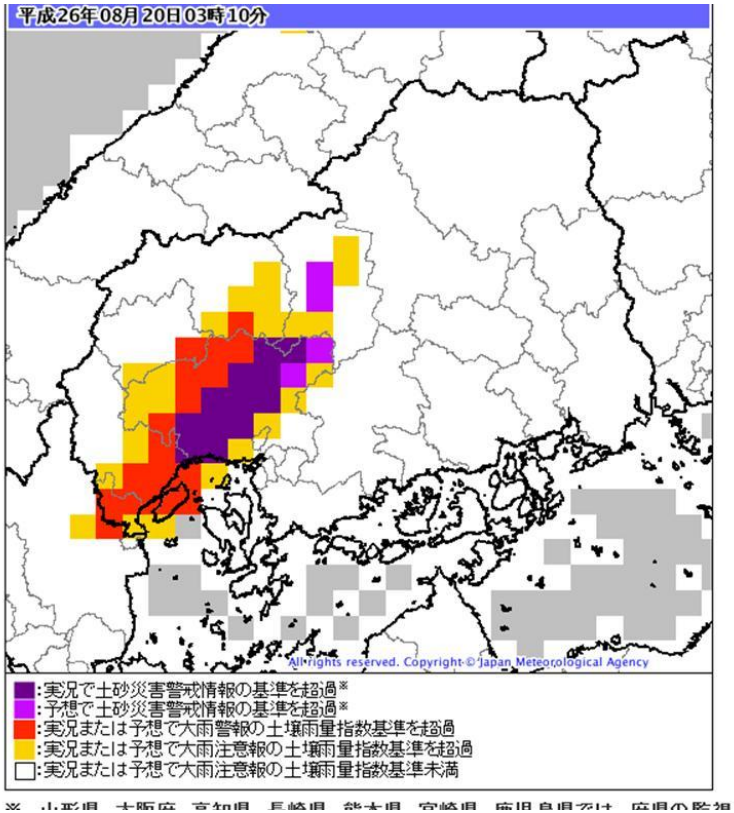
Community FM station Cable TV

Transmission of Warning Information on Sediment Disaster (Website of Japan Meteorological Agency)

"Click Here"

Grid information for the judgment on sediment disaster warning

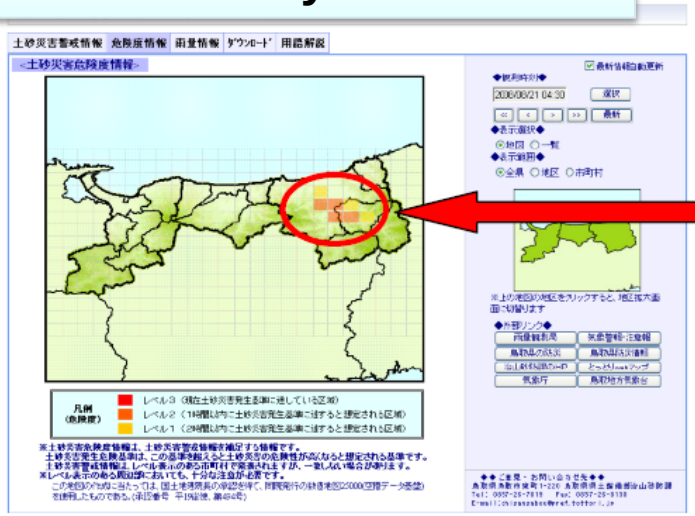
The status of the excess (prediction) of the issuance level for heavy rain advisory, heavy rain warning (sediment disaster) and warning information on sediment disaster is shown by the grid of 5km squares.



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

Supplementary Information by Prefectural Governments

Mail service by Tottori Pref.



県ホームページ提供情報（地図情報）

鳥取県土砂災害危険度情報
7月29日 10時00分
鳥取県発表
（鳥取市北部 地区別危険度一覧）
レベル2：倉田※、津ノ井※、米里※、大和※、東郷※、神戸※ 周辺
レベル1：明治 周辺
（鳥取市南部 地区別危険度一覧）
レベル2：河原町河原※、河原町国英※、河原町散岐※、河原町八上※、用瀬町大村※ 周辺
（八頭町 地区別危険度一覧）
レベル2：船岡※、隼※、大伊※、八東※、安倍※、国中※ 周辺
レベル1：中私都、上私都、丹比、大御門 周辺
「※」は前回発表から危険度が上昇した地区。

この情報は「土砂災害警戒情報」の補足情報です。
（危険度説明）
レベル3：土砂災害発生基準に達している地区
レベル2：1時間以内に土砂災害発生基準に達すると想定される地区
レベル1：2時間以内に土砂災害発生基準に達すると想定される地区
詳細情報は、下記URLを参照してください。
防災情報詳細ページ
問合せ先
0857-26-7819 （鳥取県 山砂防課）

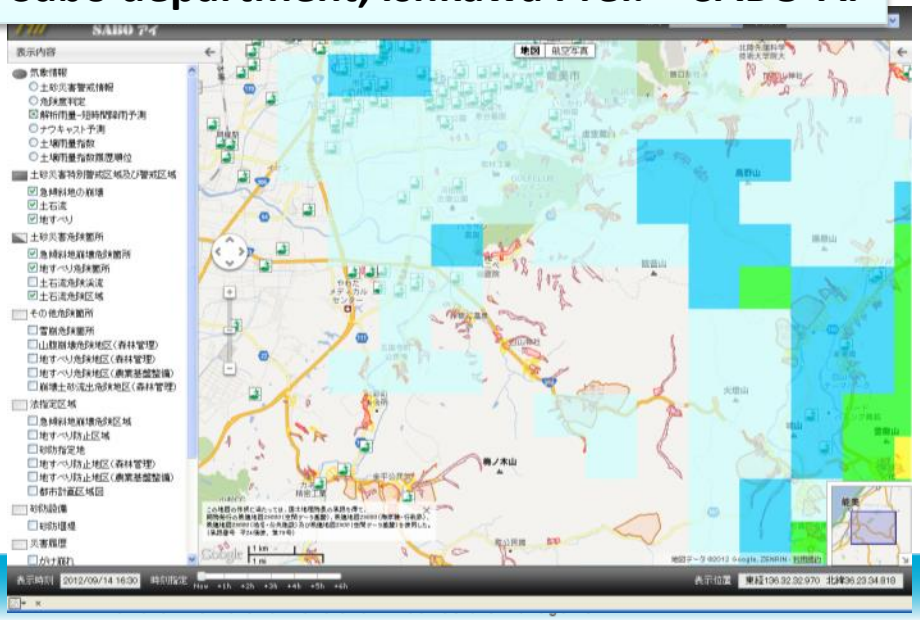
あんしんトリピーメール等提供情報（文字情報）

PUSH type

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.

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

Sabo department, Ishkawa Pref.　SABO-Ai



PULL type

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.

Necessity of hydrological equipment for community-based early warning

As the climate change continues, the sediment-related disasters will increase more in the future.

Characteristic 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

- sound of rain
- water volume of mountain stream
- buzzing in forest

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

Need some objectivity.

- bucket
- basin
- pile of wood

Development of equipment for the community and individuals

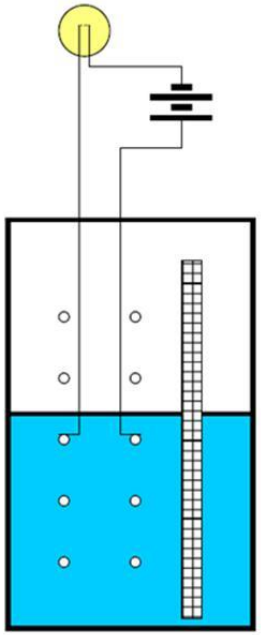
Development goals

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 loccaly
5. Performed safely from indoors

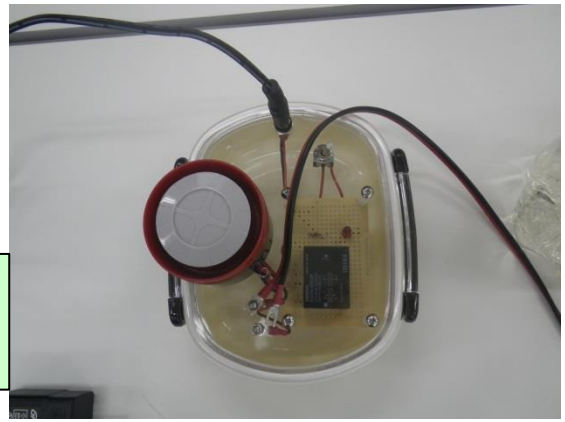
Development of Simple Rainfall Gage for Monitoring & Warning System

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' a 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.

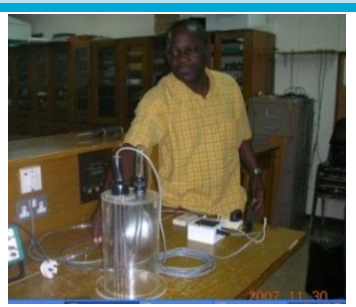


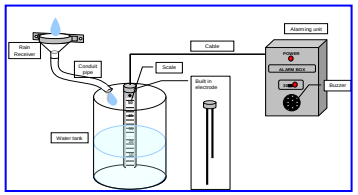
Simple monitor and buzzer

Reservoir bottle can also be set outdoors.

Development and improvement of water gauge①

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

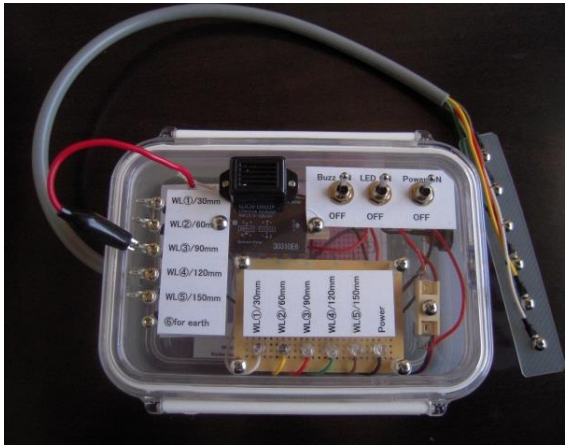




Ceramics cylinder → Polyethylene bottle for easy availability
Conduit pipe →Cable for the longer connection between rain receiver and monitor

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

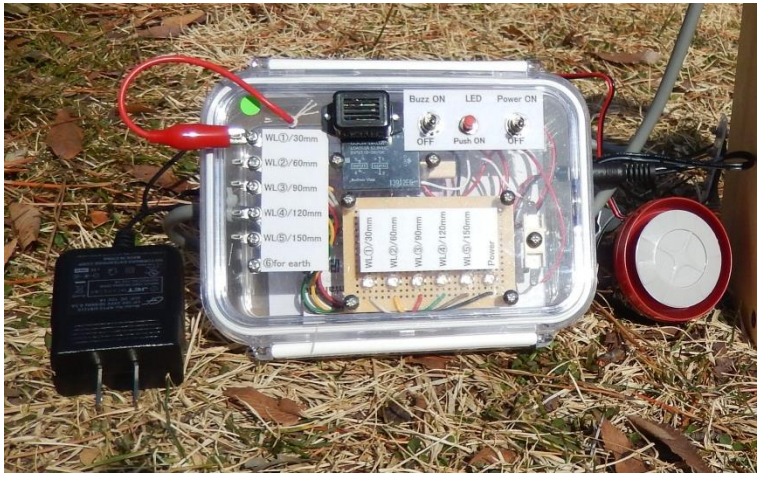
Development and improvement of water gauge②



Small buzzer

↓

Loud buzzer

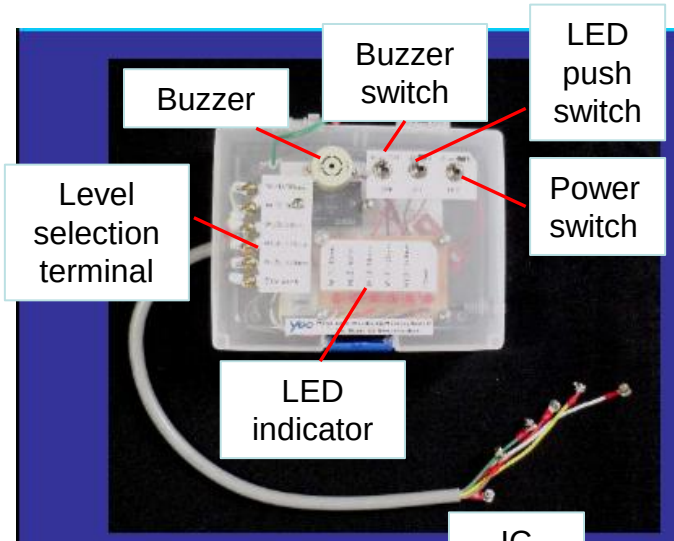


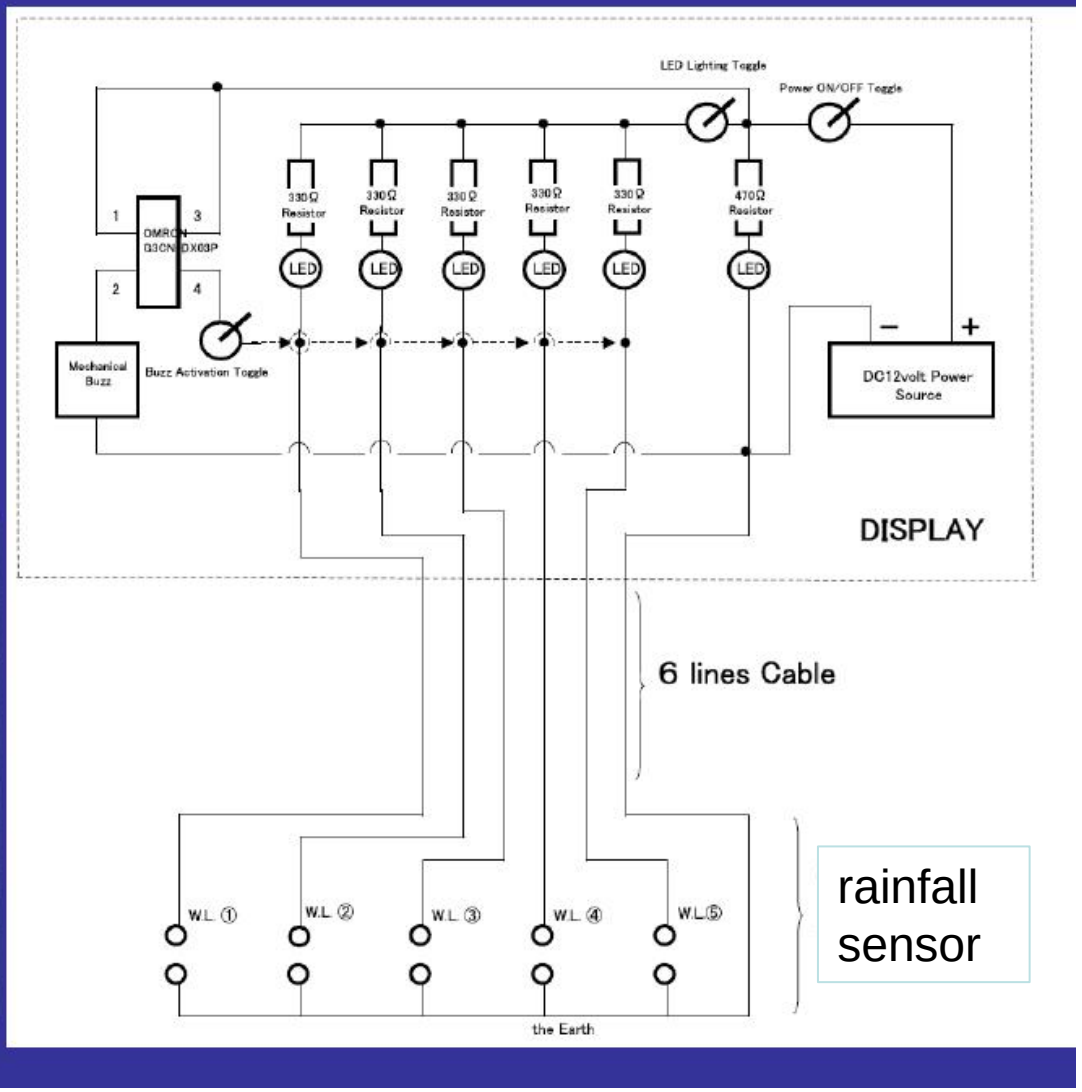
One point sensor only for “evacuation” can be an option.

Advantages:

- Simple operation
- Simple assembling
- Cheap cost

MONITOR


Buzzer
Buzzer switch
LED push switch
Level selection terminal
Power switch
LED indicator
IC board


LED Lighting Toggle
Power ON/OFF Toggle
330Ω Resistor
330Ω Resistor
330Ω Resistor
330Ω Resistor
330Ω Resistor
470Ω Resistor
LED
OMRON G3CN-DX03P
Mechanical Buzz
Buzz Activation Toggle
DC12volt Power Source
DISPLAY
6 lines Cable
W.L ①
W.L ②
W.L ③
W.L ④
W.L⑤
the Earth
rainfall sensor

Manufacture of monitoring alarm section

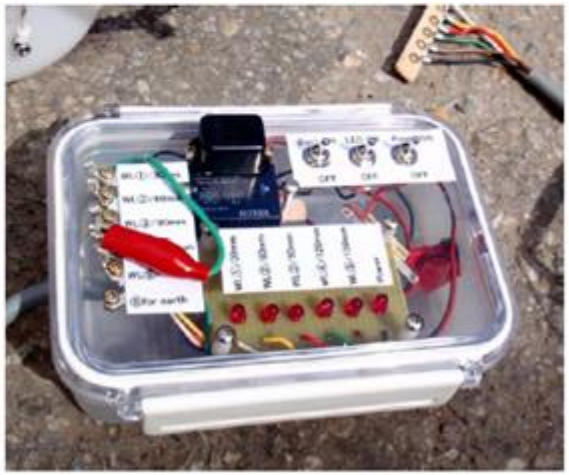
Sets

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

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

Soldered

Cautiously by looking at the sample



Completed monitor alarm section

Manufacture of Rain Gauge

Parts

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!