The Battle against Landslide Disaster in the Recent History of Japan

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Abstract

In these years, there are many landslide disasters occurred in city ares and mountainous area of Japan. Some of them were triggered by heavy rainfall, and some were induced by earthquake or snow-melting.

In this presentation, we focus on landslide disaster due to heavy rainfall.

Then the countermeasure facilities and the warning systems are described as a mitigation plan.

Finally, we show the some suggestions on the question of "What shall we do for landslide disaster mitigation in our life?"

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The battle against landslide disaster in the recent history of Japan

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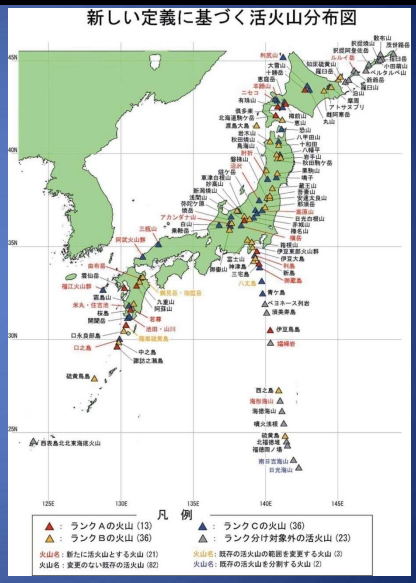
Contents

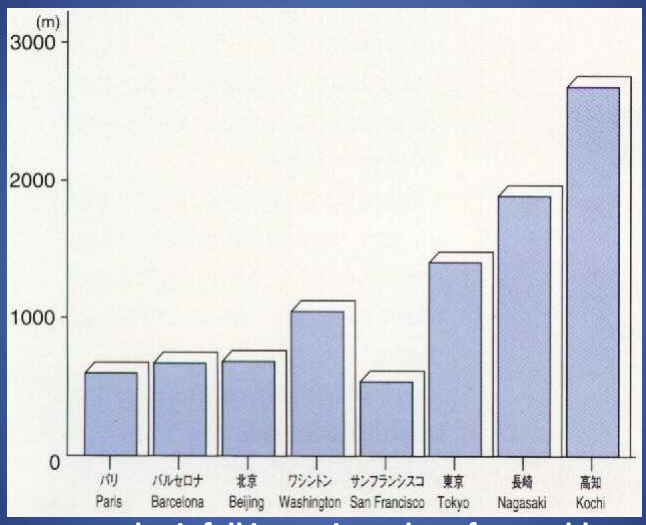
Natural conditions in Japan ~ Steep mountains and Volcanoes



Mountains and hilly areas make up 70% of the total land area of Japan

Location of Japan

- Area :370,000km^2
- Population : 1.2 Billion
- Population Density : 326/km^2

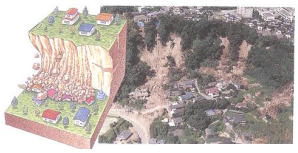
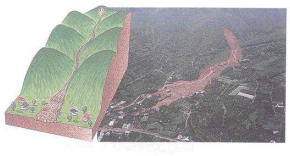


Mean annual rainfall intensity values for world stations

City area and mountainous area

(Kobe city in Japan)

3 types of sediment-related disasters

Slope failure		A phenomenon where soil is weakened by the rain, earthquakes, etc. causing a slope to crumble suddenly
Debris flow		A phenomenon where long or localized torrential rainfall causes mountainside soil, sand, and gravel (debris) from hillsides or stream beds to fall into lower reaches, where they are suddenly washed away downstream at speeds from 20 to 40 km/h
Landslide		A phenomenon where dirt clods on a slope are slowly moved downward by groundwater, etc., along a landslide surface at speeds from 0.01 to 10 mm/day.

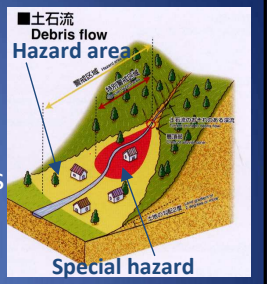
'Sediment-related Disaster Prevention Law'

- Was in effect on *April 1, 2001,*
- In order to protect the public from sediment-related disasters caused by slope failure, debris flow and landslide with *non-structural preventive measures.*

– Non-structural preventive measures mean development of a warning and evacuation system, designation of restrictions on land use.

Debris flow case for instance…

Restrictions on land use
- Debris flow -



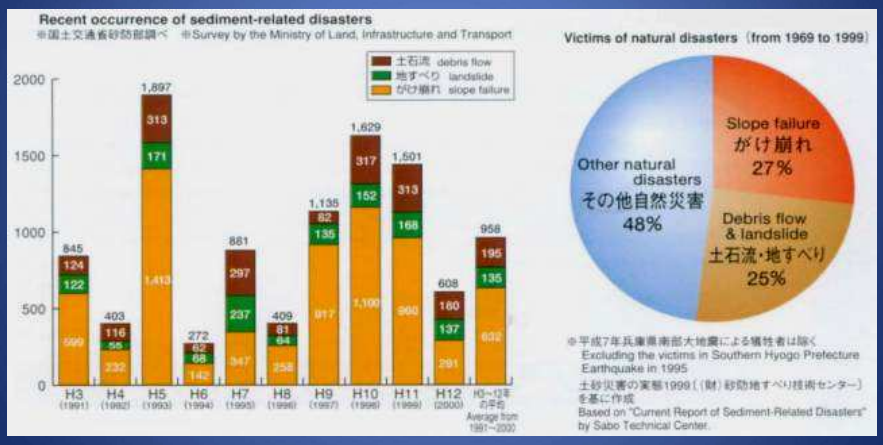
- ‘Hazard areas‘
  - Areas prone to sediment-related disasters
    / Downstream from valley mouth
    / Ground slope is steeper than two degrees.
- ‘Special hazard areas‘
  - Areas prone to sediment-related serious disasters
    /Areas where the hydrodynamic force of a debris flow exceeds the structural strength of a building is designated as the special disaster hazard area.

We need to improve the method to designate the hazard areas and special hazard areas, because this law restricts private right.

An important traffic network and its vulnerable areas

Damaged in August 1993

Recent occurrence of sediment-related and Victims of natural disasters



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1. Introduction
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4. Early-Warning and Evacuation
5. The problems for the future of warning
6. Conclusion remarks

① Debris flow

2. Classification of debris flows

2.1 Classification according to flowing characteristics

(1) Gravel-filled debris flow

A. The tip of a debris flow moves quite straight with a large concentration of gravel and boulders that are two to five meters in diameter, or larger in some cases.

B. Behind the tip of a debris flow follows a muddy water flow (a subsequent flow) that contains less gravel than the tip of a debris flow.

C. The velocity of the flow is about three to ten meters.

D. Boulders are concentrated at the tip of a debris flow, and it takes about several tens of seconds for the tip of a debris flow with concentrated boulders to pass. Subsequent flows are muddy, and they gradually slow down.

E. Debris flows rise and flow in an outer direction around the corner of a watercourse.

Flowing conditions of gravel-filled debris flows

Kamikamihorisawa, Yakedake Volcano on August 3, 1976
(width of waterway of groundsill: 16 m; tip speed: 3.8 m/sec)

Photo 1. Start of overflowing at the head of a debris flow

Flowing conditions of gravel-filled debris flows

Photo 2. Two seconds after the occurrence

Flowing conditions of gravel-filled debris flows

Photo 3. An additional three seconds later

Flowing conditions of gravel-filled debris flows

Photo 4. An additional two seconds later

Longitudinal section of debris flows

(Kamikamihorisawa, Yakedake Volcano in July 21, 1985)

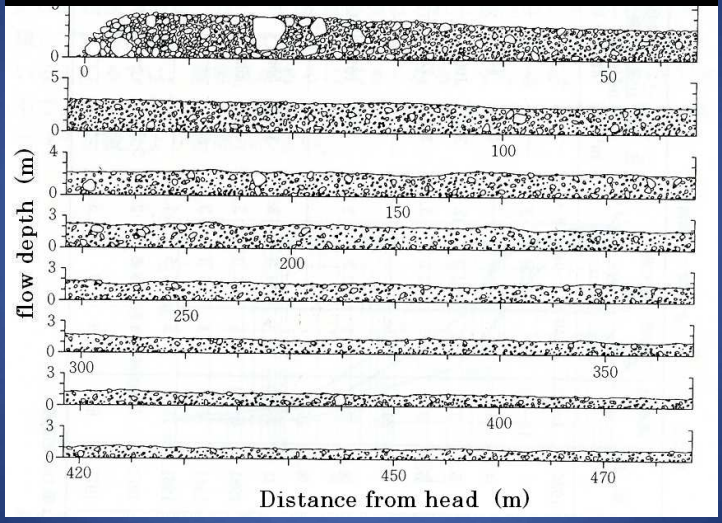


Figure 2. Longitudinal section of debris flows, and distribution of gravels (sketch)

Northern part of Nagano Prefecture in 1995

Before the occurrence of a debris flow around 6:30 pm on July 11, 1995

After the occurrence of a debris flow on the morning on July 12, 1995

Photo 19. Comparison of conditions before and after the occurrence of a debris flow

Minamata City, Kumamoto Prefecture, in 2003

Before the occurrence of a disaster in 1974

Immediately after the occurrence of a disaster in July 2003

Photo 22.

Photos taken before and after the occurrence of a disaster

Niigata Chuetsu Earthquake in 2004

River before the earthquake on September 3, 2002

River after the earthquake on October 26, 2004

Photo 32. Conditions of a blocked river course

Occurrence of sediment-related disasters 1

Hime river in Itoigawa city

Before the disaster in 1987

After the disaster in 1995

Occurrence of sediment-related disasters 2

Debris flow disaster occurred under the influence of the seasonal rain front. 2003 Minamata

Hokawachi

Shinyashiki

Occurrence of sediment-related disasters 3

Sediment-related disaster caused by a localized torrential downpour (Social welfare facility)

August 1998 Nishigo Fukushima

disaster of debris flow accompanied by trees

2001 Tosashimizu kouchi

Occurrence of sediment-related disasters 4

Volcanic disaster in the area of Mt. Unzenfugendake. June 1991

Occurrence of sediment-related disasters

Miyake island

Boutazawa

Volcanic disaster and mudflow in Miyake Island. 2000

② Slope failure

Occurrence of sediment-related disasters 5

Slope failure caused by earthquake.

July 2003 Miyagi

Hillside landslide caused by earthquake

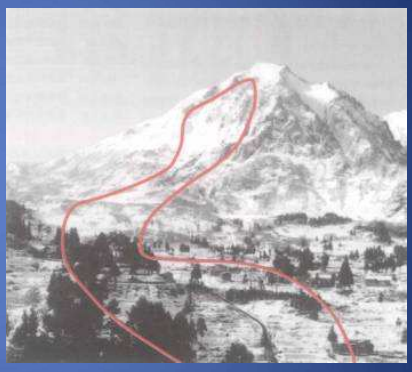
January 1995 Nishinomiya

③ Landslide

Occurrence of sediment-related disasters 6

Landslide caused by snowmelt

May 1997 Kazuno



Avalanche caused by heavy snowfall

January 1986 Nou
Niigata

④ Others (Volcanic eruption)

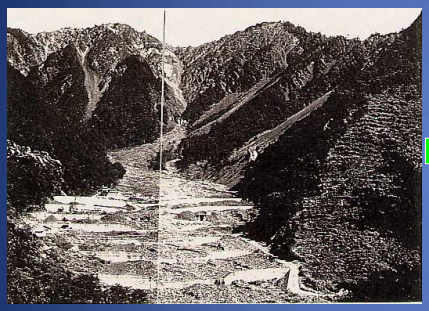
Sabo works on Mt. Tanakami

(Barren mountain 1970)

(Just after hillside works)

(At present, restoring green trees)

Sabo works on Oya Collapse



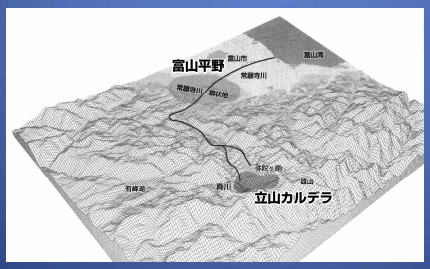
(Barren mountain about 40 years ago)

(At present, restoring green trees)

Sabo Works in Joganji

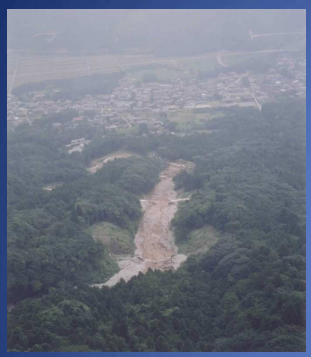
Tateyama caldera

Shiraiwa sabo dam



Joganji river is very rapid. Sabo works in Joganji protects Toyama plain from floods caused by riverbed rising-up.

The effect of sabo works



A debris flow was caused along the Nisinogaito River in Mie prefecture in July 2002. Sabo dams captured debris flow

Permeable-type dam captured flowing drift-wood and debris, thereby preventing damages in down-stream areas

Landslide and Prevention works

July 1985　　June 1990

Landslide prevention works have made this area safe on Mt. Jizuki

26killed, 4 injured, houses completely destroyed 52, amount of soil slid 3.6 million m^3

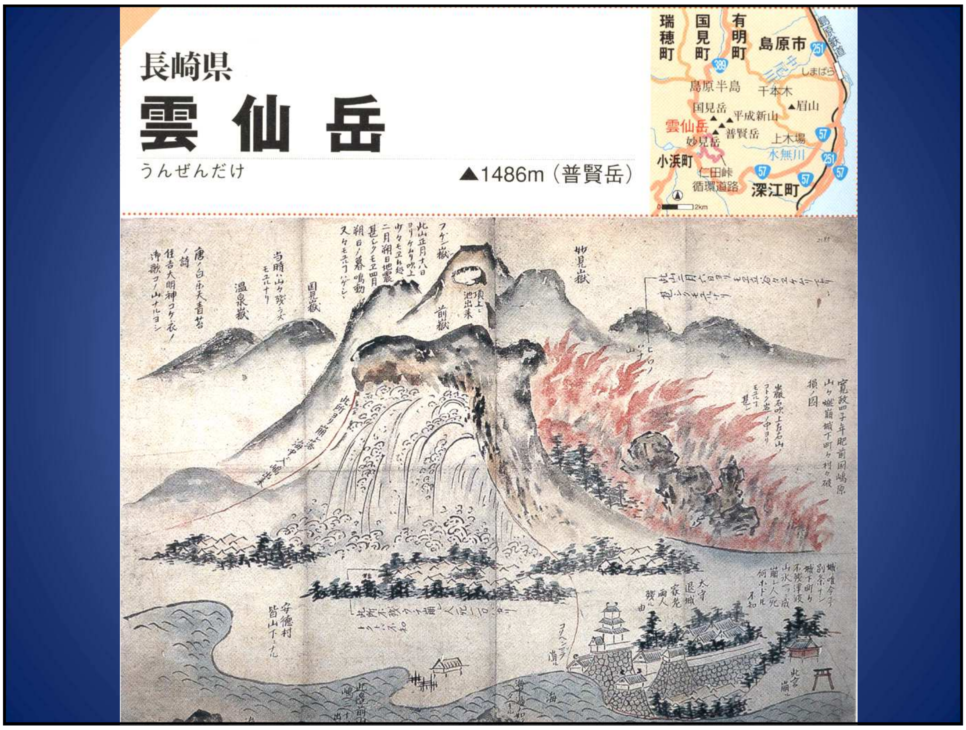
Slope failure prevention works for safe living

Immediately after a slope failure disaster

Immediately after the completion of the works

Several years after the completion of the works

Kagoshima city


長崎県
雲仙岳
うんぜんだけ
▲1486m（普賢岳）
瑞穂町
国見町
有明町
島原市
島原半島
千本木
国見岳
平成新山
眉山
雲仙岳
普賢岳
妙見岳
上木場
水無川
小浜町
仁田峠
循環道路
深江町


H3 9/18


H5 9/6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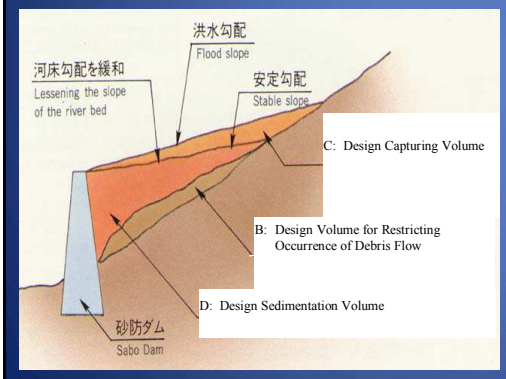
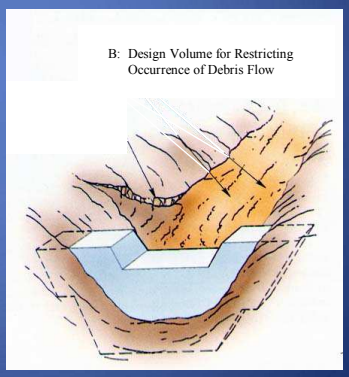
Debris Flow Countermeasure Facilities Arrangement Plan

$$Q\text{-}E\text{-}(C+D+B)=0$$





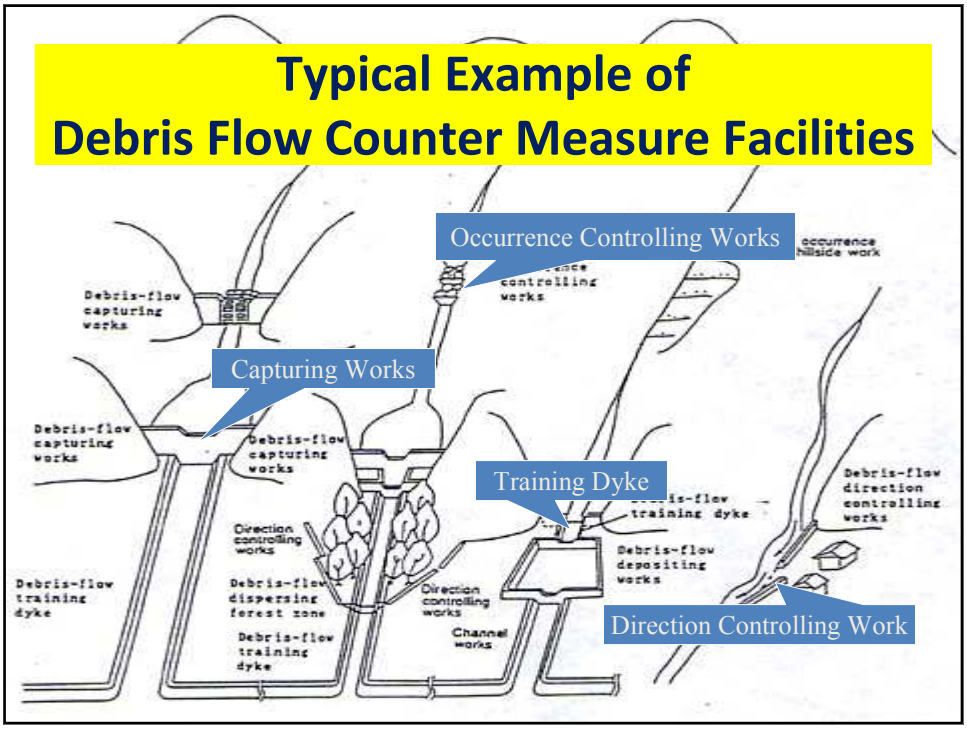
Basis of Debris Flow Countermeasure Facilities Plan

- to Decrease the Sediment Discharge of Debris Flow
- to Safely Discharge the Subsequent Flows
- to Consider
  - the Facilities Order which Brings about the Best Effect

Kinds of Debris Flow Countermeasure Facilities

- Debris Flow Capturing Works
- Debris Flow Depositing Works
- Debris Flow Training Works
- Debris Flow Dispersing Works
- Debris Flow Direction Controlling Works
- Works for Restricting the Occurrence of Debris Flow

Typical Example of Debris Flow Counter Measure Facilities



Debris Flow Capturing Works Typical Structure: Dam

- to Reduce the Scale
- to Lengthen the Travel Time
- to Prevent the Movement of Fluvial Deposits
- to Capture the Boulders and Woody Debris
- to Turn the Debris Flow into Sediment Flow
- to Reduce the Peak Discharge

Sabo Dam

- Impermeable Dam
  - – Concrete Dam
  - – Steel-Framed Dam
- Permeable Dam
  - – Steel-Pipe Dam
  - – Slit Dam


Impermeable Dam (1)
Concrete Dam

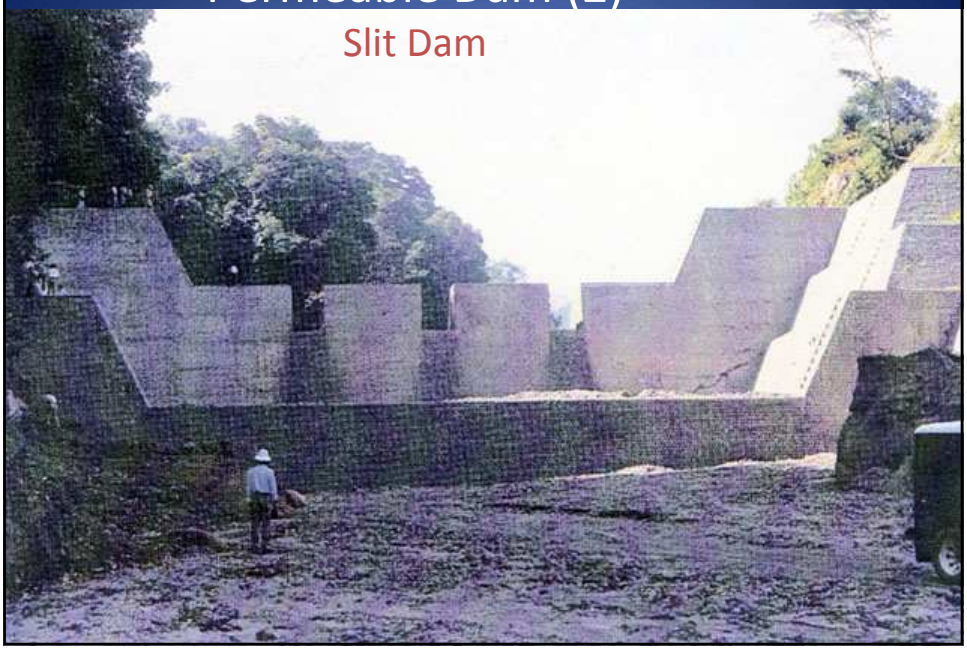

Impermeable Dam (2)
Steel-framed Dam

Permeable Dam (1)

Steel-pipe Dam

Permeable Dam (2)

Slit Dam



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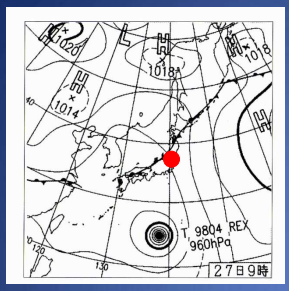
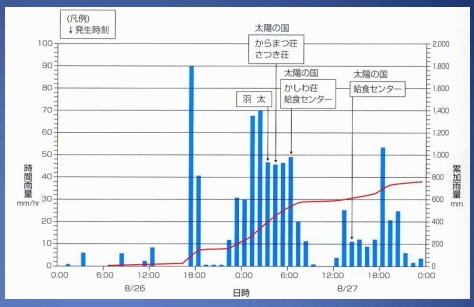
Sediment-Related Disaster Forecasting and Warning System

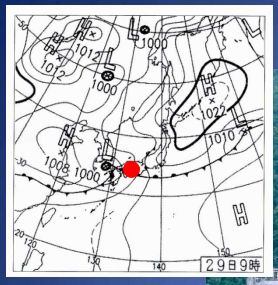
Evacuation to the place of safety before the disaster occurs by adequate information transmission is important to defend the life from the sediment-related disaster.

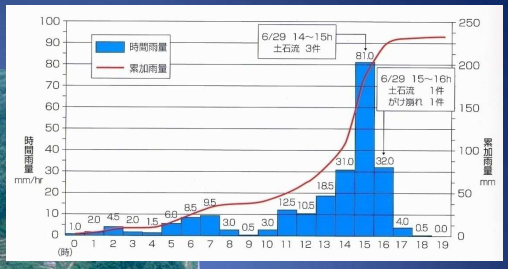
The monitoring and the observation equipment such as rain gauges and the debris-flow detection sensors are arranged, and the resident's warning and evacuation activity are supported.





Weather at sediment-related disaster（1998/8 Hukushima Pref.）





Weather at sediment-related disaster（1999/6 Hiroshima Pref.）

Target of Early-Warning and Evacuation System

Resident

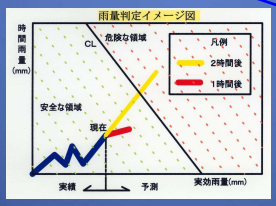
Organization related to disaster prevention

Weather and Rainfall

Rain gauge

Meteorological radar

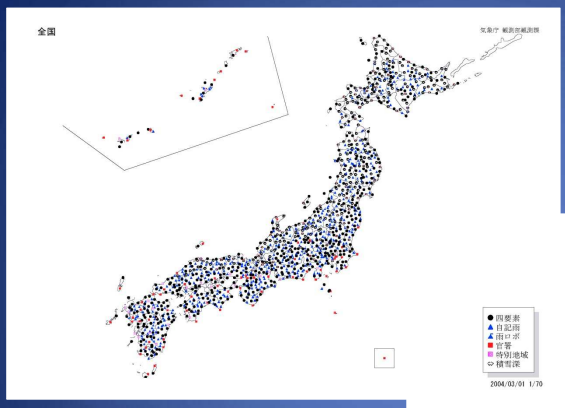
Observation of high accuracy



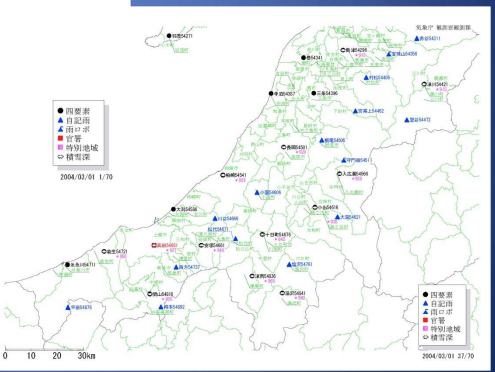
Risk judgment of high accuracy

Information transmission with resident

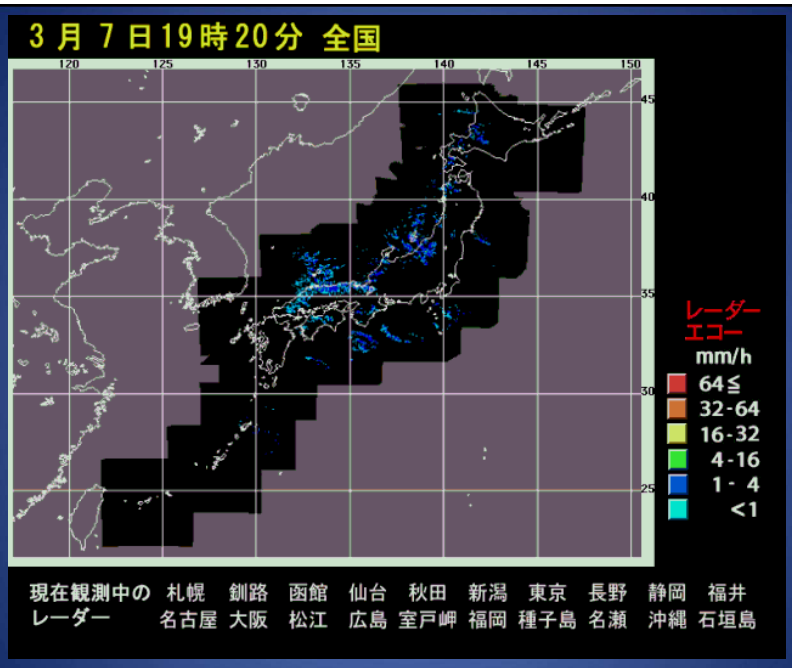
Large area weather（The Meteorological agency）



雨量観測：1,300箇所（約17km間隔）
4要素（風向風速・気温・日照時間・雨量）：850箇所
積雪観測：280箇所



Observation net of AMeDAS



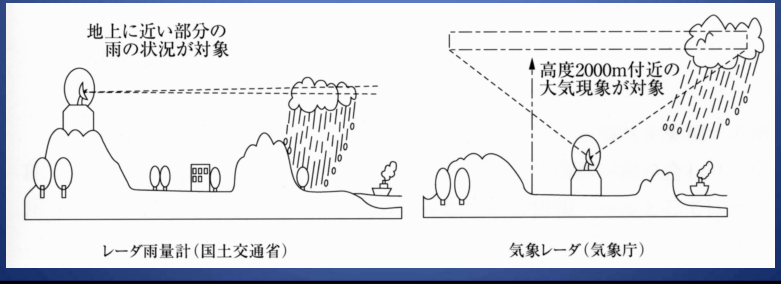
Rainfall distribution with Meteorological radar（5km × 5km)

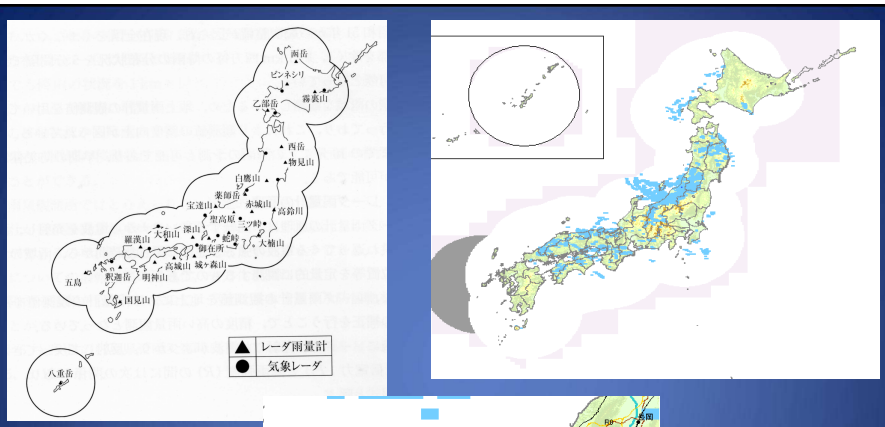
Large Area Meteorological Observation

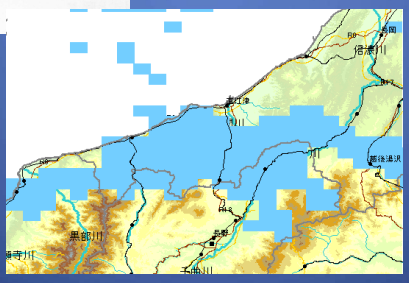
The Weather Forecast and General Condition of Rainfall

Fault to sediment-related disaster prevention

1）The difference of the rainfall on the mountains ground where the sediment-related disaster occurs is large.
2）It is necessary to understand a part near surface of the ground, because the meteorological radar target a high space in the coast part.



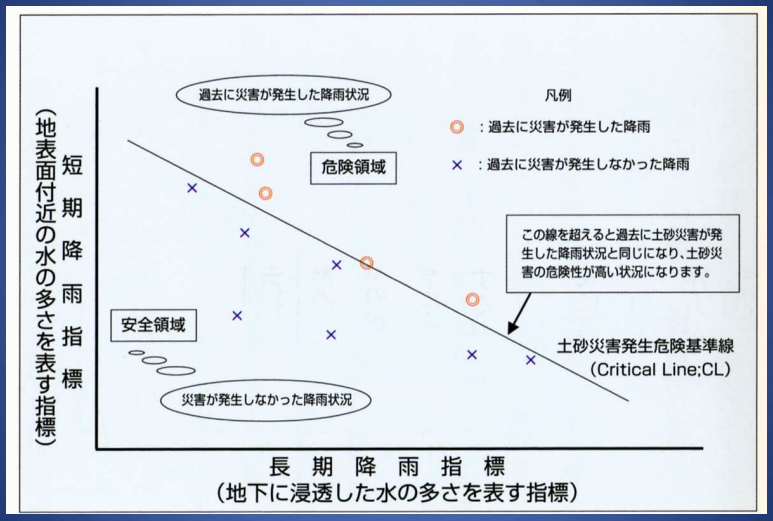




Observation accuracy
：1km × 1km

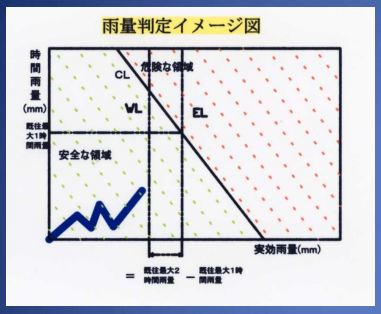
Arrangement at radar rain gauge and situation of rainfall

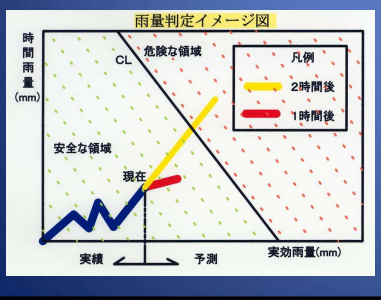
1）Critical rainfall for warning and evacuation

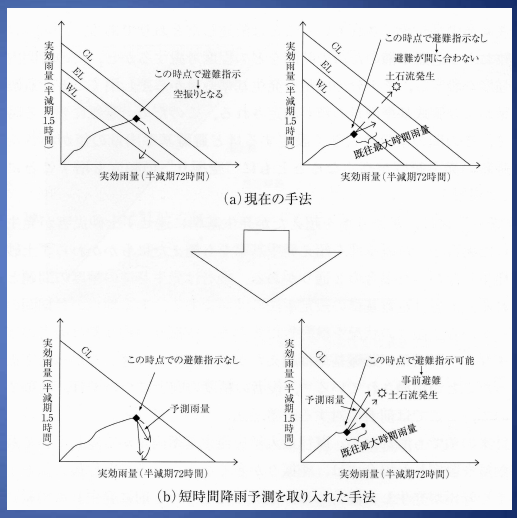


Set concept chart of Critical rainfall

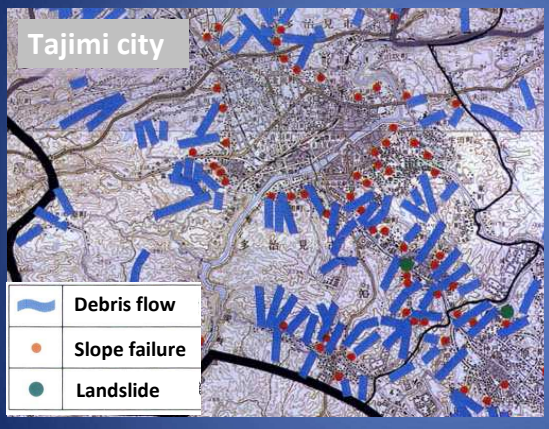
2）Critical rainfall for warning and evacuation that uses rainfall forecast







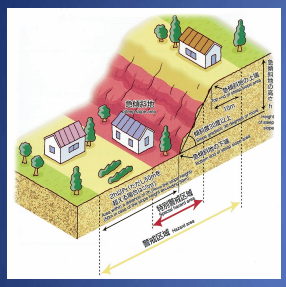
Dissemination of sediment-related disaster information



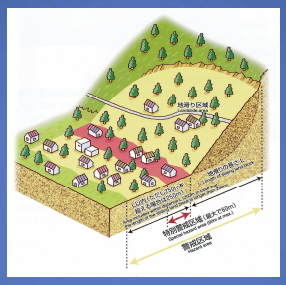
Distribution of a hazard map on sediment-related disasters

Dissemination by direct mail

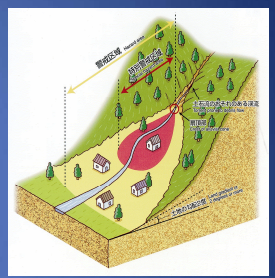
Designation of Hazard Areas and Preventive Measures



Steep slope failure



Landslide



Debris Flow

Yellow zone :Sediment-related disaster hazard area

Red zone :Special sediment-related disaster hazard area

The Law for Promoting Prevention Measures Against Sediment Disasters

Subjects of Sediment Disasters : Slope Failures, Debris Flow, Landslide

Preparation for Guidelines on Sediment Disasters Prevention Measures［Minister of Land, Infrastructure and Transport］

- Basic matters related to measures for sediment disasters prevention
- Guidelines on basic survey
- Guidelines on designation of potential sediment disasters areas
- Guidelines on moving structures from high potential sediment disasters areas

↓

Implementation of Basic Survey［Each Prefecture］

- Investigation for designation of potential and high potential sediment disasters areas

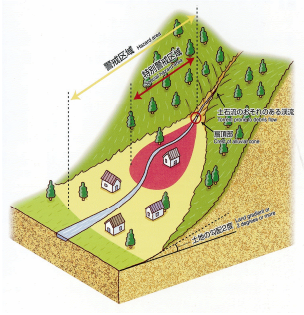
↓

Designation of Potential Sediment Disasters Areas［Each Prefecture］
〈The Areas in Danger of Sediment Disasters〉

○ Preparing for the warning, information and evacuation system
○ Informing inhabitants of matters on the warning and evacuation

Designation of High Potential Sediment Disasters Areas［Each prefecture］
〈In the areas, buildings and inhabitants might suffer heavily from the disasters〉

○ The permission for certain development works
examples : development works aimed at sale of building lots for residence or constructing social welfare facilities
○ Setting up of building regulations
○ Advice of moving the building which might be destroyed in case of sediment disasters
○ Organizing financial support system for the people who move according to the advice



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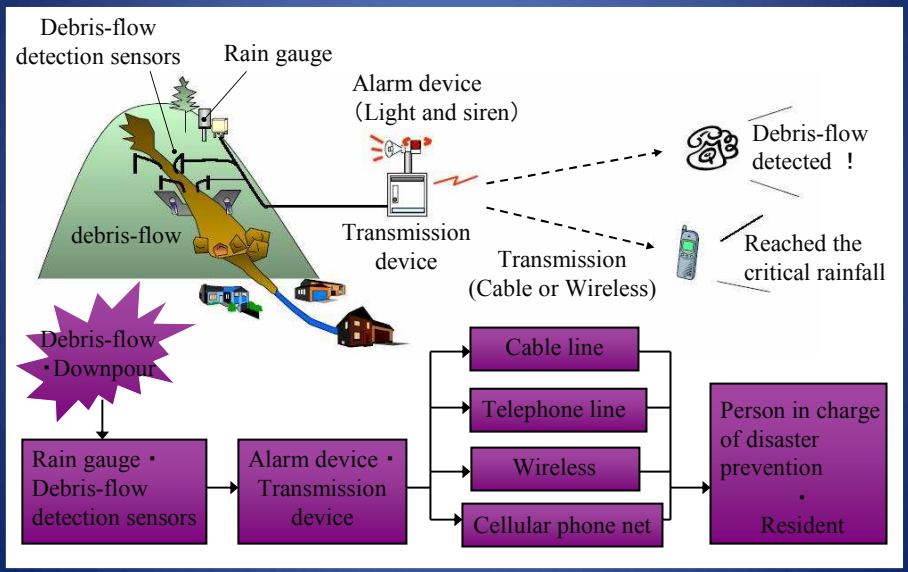
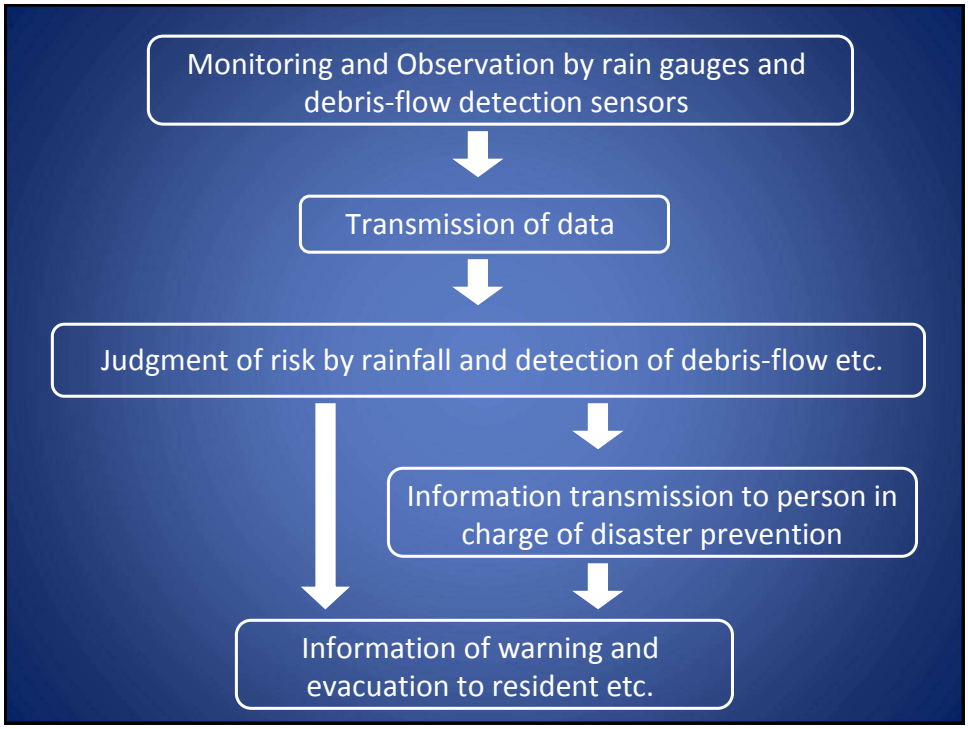
6. Conclusion remarks

Monitoring and observation of debris-flow on the debris-flow-torrent etc.





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2. Landslide disasters in Japan
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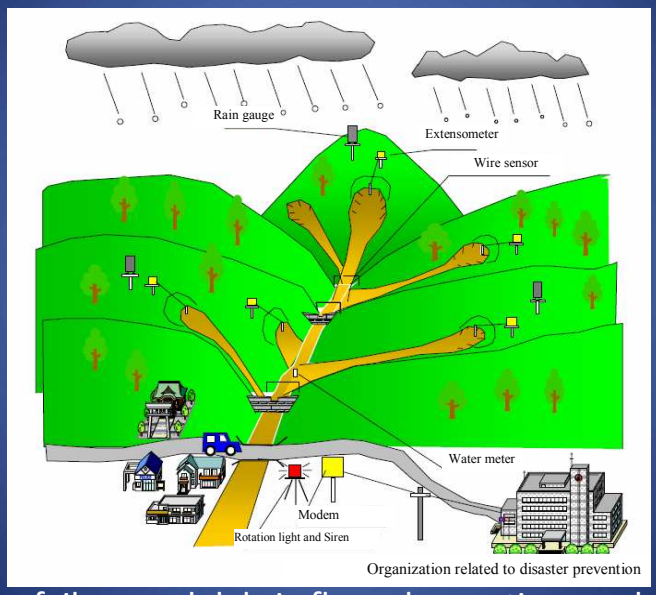
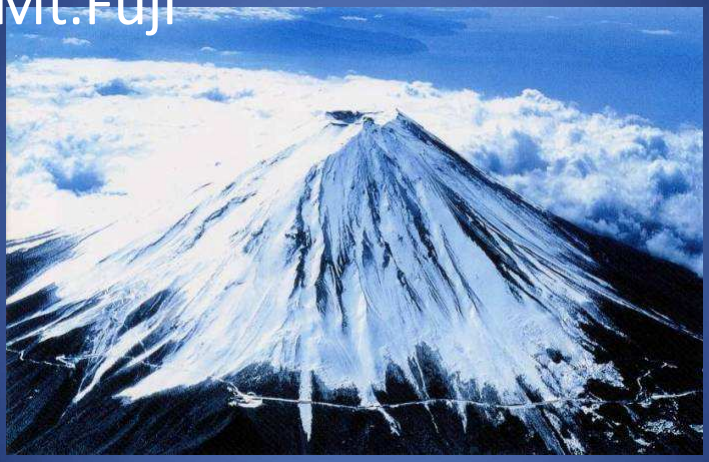
6. Conclusion remarks

What shall I do for landslide disaster mitigation?



Slope failure and debris-flow observation model chart

Mt.Fuji



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