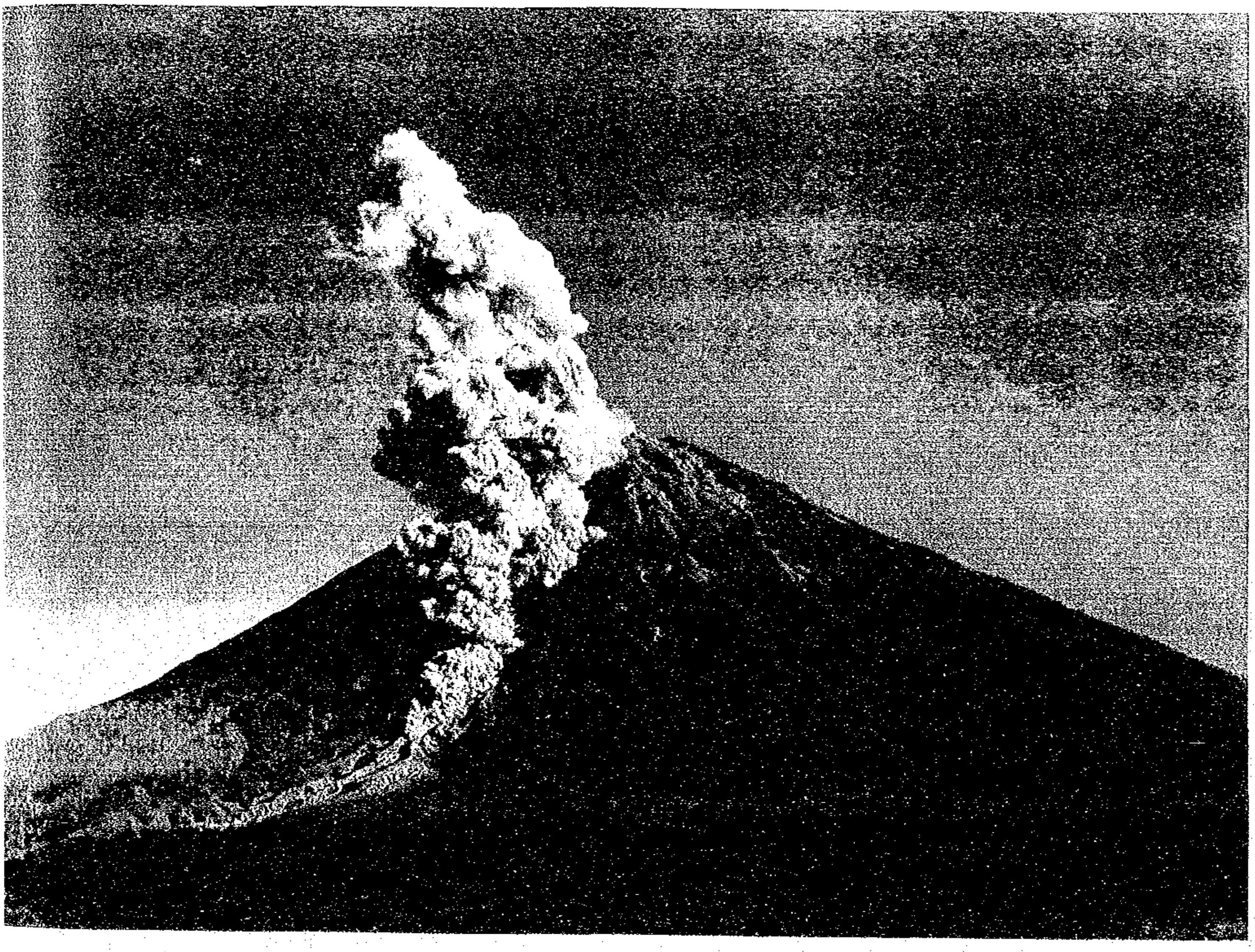
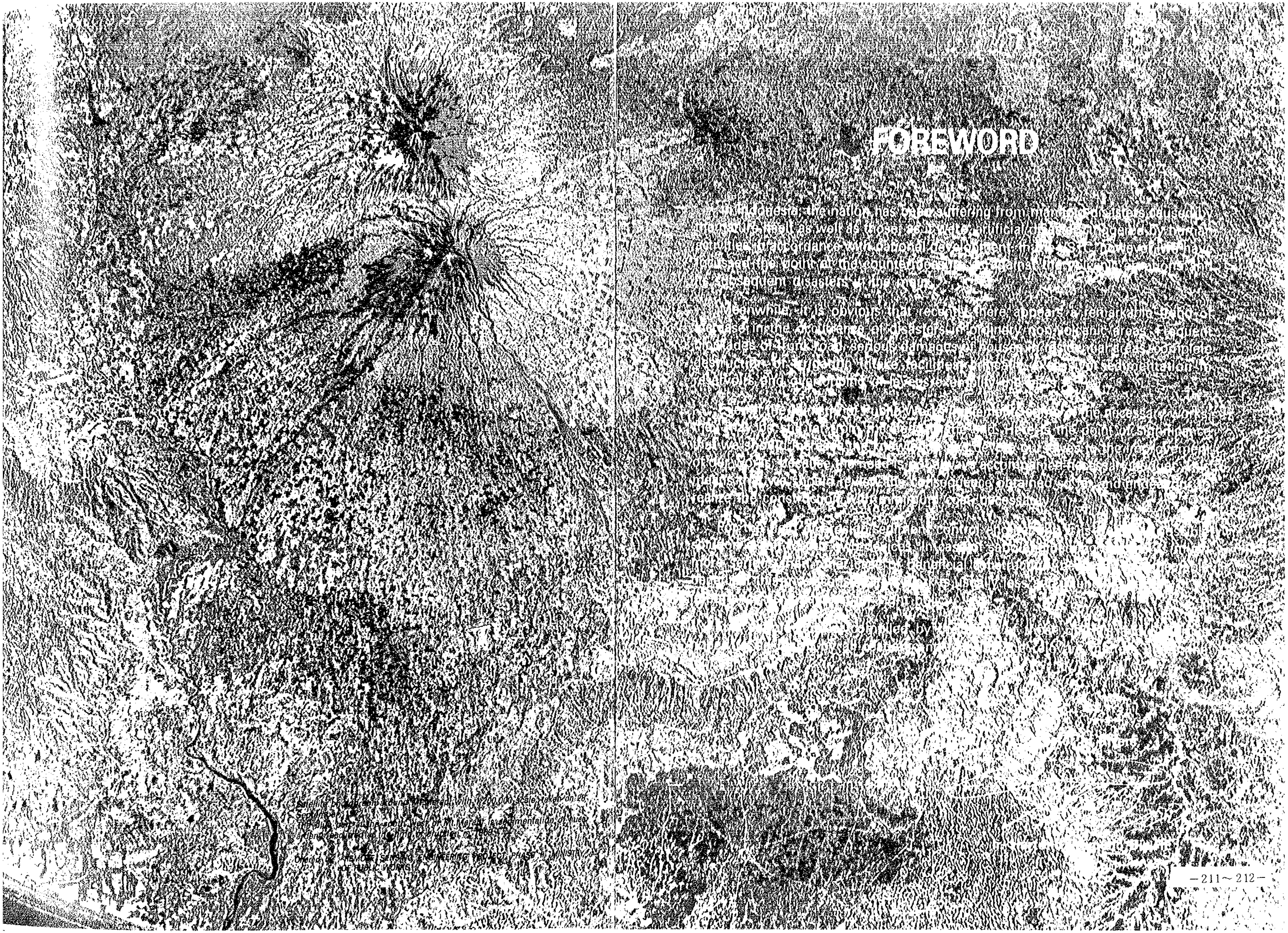
附属資料8.

SABO IN INDONESIA



MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
DIRECTORATE OF RIVERS

VOLCANIC SABO TECHNICAL CENTRE



Satellite [illegible] with 1:200,000 scale, taken on 28 September [illegible]
[illegible] south west of Mt. Merapi [illegible] sedimentation [illegible]
Offered by REMOTE SENSING ENGINEERING PROJECT PHASE II, MINISTRY OF PUBLIC WORKS

FOREWORD

In Indonesia, the nation has been suffering from many [illegible] disasters caused by the nature itself as well as those [illegible] artificial [illegible] by human activities in accordance with national development [illegible] the counter [illegible] subsequent disasters in the [illegible]

Meanwhile, it is obvious that recently there appears a remarkable trend of increase in the occurrence of disasters in ordinary non-volcanic areas. Frequent landslides [illegible] serious damages [illegible] complete destruction of [illegible] facilities [illegible] sedimentation in reservoirs and [illegible]

[illegible]

• Natural and Social Condition

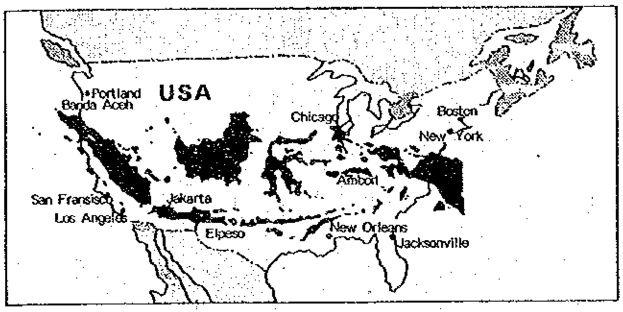
Indonesia is the largest archipelago in the world, which has a land area of 1,919,443 sq.kms and its 13,677 islands stretch 5,152 kms from East to West and 1,770 kms from North to South.

The climate is almost tropical with high humidity and heavy rainfall and the average temperature at coastal plains is about 27° C. The Indonesian islands lie along the equator. The seasons consist of a dry and a rainy one. The rainfall is concentrated in the rainy season and in general is squall type whose duration is short.

Lying on the Circum-Pacific active volcanic zone, Indonesia has 129 active volcanoes. Geology is very complex and there are many faults and many geological weak zones such as faults, fractured zones and the Tertiary. In the Tertiary area, especially, landslide occurs frequently.

According to the speech at the United Nations in 1989 by President Soeharto, the total population of Indonesia is an estimated 178 million in 1989. About 60% people of the total population live in Java island and the population density reaches to 817 person/km². Java island is one of the most population concentrated areas in the world. From a view of national land utilization point the rate of residential zone is 17.23% in the case of Java island, and 7.31% in the case of all Indonesia. It is clear that the national development is done concentrically in Java island. Recently the sediment disaster has been occuring frequently that combined with the concentration of population in Java island makes it one of the big social matters in Indonesia.

• Scale of National Land



The territory of Indonesia stretches from 6°08' north latitude to 11°15' south latitude, and from 94°45' to 141°05' east longitude. The east-west lengh of Indonesia is more than either Europe or the United States of America.

• Population and population density

Island	Area (km²)	(%)	Population (1985)	(%)	Population Density (Person/km²) (1985)	Annual Population Growth Rate (%) 1980-1985
Sumatera	473,606	(24.67)	32,719,820	(19.87)	69	3.08
Jawa	132,187	(6.89)	100,207,449	(60.87)	755	1.81
Nusa Tenggara	88,488	(4.61)	9,369,197	(5.69)	106	1.93
Kalimantan	539,460	(28.11)	7,749,096	(4.71)	14	2.61
Sulawesi	189,216	(9.85)	11,593,949	(7.04)	61	2.11
Maluku	74,505	(3.88)	1,614,271	(0.98)	22	2.66
Irian Jaya	421,981	(21.99)	1,375,842	(0.84)	3	3.15
Indonesia	1,919,443	(100.0)	164,629,618	(100.0)	85	2.15

Source : Statistical Year Book of Indonesia, 1987.

According to the national census in 1985, about 60 % people of the total population live in Java island and the population density reaches to 755 persons/km². On the other extreme is Irian Jaya, which has about 22 % of the national land, is only 3 persons/km²

The concentration of population becomes one of the serious social matters. Hence, the immigration from Java island to the other islands such as Sumatra, Kalimantan and Sulawesi is conducted positively as a countermeasure to prevent the concentration of population.

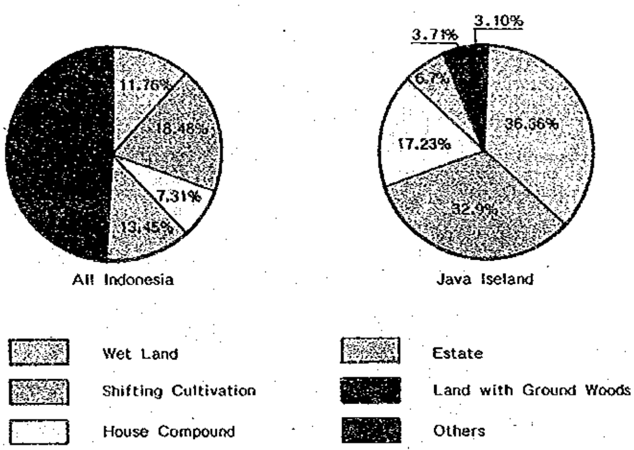
• Temperature and Rainfall

NAME OF CITY	MEAN MONTHLY TEMPERATURE (C) AND RAINFALL (mm)												
	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
JAKARTA	26.2	26.4	26.8	27.5	27.6	27.3	27.0	27.2	27.5	27.8	27.2	26.8	27.1
(JAVA)	398	286	242	131	113	95	64	69	72	96	125	192	1885
BANDUNG	22.6	22.7	22.9	23.2	23.1	22.6	22.2	22.7	23.0	23.4	23.2	23.0	22.9
(JAVA)	213	165	232	256	180	76	70	65	69	163	261	259	2049
YOGYAKARTA	25.6	25.5	26.0	26.6	26.6	26.2	26.1	26.8	27.3	27.9	27.5	26.6	26.5
(JAVA)	331	314	304	159	118	53	38	35	35	91	173	289	1937
MEDAN	25.5	26.0	26.4	26.5	26.9	26.9	26.5	26.4	26.2	26.0	25.8	25.6	26.2
(SUMATERA)	108	116	113	163	182	139	165	157	239	254	234	231	2099
UJUNGPANDANG	25.7	25.7	26.1	26.5	26.7	26.5	26.1	26.3	26.8	27.1	26.5	25.8	26.3
(SULAWESI)	693	531	460	157	106	64	36	21	28	75	276	554	3001
SAMARINDA	26.3	26.4	26.8	27.0	26.7	26.4	25.6	26.1	26.1	26.8	26.8	26.4	26.5
(KALIMANTAN)	156	171	208	195	182	175	144	100	121	129	184	195	1957
DILI	27.9	27.5	27.5	27.7	27.4	26.5	25.5	25.5	26.3	27.6	28.9	28.5	27.2
(TIMOR)	146	108	119	104	105	29	23	6	17	14	56	125	852
JAYAPURA	27.1	26.5	27.0	27.0	26.9	26.8	26.6	26.6	27.2	27.2	27.3	27.3	27.0
(IRIAN JAYA)	304	259	297	206	173	162	124	136	148	154	175	239	2377

Note : The up and down columns mean the mean monthly temperature and the mean monthly rainfall, respectively.
The mean monthly temperature of Yogyakarta shows one of Madiun where the topographical condition is the most similar to Yogyakarta.
Source : Department of Communications, Meteorological and Geophysical Agency. Mean monthly temperature and rainfall (1951 – 1987), Jakarta

The temperature is very high all year, because Indonesia lies along the equator. The mean annual temperature is 27° in coastal plains, 25°C in inland and mountain areas and 22°C in higher mountain areas. The rain is concentrated in a rainy season and the mean annual rainfall is about 2,000 mm.

• National land utilization (comparing all Indonesia with Java island)



NOTE : Timor Timur does not enter *Source : Statistical Year Book of Indonesia, 1987*

The national land utilization of Java island is quite different from the whole of Indonesia, that is, the rate of wet land is about three times and the rate of house compound is about 2.4 times larger than the value for all of Indonesia. It is clear that the high national land utilization is done in Java island.

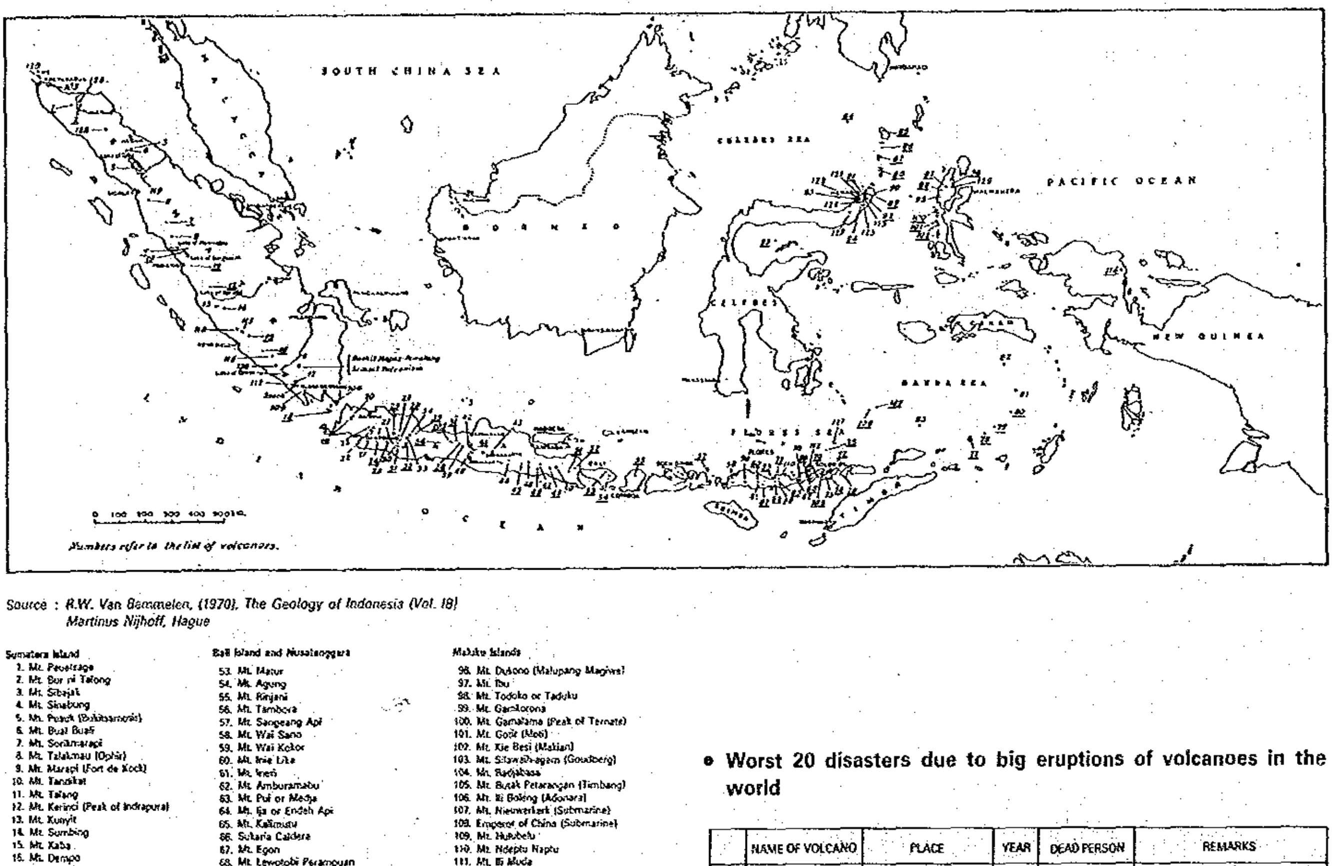
● Actual Circumstances of Sediment Disaster

– Volcanic Eruption –

About 17 % of the active volcanoes in the world are distributed in Indonesia. There are many active volcanoes, especially in the areas fronting the Indonesian Ocean along the tectonic plate, such as Sumatra, Java and Flores islands. About 30 % of the active volcanoes in Indonesia are found in Java and Bali islands.

The volcanic eruption occures frequently and only the recent main eruptions are as follows : Mt. Tambora (West Nusa Tenggara), Mt. Lokon (North Sulawesi), Mt. Lepembusu (East Nusa Tenggara) in 1986, Mt. Mandasewu, Mt. Anaka (East Nusa Tenggara) in 1987, Mt. Gamalama, Mt. Kie Besi (Maluku), Mt. Slamet (Central Java) in 1988, Mt. Semeru (East Java) in 1989 and Mt. Kelud in 1990. Not only the direct disaster due to the eruption, pyroclastic flow and nuee ardente but also the indirect disaster due to secondary lahar caused by the rainfall after eruption have occurred, and a lot of irreplacable lives have been lost.

● Active volcanoes in Indonesia



Source : R.W. Van Bemmelen, (1970), The Geology of Indonesia (Vol. IB) Martinus Nijhoff, Hague

Sumatera Island
1. Mt. Peuetsage
2. Mt. Bur ni Telong
3. Mt. Sibajak
4. Mt. Sinabung
5. Mt. Pusuk (Bukitbarisan)
6. Mt. Bual Buali
7. Mt. Sorikmarapi
8. Mt. Talakmau (Ophir)
9. Mt. Marapi (Fort de Kock)
10. Mt. Tandikat
11. Mt. Talang
12. Mt. Kerinci (Peak of Indrapura)
13. Mt. Kunyit
14. Mt. Sumbing
15. Mt. Kaba
15. Mt. Dempo
17. Mt. Selinjau Belerang

Java Island
18. Mt. Krakatau with Anak Krakatau
19. Mt. Pulasari
20. Mt. Karang
21. Mt. Salak
22. Mt. Perbakti
23. Mt. Kiaraberes-Gagak
24. Mt. Gedeh
25. Mt. Tangkubanperahu
26. Mt. Patuha (Kawah Putih)
27. Mt. Wajang-Windu
28. Mt. Guntur
29. Kamojang Crater
30. Manuk Crater
31. Mt. Papandayan
32. Mt. Galunggung
33. Mt. Telagabodas
34. Karaha Crater
35. Mt. Ceremai
36. Mt. Slamet
37. Dieng Plateau
38. Mt. Sundoro
39. Mt. Sumbing
40. Mt. Merbabu
41. Mt. Merapi (Central-Java)
42. Mt. Ungaran
43. Mt. Lawu
44. Mt. Wilis
45. Mt. Kelud
46. Mt. Arjuna-Welirang
47. Mt. Bromo
48. Mt. Semeru
49. Mt. Lamongan
50. Mt. Ijang Argapura (Hijang)
51. Mt. Raung
52. Ijen Crater

Bali Island and Nusatenggara
53. Mt. Matur
54. Mt. Agung
55. Mt. Rinjani
56. Mt. Tambora
57. Mt. Sangeang Api
58. Mt. Wai Sano
59. Mt. Wai Kokor
60. Mt. Inie Lika
61. Mt. Ineri
62. Mt. Amburambu
63. Mt. Pui or Medja
64. Mt. Ija or Endeh Api
65. Mt. Kelimutu
66. Sukaria Caldera
67. Mt. Egon
68. Mt. Lewotobi Perampuan
59. Mt. Lewotobi Laki-laki
70. Mt. Leweno (Lorobelong)
71. Mt. Palewuh (Rokatinda)
72. Mt. Ili Lewotolo or Wariran (Lomblen)
73. Mt. Ili Labalekan (Lomblen)
74. Mt. Ili Werung (Lomblen)
75. Mt. Batu Tara (P. Kombe)
76. Mt. Sirung (Pantar)

Banda Island
77. Mt. Damar (Daam or Wurlah)
78. Mt. Surawerna (Teon)-(Tijaw or Mesah)
79. Mt. Lewotkawa (Nila)-(Kokon)
80. Mt. Serua (Legatala)
81. Mt. Manuk
82. Mt. Banda Api
83. Mt. Api, North of Wetar

Sulawesi Island and Sangir
84. Submarine Volcano (West of Sangihe)
85. Mt. Awu
86. Mt. Banua Wuhu (Mahangetang)
87. Mt. Karangetang (Api Siau)
88. Mt. Ruang (Duwang, Duang)
89. Mt. Tiongkoko (Batu angus)
90. Mt. Klabat
91. Mt. Lokon-Empung
92. Mt. Mahawu or Rumengan
93. Mt. Tampusu
94. Mt. Soputan (Aseput)
95. Mt. Colo (Una-una)

Maluku Islands
98. Mt. Dukono (Malupang Magiwe)
97. Mt. Ibu
98. Mt. Todoko or Taduku
99. Mt. Gamkonora
100. Mt. Gamalama (Peak of Ternate)
101. Mt. Gośr (Moti)
102. Mt. Kie Besi (Makian)
103. Mt. Sirawah-agam (Goudberg)
104. Mt. Badjabasa
105. Mt. Busak Petarangan (Timbang)
106. Mt. Ili Boleng (Adonara)
107. Mt. Nieuwerkerk (Submarine)
109. Emperor of China (Submarine)
109. Mt. Hubabelu
110. Mt. Ndeptu Naptu
111. Mt. Ili Muda
112. Mt. Riang Kotang
113. Mt. Tampeng (Tempaso)
114. Mt. Umsini (Arfak Mts)
115. Mt. Daun
116. Mt. Lumut Balai
117. mt. Pematang Bata
118. Mt. Blerang Beriti
119. Mt. Helatoba-Tarutung
120. Mt. Pulau Weh
121. Mt. Lahendong
122. Mt. Sarongsong
123. Mt. Sampu
124. Mt. Batu Kolok
125. Mt. Walupang Waritang
126. Mt. Bur ni Geueudong
127. Yersey volcano (Submarine)
128. Gajolesten solf. and fum.
129. Mt. Ambang

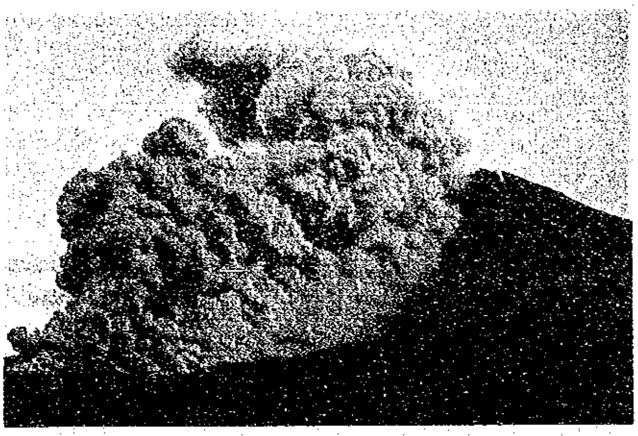
● Worst 20 disasters due to big eruptions of volcanoes in the world

	NAME OF VOLCANO	PLACE	YEAR	DEAD PERSON	REMARKS
	Tambora	Indonesia, Sumbawa	1815	90,000	About 90 % killed by starvation
	Krakatau	Indonesia, Sunda Strait	1883	36,417	About 90 % killed by tidal wave
3	Pelee	West Indies	1902	29,025	Pyroclastic flows
4	Nevado del Ruiz	Colombia	1985	24,700	Mudflow
5	Vesuvius	Italy	1631	18,000	Big eruption since A.D. 79
6	Etna	Italy	1169	15,00	
7	Unzen	Japan, Kyushu	1792	14,300	About 70 % killed by cone collapse
	Kelud	Indonesia, Jawa	1586	10,000	Mudflow
9	Etna	Italy	1669	10,000	
10	Laki	Iceland	1783	10,000	
	Merapi	Indonesia, Jawa	1006	several thousand	Nuee Ardente
	Kelud	Indonesia, Jawa	1919	5,110	Mudflow
	Galunggung	Indonesia, Jawa	1822	4,011	Mudflow
	Awu	Indonesia, Sangihe	1711	3,200	Mudflow
15	Lamington	Papua New Guinea	1951	3,000	Nuee Ardente
	Merapi	Indonesia, Jawa	1672	3,000	Nuee Ardente and mudflow
	Papandayan	Indonesia, Jawa	1772	2,957	Eruption
	Awu	Indonesia, Sangihe	1856	2,806	Mudflow
	Kie Besi	Indonesia, Maluku	1760	2,000	Nuee Ardente and mudflow
20	Sufufier	West Indies	1902	1,600	Nuee Ardente

Source : – Volcanic disasters in the world by Iwao Murayama
– Volcanic Hazards, A Sourcebook on the Effects of Eruptions, R.J. BLONG, 1984
– Data Dasar Gunung Api Indonesia
Note : Red mark means the disaster in Indonesia

"11" cases of the worst 20 disasters in the world occurred in Indonesia. More than 60 % of it are due to lahar and others are caused by pyroclastic flow, starvation and tunami.

● Nuee ardente of Mt. Semeru (East Java)

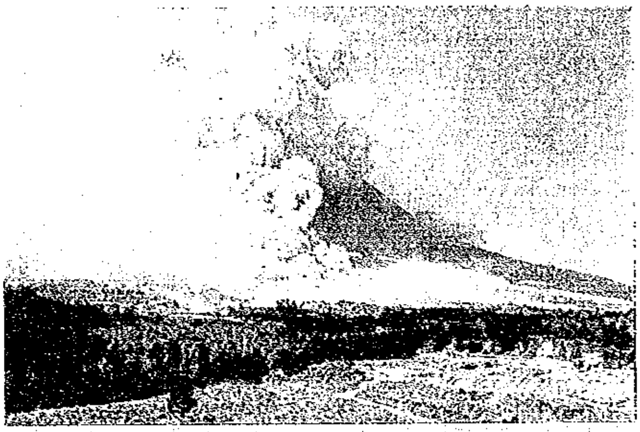


Nuee ardente occurred in Mt. Semeru on 10 June, 1989. The nuee ardente flowed down along the gully with speed from 8 to 50 m/sec and stopped at the downstream where the gradient of riverbed is about 1/7. It seemed that much volcanic material would be deposited at the downstream area. It is very feared that the hot lahar will be caused by rainfall.

● Nuee ardente of Mt. Kie Besi (Makian island, Maluku)

The nuee ardente occurred at three locations due to the big volcanic eruption of Mt. Kie Besi on 30th July, 1988 and reached to the coastline along the gully. Fortunately no one was lost because the inhabitants (about 13,000 persons) had already evacuated nine days before the eruption. But a lot of residences were flowed out and many roads were destroyed by lahar which occurred everywhere. The island became ruins in an instant.

● Nuee ardente of Mt. Merapi (Central Java)



A nuee ardente occurred due to eruption of Mt. Merapi on 15th June. 1984. It flowed down along the Putih river and stopped at the immediate upstream of the village. The lahar occurs frequently in the Putih river after the eruption because the sedimentation due to volcanic eruption is easily eroded by rainfall and is a source of lahar.

● Eruption of Mt. Anaka (Flores island, Nusa Tenggara)

Mt. Anaka erupted on 28th December. 1987 and nuee ardente occurred in two torrential streams. Fortunately nobody was lost because of the previous evacuation. But a lot of forests were burned and two important bridges, which have been constructed on the main national road, were destroyed due to lahar caused by rainfall after the eruption. Also, it gave a big damage for agricultural products so that the function of the island was lost completely.

– Lahar Disaster –

Volcanic eruption makes nuee ardente and pyroclastic flow occur and supplies much unstable volcanic material, which buries valleys and completely withers the vegetation at the source area with fallen volcanic ash. The unstable volcanic material which buried the valley is eroded by rainfall and the lahar, transports much sediment in an instant. The lahar disaster caused by rainfall after big volcanic eruptions is the most noticeable one.

• Recent volcanic eruptions with lahar disaster

YEAR OCCURRENCE	NAME OF VOLCANO	DAMAGE		
		DEAD MISSING	HOUSES DESTROYED	FARMLAND BURRIED
1963	Agung	1148	7899	68,489 ha
1966	Kelud	210	2620	11,600
1969	Merapi	3	322	–
1976	Merapi	29	810	780
1978	Semeru	14	–	4,000
1981	Semeru	369	535	1,000
1982	Galunggung	27	22 (hamlets damaged)	

Source : Directorate of Volcanology, Ministry of Mining and Energy. Basic data on active volcanoes in Indonesia, 1979, Jakarta and others.

Huge amounts of volcanic products such as ash, sand and gravel are deposited loosely on the slope around a crater at the time of eruption. According to the records of recent disasterous eruptions, approximately 300 million cubic meters of volcanic products were produced by the eruption of Mt. Agung in 1963. Similarly 22 million and 53 million cubic meters of volcanic products were produced by the eruption of Mt. Merapi in 1969 and Mt. Galunggung in 1982, respectively.

As these new deposits are unstable and unconsolidated, they are liquified and ready to move downstream in the form of massive flow due to rainfall which is called "lahar or mudflow". The lahar causes many miserable human disasters if it overflows and runs over a village, because of the powerfull energy of lahar. Most of the volcanic disasters shown in table above were caused by lahar.

• Recent eruptions of main volcanoes at which sabo works have been implemented.

Mt. Merapi	Mt. Semeru	Mt. Kelud	Mt. Galunggung	Mt. Agung
1672 – ?	1818	1586	1822	1843
1822 – 1823	1829 – 1847	1826	1894	1963
1872 – 1873	1856 – 1865	1848	1982	
1930 – 1931	1872 – 1879	1864		
1942 – 1943	1885 – 1913	1901		
1948	1941 – 1942	1919		
1957 – ?	1945 – 1947	1951		
1961 – ?	1950 – 1964	1966		
1967 – 1969	1969 – 1980	1990		
1972 – 1978	1981			
1984	1989			
Period of eruption is about a few years. Nuee ardente due to volcanic dome occurs.	Period of eruption is from a few years to several decades. Nuee ardente due to volcanic eruption occurs.	Period of eruption is several decades (20 – 30 years) There is a crater lake.	Period of eruption is several decades (70 – 90 years) There is a crater lake	Period of eruption is more than 100 years.

Source :
I. SURYO, Geographical Notes for Volcanic Debris Control Project, 1989, VSTC, YOGYAKARTA
T. FURUYA, Geomorphology of Mt. Merapi, 1989, VSTC, YOGYAKARTA

• Occurrence of lahar after volcanic eruption (Example of Putih river in Mt. Merapi, Central Java)

No.	DATE	OCCURRENCE TIME (MRANGGEN)	MAXIMUM WATER DEPTH (MRANGGEN)	RAINFALL (MT.MARON STATION)		
				TOTAL RAINFALL	MAXIMUM ONE HOUR RAINFALL	MAXIMUM 10 MINUTES RAINFALL
			cm	mm	mm	mm
1.	1985.11.20	17 : 35	593	48	51	8
2.	11.27	15 : 20	456	152	63	14
3.	11.28	12 : 20	847	152	43	13
4.	12.11	15 : 50	409	93	61	15
5.	1986.03.21	15 : 00	378	52	23	8
6.	09.03	18 : 40	306	42	35	18
7.	11.25	15 : 30	317	72	30	7
8.	12.30	15 : 50	538	101	94	28
9.	1987.01.01	15 : 30	321	33	28	19
10.	02.10	15 : 10	355	45	34	10
11.	02.14	17 : 50	362	75	43	15

Source : VSTC Data

According to the record of lahar water depth at Mranggen dam since 1985, the comparative big lahar more than three meters of water depth occurred mostly in the rainy season of year after the eruption in 1984. In 1988, however, lahar more than three meters of water depth did not occur. It was reported that the big scale aggradation occurred temporarily at the middle stream area of the Putih river in the rainy season of 1984. The big eruption on 15 June, 1984 is the newest and no eruption has occured again up to now. Hence, it seems that the relationship between the volcanic eruption and the occurrence of lahar would be close.

• Eruption of Mt. Kelud (East Java).

Mt. Kelud was erupted on 10 February, 1990 after an interval of 24 years since 1966. In upper reaches around Mt. Kelud a huge amount of volcanic products were supplyed. It is feared that mudflow will occur due to heavy rainfall.

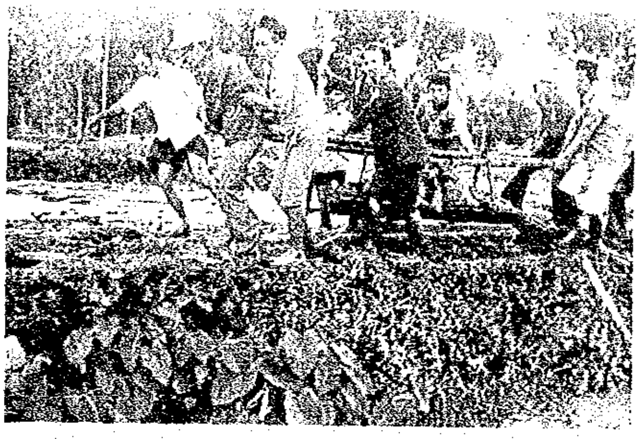
• **Hot lahar (Mt. Semeru, East Java)**

A hot lahar occurred in the Besuk Bang river on 15 July, 1988 immediately after a small scale nuee ardente had occurred. The material is still hot so that the stream occurs on the water surface of hot lahar. According to the result of a sampling survey by the Mt. Semeru Project, it was reported that the volume concentration of lahar was about 50%. Judging from this report, it is clear that the hot lahar can transport some boulders easily.

• **Lahar (Mt. Merapi, Central Java)**

A video-camera set out at Jurang Jero in the Putih river took the mudflow scene on 28 November, 1985. The runoff form of the front part obviously belongs to a type of hydraulic bore with big boulders more than 2 m diameter and of high speed. According to visual judgement from the video tape, it is reported that the mean velocity, the water depth, the maximum discharge and its specific discharge are 11.0 m/sec, 2.5 m, 825 m^3/sec and 131 m^3/sec/km^2, respectively. It is clear that we can not use a rational formula to calculate this discharge.

• **Disaster due to lahar**



Irreplaceable human lives were lost cruelly due to the lahar occurred in Mt. Semeru area. It is feared that the lahar will take away a lot of human lifes if it overflows and runs over a village, because it has a big energy and flows out straight.

Houses were buried due to lahar which occurred immediately after the eruption of Mt. Galunggung in 1982. A peaceful village was changed to mud-sea in an instant.

– Sediment Disaster in Non-Volcanic Area –

Recently the sediment disaster such as debrisflow, landslide and slope failure has been occuring frequently in the non-volcanic areas too. According to a natural disaster survey from 1986 to 1988 by the Ministry of Public Works, about 40 % of the total victims due to natural disaster are lost by sediment disaster.

The occurrence of landslide is especially frequent. Forming some sliding faces in the weak geological structure, the landslide occurs due mainly to rainfall. Hence, the occurrence of landslide is closely related to the geological condition. In the case of West Sumatra the landslide sometimes occurs around fault and fractured zones and in the case of West Java it occurs frequently in the Tertiary layer area.

The sediment disaster that occurred at Padang Panjang, West Sumatra on March, 1987 is one of typical slope failure examples. 140 human lives were lost in an instant due to the slope failure of a back hill. The slope failure disaster is a very dangerous one because it is very difficult to forecast the occurrence and the phenomenon occurs in an instant.

Although debrisflow disasters with victims have not been reported recently, it is the most dangerous disaster in consideration of the big energy and the speed of debrisflow.

Other sediment disasters such as slope failure along the road and coastal erosion occur. Except for Irian Jaya it is clear that sediment disasters have become one of the big social matters.

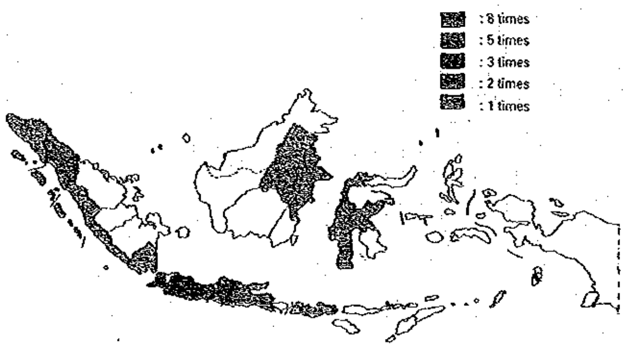
• **Recent sediment disaster**

No.	NAME OF NATURAL DISASTER	1986	1987	1988	TOTAL
1.	Flood	266	130	96	494
2.	Sediment Disaster	104	170	125	399
3.	Windstorms	28	–	1	29
4.	Flood-tide	–	3	2	5
5.	Earthquakes	–	44	1	45
6.	Volcanic eruptions	–	–	5	5
7.	Wildfires	5	1	43	49
	Total	403	348	273	1,026

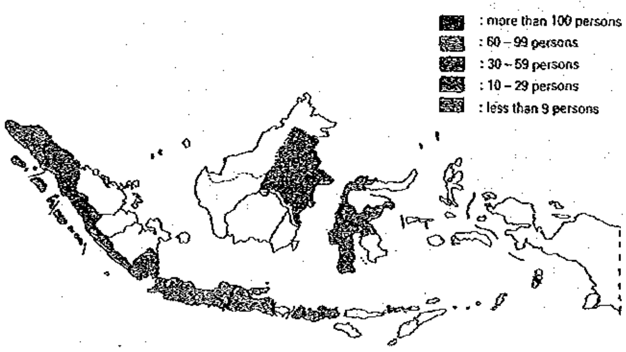
Source : Ministry of Public Works (1986, 1987 and 1988), Report on Victims and Damage due to Natural Disaster, Jakarta, Indonesia

The number of victims due to sediment disaster is second to first in natural disaster and the recent mean number of victims reaches to 133 persons.

• **Recent occurrence frequency of sediment disaster with victims in every province**



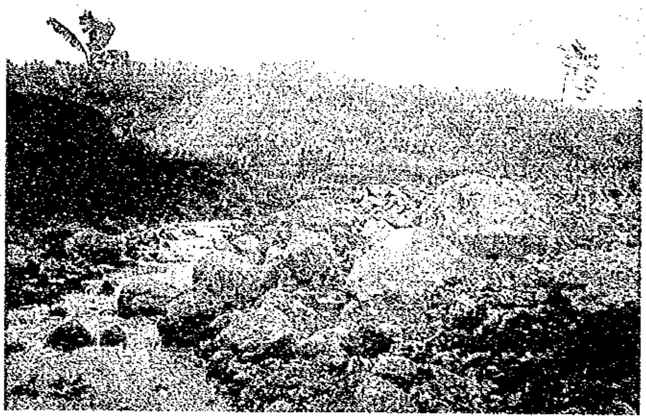
OCCURRENCE FREQUENCY OF SEDIMENT DISASTER WITH SOME VICTIMS EVERY PROVINCY (1985–1988)



NUMBER OF VICTIMS DUE TO SEDIMENT DISASTER EVERY PROVINCY (1985 – 1988)

Although the area where the sediment disaster occurred distributes widely, it is especially concentrated in Sumatra and Java islands.

• **Landslide disaster**



The big scale landslide occurs along Citanduy river and buries the river.

This landslide is a typical intrusive rock type one which occurred in the Citanduy river. The intrusive rock of andesite is intruded into the Tertiary layer and some sliding faces are formed between the intrusive rock and the Tertiary layer. The village in the landslide is studying seriously about the total movement of the village.

The landslide of Puncak, West Java occurred across the national road connected between Bandung and Jakarta. The old national road was destroyed due to the landslide and the new road was reconstructed at the upper side of the old one.

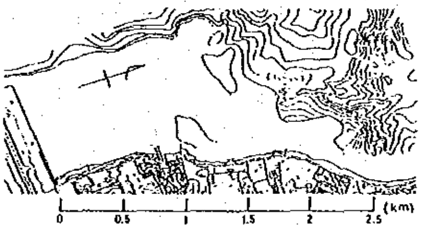
• **Slope failure disaster**

Limestone mining at the foot of hills by way of indulgent open-cutting which forms an important industry in this district is apparently the most influential cause of the big-scale slope failure that resulted in 140 casualties on 4th May, 1987 in Padang Panjang, West Sumatra. The limestone mining with the same method is still continued near the stricken area.

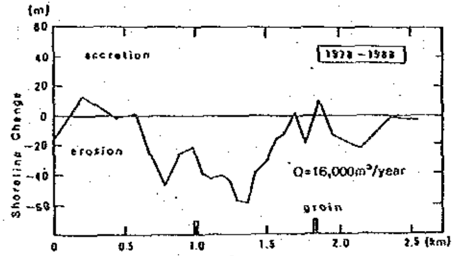
• **Debrisflow disaster** ***(Photograph in February, 1988)***

The debrisflow which occurred in the Mt. Talang area of the east side of Padang, West Sumatra buried Solok village in debris-material and logs. The debrisflow is called "Galodo" and is very feared in this district.

• **Coastal erosion**



The coastal erosion is noticeable at Kuta beach around the airport on Bali island. It was reported that the backing up of the coastal-line by 55 meters was observed for 10 years starting 1978 and there were many houses forsaken.



(Q : Average Volume of Sand Loss)

SHORELINE CHANGES AND LOSS IN KUTA BEACH

• Actual Circumstances of Sabo Project

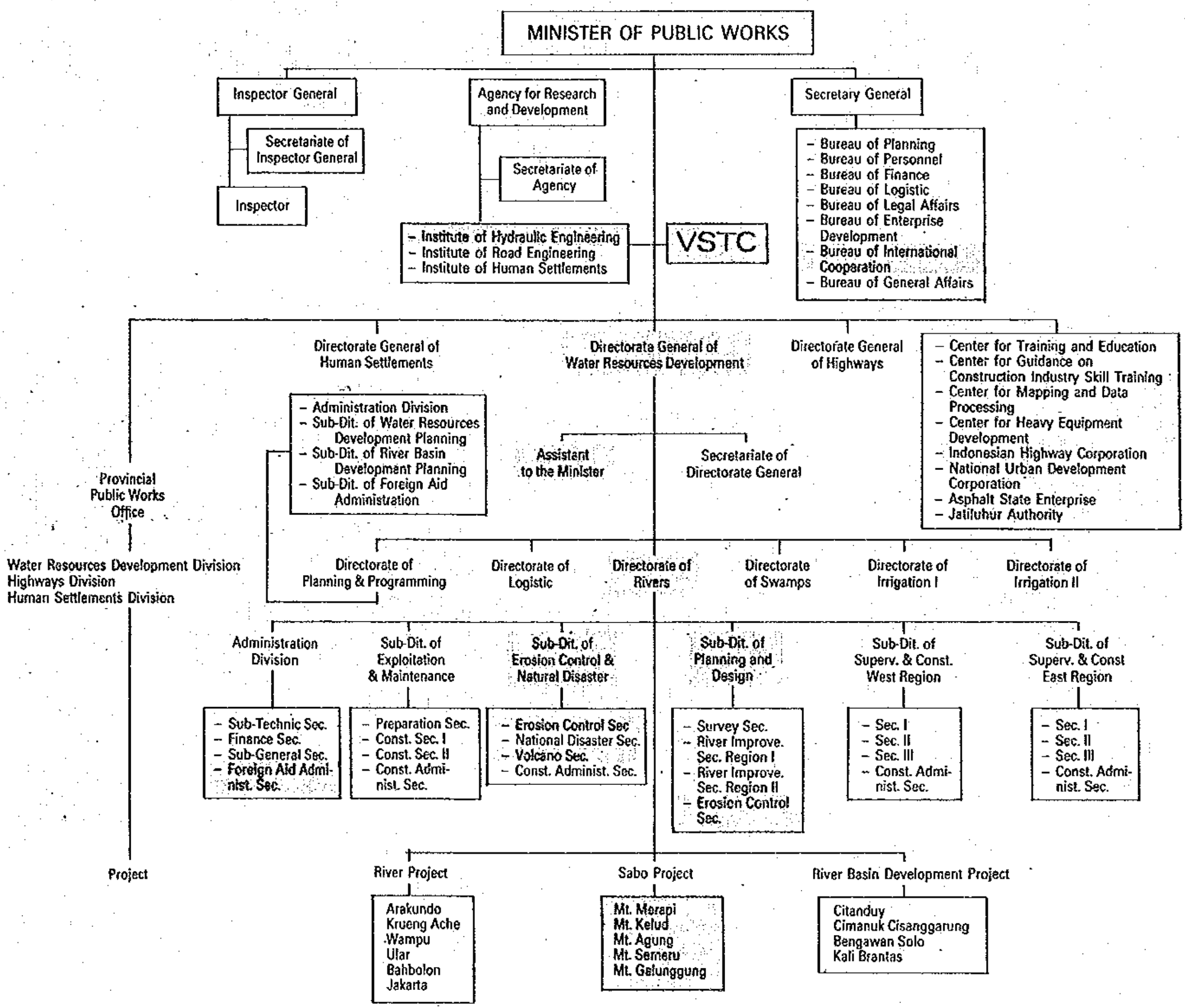
Irrigation works closely related to sabo works have been implemented throughout history. The ancient Harinjing monument dated March 25, 804 A.D. which was found at Pare – a small city located on the slope of Mt. Kelud volcano, was built to commemorate the completion of irrigation facilities and the Wringin Sapta dam. It may be thought that these facilities could have the function of sabo too.

Modern sabo technology has been introduced in earnest from Japan since 1969 and many sabo facilities such as the check dam, sand pocket, groundsill and channel work have been constructed mainly in volcanic areas. The sabo works have been implemented not only to protect human life, property and public facilities from outflow of sediment after the volcanic eruption but also to prevent the flood disaster due to aggradation and to protect the multipurpose dam from sedimentation in the reservoir.

The sabo facilities have been constructed under supervision of the Ministry of Public Works. The Directorate of Rivers in the Directorate General of Water Resources Development is mainly in charge of the survey, planning and implementation of sabo works and the Volcanic Sabo Technical Centre established under the Institute of Hydraulic Engineering of the Agency for Research and Development which is in charge of training and technical development of sabo works.

The budget for fiscal year 1988/1989 related to sabo-project and Volcanic Sabo Technical Centre reaches to 1,533 million rupiah. This occupies about 8 % for all the Directorate of Rivers. In addition, there is a budget for economical technical cooperation from Japan such as technical cooperation, grant aid and loans.

• **Organization**



• Budget of sabo works

BREAKDOWN OF BUDGET OF THE MINISTRY OF PUBLIC WORKS

Authorities	1985 Budget (Share)	1986 Budget (Share)	1987 Budget (Share)	1988 Budget (Share)
	Rp Bil. (%)	Rp bil. (%)		
1. Directorate General of Water Resources Development	368.0 (49.4)	162.8 (44.3)	125.3 (42.6)	79.4 (42.6)
2. Directorate General of Highways	282.1 (37.9)	133.7 (36.4)	134.7 (45.7)	72.1 (38.6)
3. Directorate General of Housing, Building Planning and Urban Development	73.3 (9.8)	51.7 (14.1)	26.7 (9.1)	26.4 (14.1)
4. Agency for Research and Development	7.5 (1.0)	5.8 (1.6)	1.9 (0.6)	2.0 (1.1)
5. Secretariate General	12.5 (1.7)	11.9 (3.2)	5.6 (1.9)	6.4 (3.4)
6. Inspectorate General	1.5 (0.2)	1.4 (0.4)	0.3 (0.1)	0.4 (0.2)
Total	744.9 (100)	367.3 (100)	294.5 (100)	186.6 (100)

The budget of the Ministry of Public Works has been decreased noticeably since fiscal year 1985/1986. The budget of 1988/1989 is a quarter smaller than that of 1985/1986. The budget of sabo works has had the same tendency too. It is clear that the budget circumstance of sabo works is very severe.

SABO PROJECT BUDGET EVERY FISCAL YEAR (1982-1988)

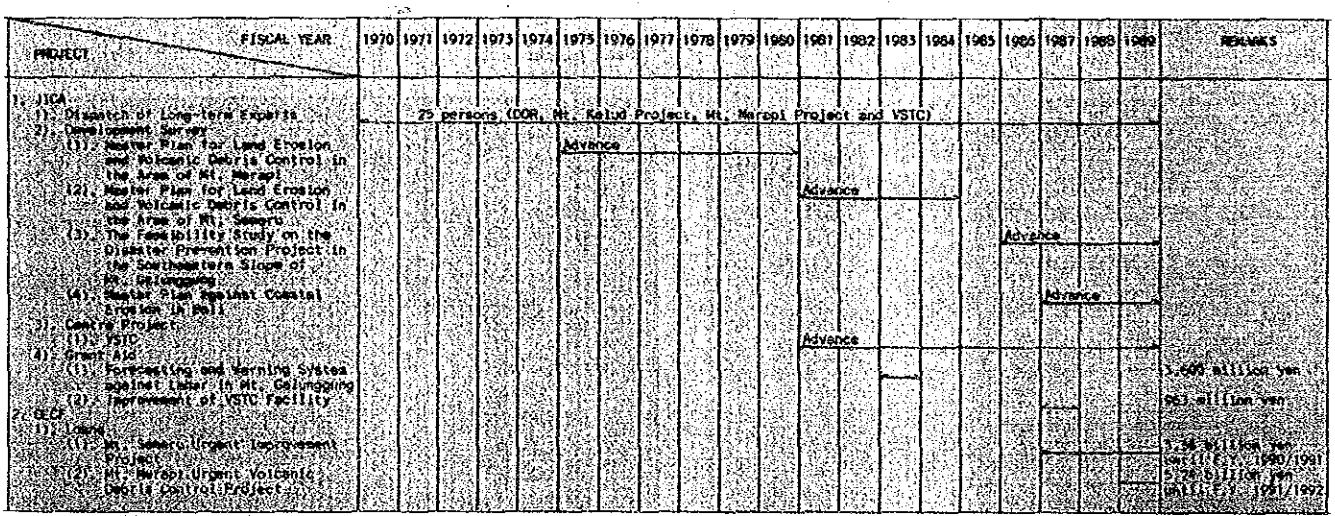
Unit : Million Rp.

Project \ Fiscal Year	1982	1983	1984	1985	1986	1987	1988
Merapi	1,918	1,265	1,389	1,392	655	991	366
Kelud	1,290	933	888	897	345	845	232
Agung	780	640	695	650	253	293	224
Semeru	1,220	1,175	1,000	994	447	636	357
Galunggung	(3,000)	975	893	1,000	489	152	311
V S T C	142	250	197	206	129	149	143
Total	5,350	5,238	5,062	5,139	2,318	3,066	1,533

Note : Table above shows only local budget.
Value in the bracket shows the special budget for emergency works.

• Economical and technical cooperation from Japan

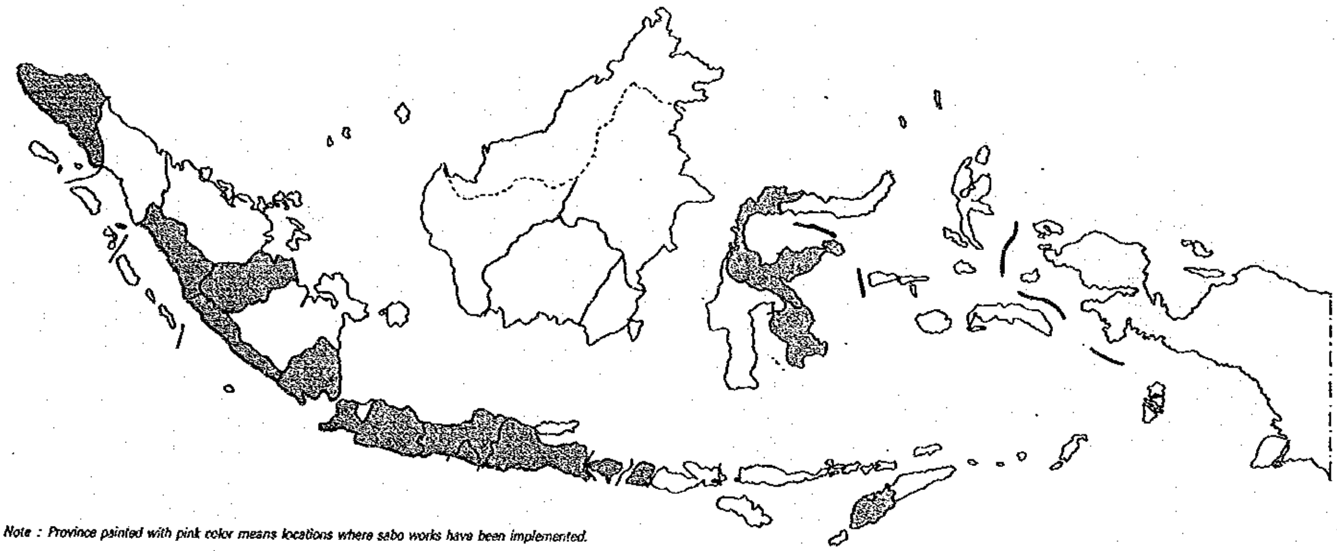
HISTORY OF SABO TECHNICAL COOPERATION BETWEEN JAPAN AND INDONESIA



Note : DOR means Directorate of Rivers, Ministry of Public Works
Source : Data from JICA and OECF

The economical and technical cooperation from Japan has been given since fiscal year 1970/1971 and the number of dispatched Long-term Experts is 25 persons. The number of development surveys is four cases, the total budget for grant aid from Japan International Cooperation Agency (JICA) reaches about 1.3 billion yen and the total budget for loans from Overseas Economic Cooperation Fund (OECF) reaches about 8.6 billion yen.

• Present situation of sabo works

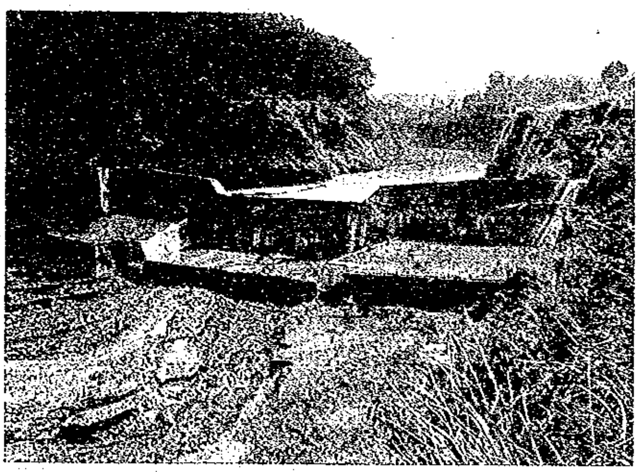


Note : Province painted with pink color means locations where sabo works have been implemented.

Sabo works are implemented by five volcanic sabo projects, three river projects and ten local governments. It has been spread over all of Indonesia except for Kalimantan and Irian Jaya islands.

• Main sabo facilities

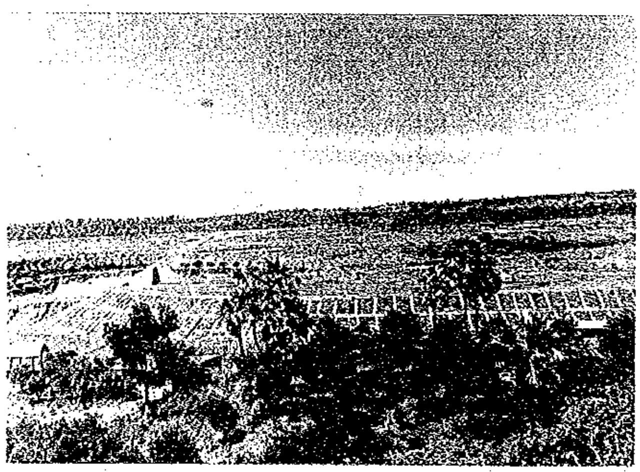
Check dam



Semut river, Mt. Kelud

Check dams are constructed to decrease the riverbed gradient as well as to directly catch the sediment outflow, to fix the foot of the hill and to control the torrential flow.

Sand pocket



Daya River, Mt. Agung.

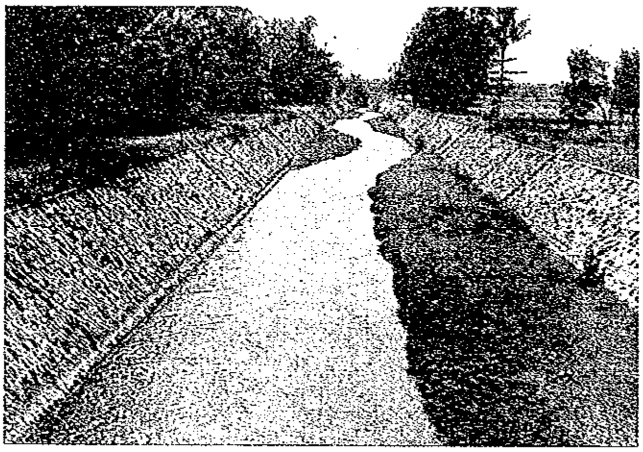
Sand pockets are constructed to catch the sediment outflow and to prevent the overflow of sediment from the alluvial fan.

Groundsill

Bebeng river, Mt. Merapi

Groundsills are generally constructed to prevent the longitudinal and lateral erosion mainly in the outflow section of sediment and to control disturbed flow.

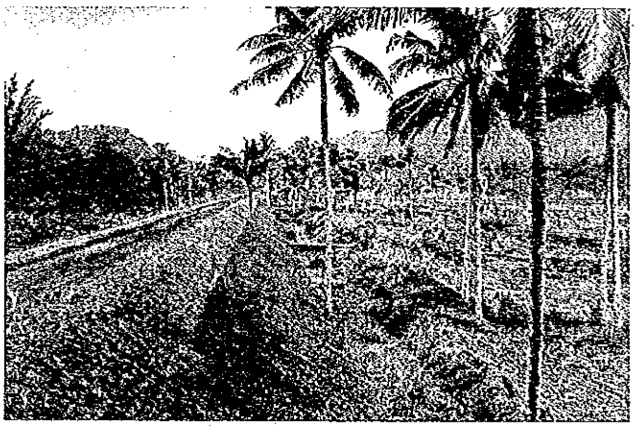
Channel work



Termas baru river, Mt. Kelud

Channel works are constructed to fix the river course and to prevent the overflow of sediment into residential areas.

Training dyke



Dyke in the middle reaches of Rejali river, Mt. Semeru

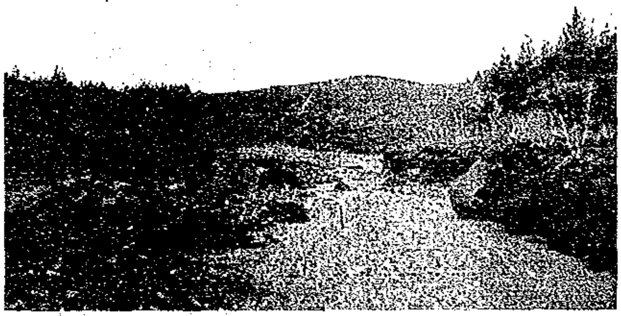
Training dykes are constructed to control the river course and to prevent the overflow of sediment into residential areas.

• Spur-dyke

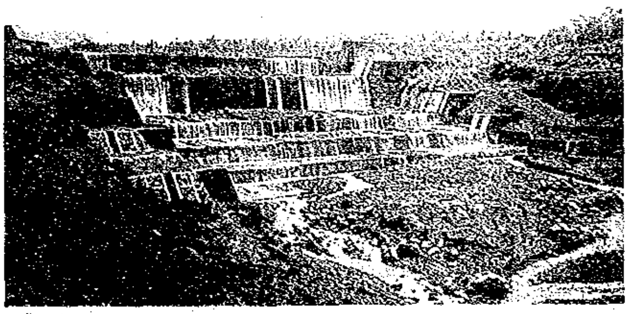
Spur-dyke is constructed to protect the revetment from local scouring and meander.

- **Volcanic sabo project**

Mt. Merapi project (Central Java)



Toe portion of nueo ardente accumulation which occured in 1984. (1988)



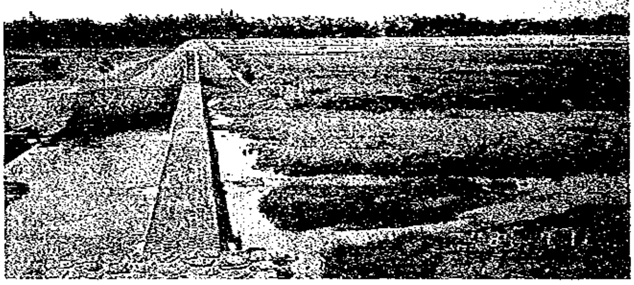
Check dam in Krasak river

Mt. Merapi is one of the most active volcanoes in Indonesia. In recent times big eruptions occurred in 1969 and 1984. At that time huge amounts of volcanic products were deposited loosely in the upper reaches of the Putih and Krasak rivers due to nuee ardente and pyroclastic flow. The sedimentation is eroded easily due to rainfall and the lahar occurs frequently.

In order to prevent the residential area from south-east to south-west of Mt. Merapi from lahar disaster as well as to control the occurrence of flooding due to the aggradation in Progo river, which is a main river of the Putih and Krasak rivers, sabo works have been commenced since fiscal year 1969/1970. Mainly sabo facilities such as check dam and training dyke have been constructed. Using the loans of about 5.2 billion yen from OECF, six steel check dams, two groundsills and 12 kms training dykes will be completed in the Putih river and Bebeng rivers for three years from fiscal year 1989/1990.

Mt. Kelud project (East Java)

Crater lake

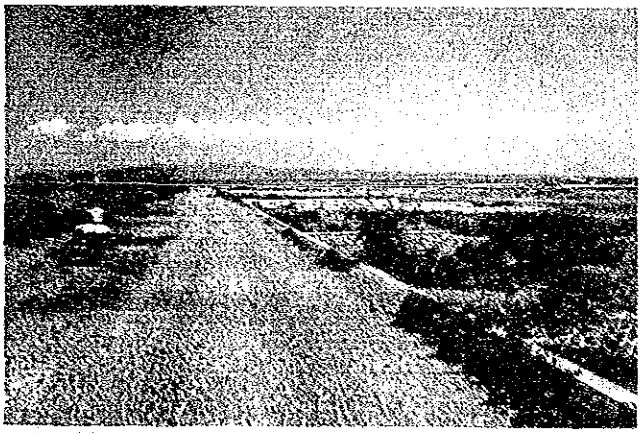


Sand pocket in Konto river

In order to prevent the residential area from north-west to the south of Mt. Kelud from lahar disaster as well as to control the occurrence of flooding due to aggradation in the Brantas river and to prevent the multipurpose dams constructed in Brantas river from sedimentation in the reservoir, sabo works have been commenced since fiscal year 1969/1970; mainly sabo facilities such as sand pockets and check dams to catch the sediment outflow and to fix the river course, respectively. As a part of the total countermeasures against sedimentation in the reservoir the excavation has been in process since fiscal year 1989/1990 in reservoirs such as the Wlingi dam by using the loans from OECF.

Mt. Agung project (Bali)

Eruption of Mt. Agung (1963)



Channel work with spur dykes in the Tukad Unda river

In order to prevent the north and south residential area of Mt. Agung from lahar and sediment disaster, sabo works have been in implementation since fiscal year 1969/1970. Mainly sabo facilities such as sand pocket and channel works have been constructed to catch the sediment outflow and to prevent the overflow of sediment into the residential areas, respectively. The Unda river, which flows out from south-west side of Mt. Agung to the Indian ocean, is only one in Indonesia at which sabo works have been implemented based on a similar sabo plan from the source area of sediment to the estuary.

Mt. Semeru project (East Java)

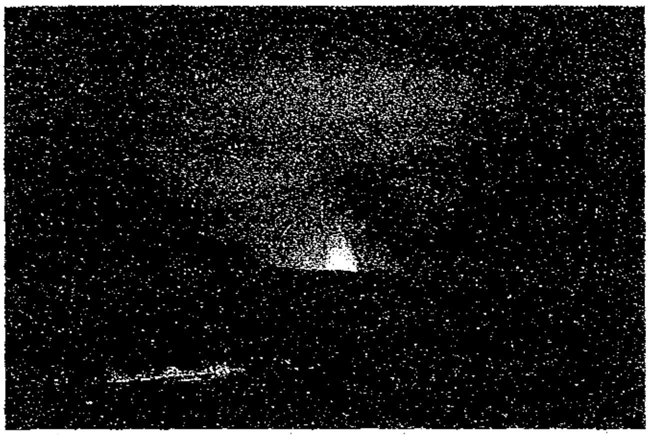
Remarkable deepening in the upper reaches or Rejali river

A training dyke and spur dyke in the Leprak river

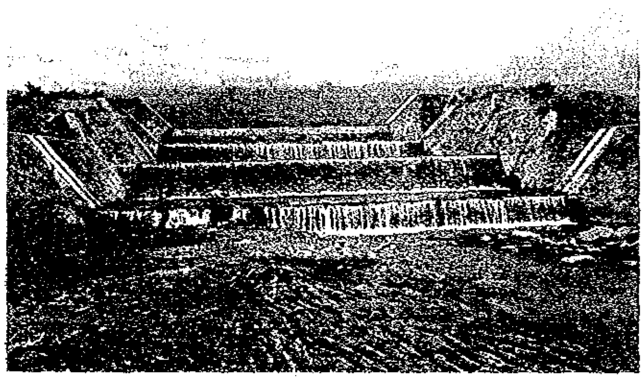
At present Mt. Semeru is the most active volcano in Indonesia, because some nuee ardente sometimes occurs in the southeastern area of Mt. Semeru at the time of eruption.

In order to prevent the southeastern residential area of Mt. Semeru from lahar disaster as well as to control the occurrence of flooding due to aggradation in the Mujur river, sabo works have been implemented since fiscal year 1977/1978. Mainly sabo facilities such as training dykes have been constructed to prevent the residential area from the overflow of lahar. The sabo works have been implemented since fiscal year 1987/1988 by using the loans of about 3.4 billion yen from OECF and the training dyke of 111 kms and the two check dams will have been completed by fiscal year 1991/1992.

Mt. Galunggung project (West Java)



Lava flow disgorged from Mt. Galunggung (18 May 1982)

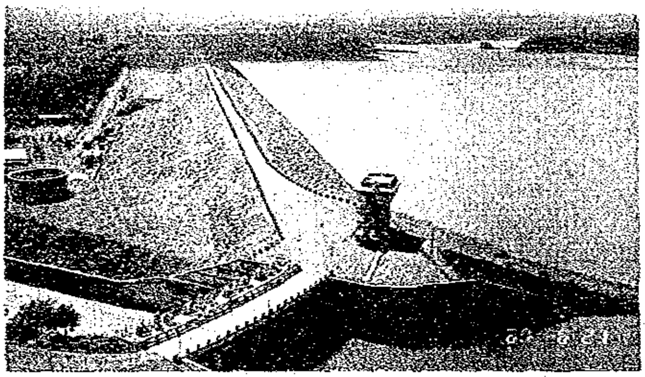


A sand pocket in the Ciloseh river

In order to prevent the residential area from the south-east to the south of Mt. Galunggung from lahar and the sediment disaster as well as to control the occurrence of flooding due to aggradation in the Cikunir and Ciloseh rivers, sabo works have been in process since fiscal year 1982/1983; mainly sabo facilities such as sand pockets and check dams to catch the sediment outflow and to fix the river course, respectively. In fiscal year 1989/1990 a master plan of sabo works was made to promote sabo works positively.

- **Sabo works in the upper reaches of a big river**

Bengawan Solo river (Central Java)



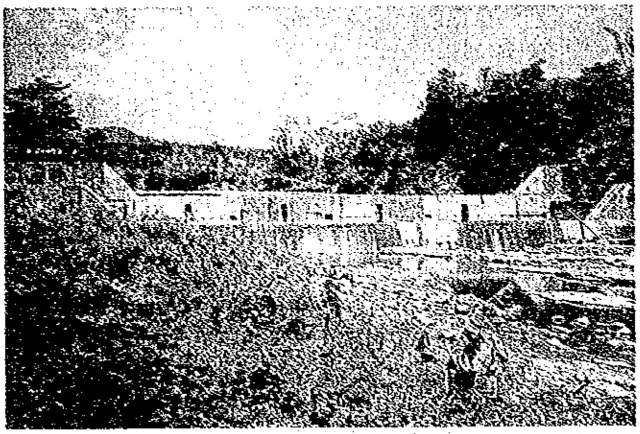
Wonogiri dam (rock-fill type) located at the upstream of Bengawan Solo river was completed in 1982.

Check dam constructed in the upper reaches of Wonogiri dam

In the upper reaches of the Bengawan Solo river, which is the most important river societally and economically, some check dams have been constructed as a part of total countermeasures against the sedimentation of the reservoir of Wonogiri dam.

Cimanuk river (West Java)

Densely populated Java island where 60% of the 178,000,000 population of Indonesia is concentrated is mountainous and intensively cultivated even up to the tops of hills. This fact results in extensive stretches of critical barrens or sparse and poor forest. The photo shows the headwaters of Cimanuk river where sheet erosion prevails.

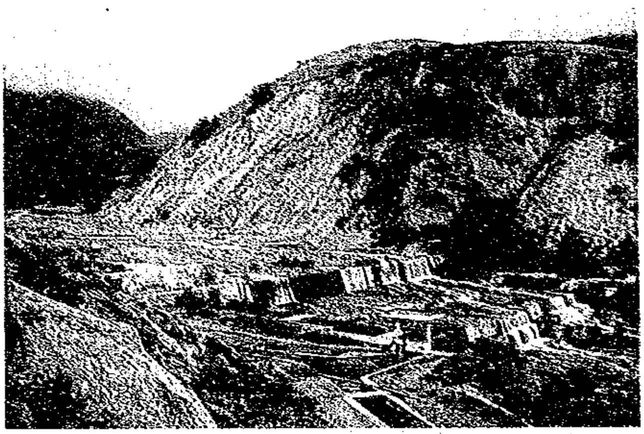


A consolidation dam in the Cimanuk river

In the upper reaches of the Cimanuk river there are many Tertiary layer areas which are very weak geologically. Hence, landslide and slope failure, which are one of the big causes of sediment yield, occur frequently. In order to prevent the upper residential areas from debrisflow and sediment disaster as well as to control the occurrence of dlooding due to aggradation in the Cimanuk river, sabo works have been implemented in the upper reaches of the Cimanuk river since fiscal year 1978/1979.

Palu river (Central Sulawesi)

Sediment scattered on the foot of an alluvial fan in the Palu river basin

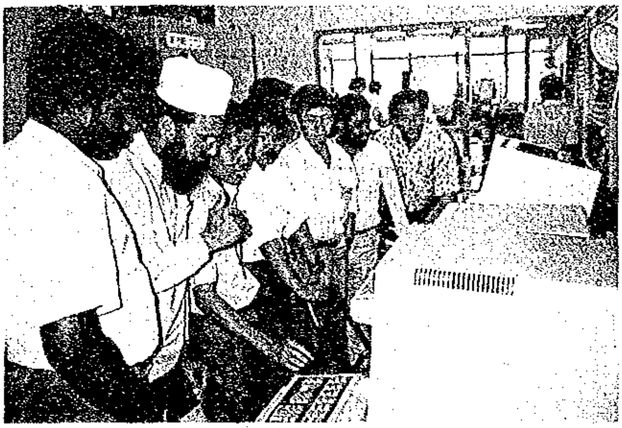


A check dam constructed on the foot of slope erosion in the Sombe river

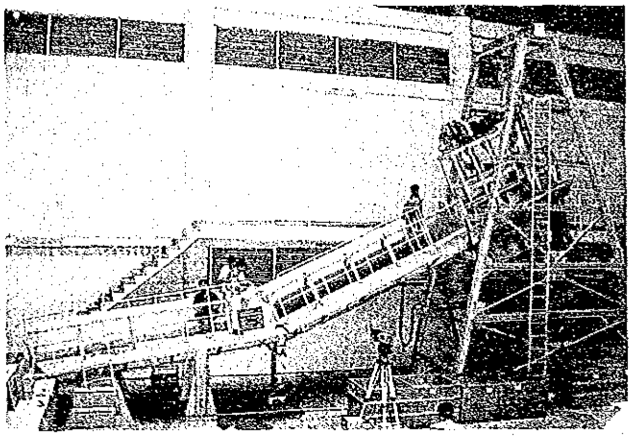
There are many slope failures along the branch river of the Palu river such as the Sombe river and they are a source of sediment yield. Also, there are typical alluvial fans between the outlet of torrential streams to the confluence of the Palu river. On the alluvial fan the river course is very unstable and the sediment flows out the the Palu river causing a secondary erosion.

In order to prevent the residential area from debris flow disaster as well as to control the occurrence of flooding due to aggradation in the Palu river, sabo works have been implemented in the branch river of the Palu river such as the Sombe river since fiscal year 1983/1984. Using the sector loans from OECF, 13 check dams were completed in fiscal years 1987/1988 and 1988/1989.

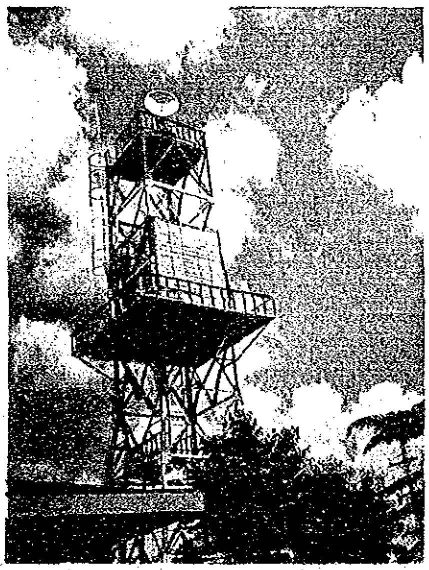
• Organization of sabo training and research



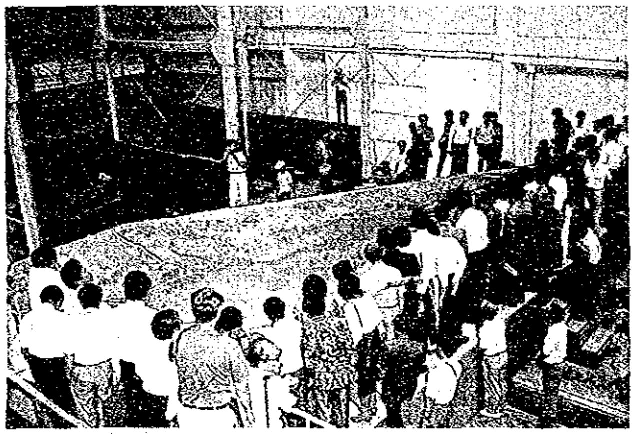
Second International Training Course on Sabo Engineering (18 January–14 February, 1990)



Hydraulic model test on mudflow occurrence and outflow mechanism by using mudflow generator



The parabolic antenna of a radar raingauge installed at VSTC to monitor the rainfall around Mt. Merapi.



A demonstrational experiment at the time of ISEV '89.

The training and technical development of sabo works have been conducted in VSTC since fiscal year 1982/1983. Three sorts of domestic training courses such as general, intensive and comprehensive ones are performed. The number of participants graduated reached 453 persons in fiscal year 1988/1989. International sabo training has been conducted since fiscal year 1988/1989. In fiscal year 1988/1989 training was conducted for about one month for the 13 participants from Sri Lanka, Thailand, Papua New Guinea, Malaysia, India and Indonesia. It will be done in VSTC every year up to fiscal year 1993/1994.

The technical development is done to develop appropriate techniques, to study countermeasures through hydraulic model tests and to establish a forecasting and warning system against lahar in the area of Mt. Merapi. Also, an international symposium on erosion and volcanic debris flow technology was held in Yogyakarta from 31 July to 2 August, 1989. The number of participants reached to 229 persons from nine countries such as Japan, America, Italy, Australia, China, New Zealand, Denmark, India and Indonesia. In VSTC the exhibition, such as a demonstrational hydraulic model test, the monitoring system for a forecasting and warning against lahar and the panel on sabo in Indonesia, was held to introduce the activity of VSTC.

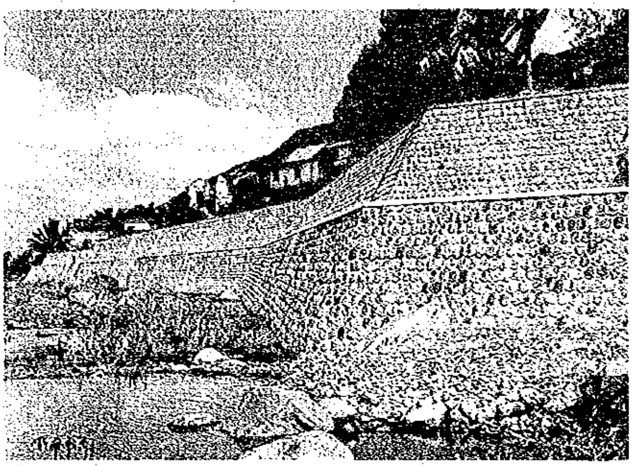
● Effects of Sabo Project

Sabo facilities such as check dams not only prevent irreplaceable lives from debris flow disaster but also secure property of inhabitants, public facilities such as roads and bridges and arable land. Sabo works give a stable base to social life and the effect to the community economy is too large to measure.

From economical effect view point, there are two kinds of effectiveness of sabo works; one of them is direct effectiveness such as the effect to human lives, general assets, public facilities and agricultural products; the other is an indirect effectiveness such as a ripple effect to the community economy.

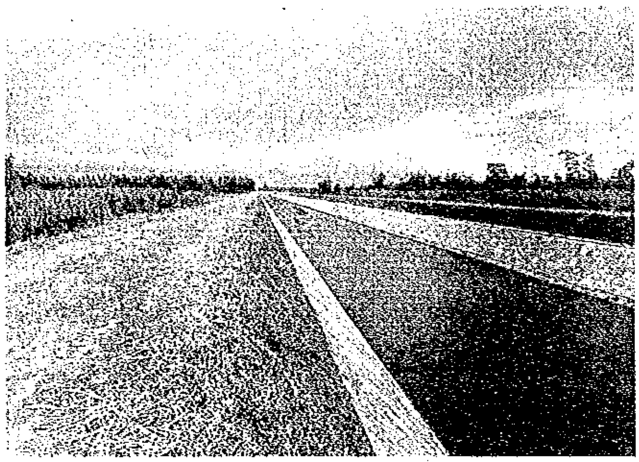
Also, sabo facilities are utilized as not only prevention of disaster but also as water intake facilities for agriculture and human life, the generation of electricity, the constructional aggregate of sediment deposited in sand pockets and the local bridges for transportation. Multiple availability of sabo facilities is done positively so as to increase the benefits as much as possible.

● Protection of human life and property



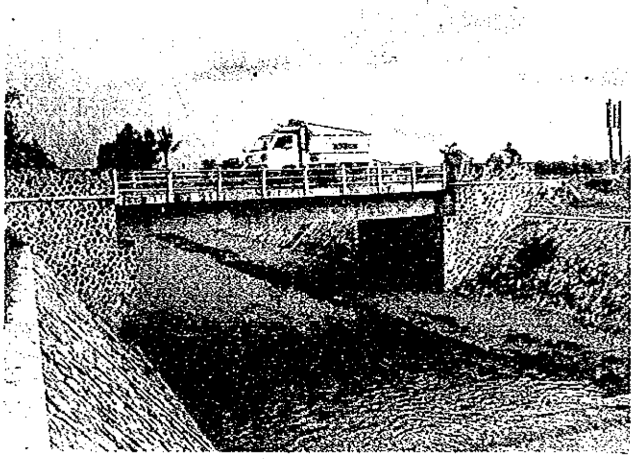
Revetment work protecting the houses located on the right bank of the Lekso river, Mt. Kelud.

● Secures arable land



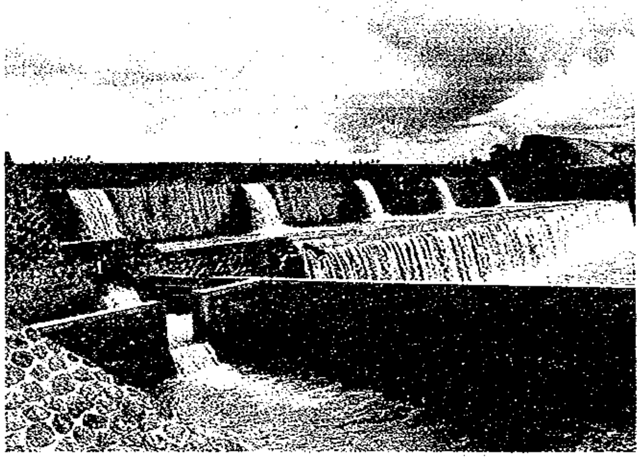
Channel work along the Termas Baru river securing the arable land and irrigation water, Mt. Kelud.

● Secures public facilities



● Multiple availability of sabo facilities

– Water intake –



Water intake attached to overflow section of sand-pocket in the Konto river, Mt. Kelud

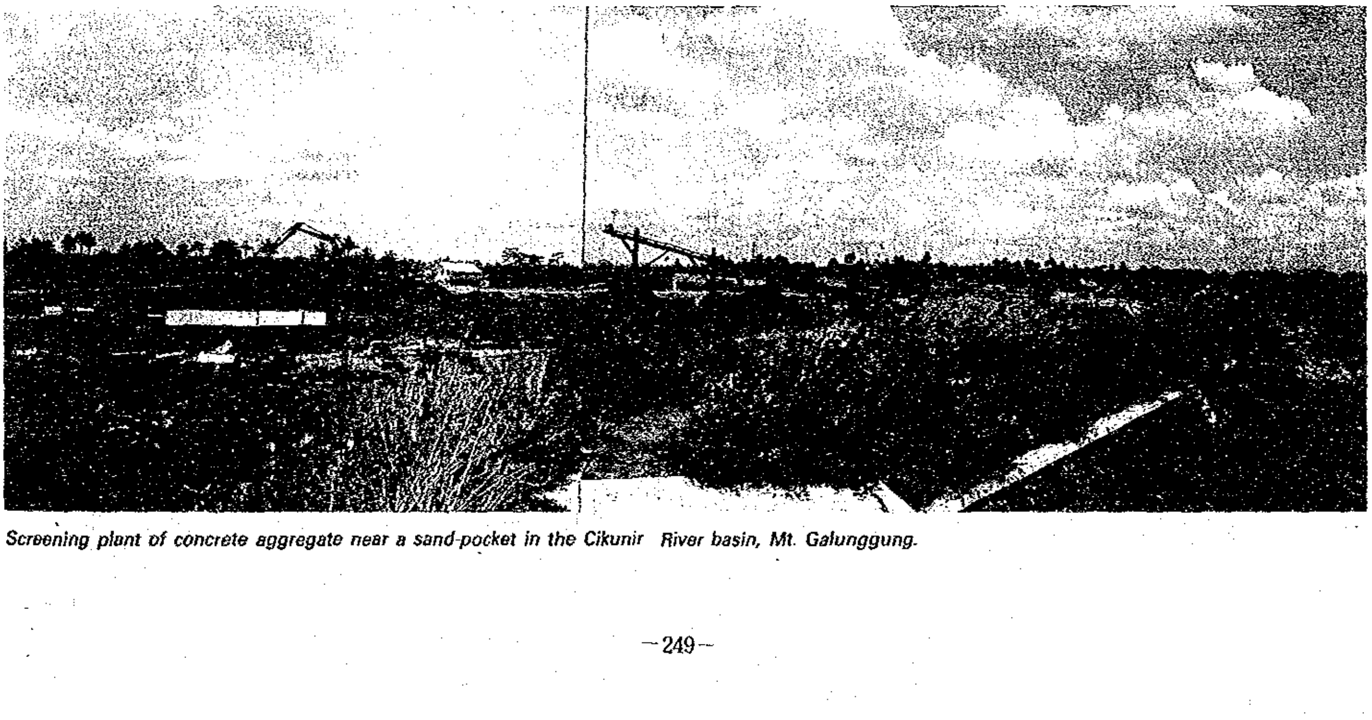
– Local transportation –

The overflow section of a groundsill with big drain holes and a gentle slope of wings functioning as a local bridge for people's daily life, Mt. Kelud.

– Generation of electricity –

A small-scale power generating equipment attached to a groundsill in the Cimanuk river basin.

– Concrete aggregate –



Screening plant of concrete aggregate near a sand-pocket in the Cikunir River basin, Mt. Galunggung.

• Pending Problems for Effective Promotion of Sabo Project

• **Secure budget of sabo works**

Recently sediment disaster such as debris flow, landslides and slope failures often occurs in not only volcanic area but also non-volcanic areas. Also the existing sabo facilities have been destroyed due to lahar or sediment flow because of the shortage of maintenance. These countermeasures are one of the emergency subjects for national land conservation. It is necessary to increase the budget of sabo works.

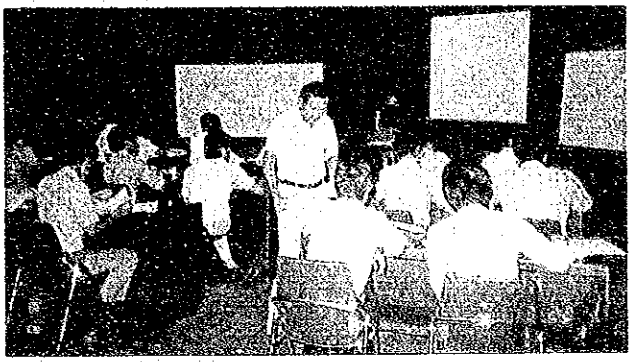
Landslide occured in the Cijolang river basin (Ciamis District)

Slope failure occured along local roads in the Cimanuk River basin.

Lost wing of check-dam due to a fierce clashing energy of lahar flow,

• **Bring up sabo-engineer**

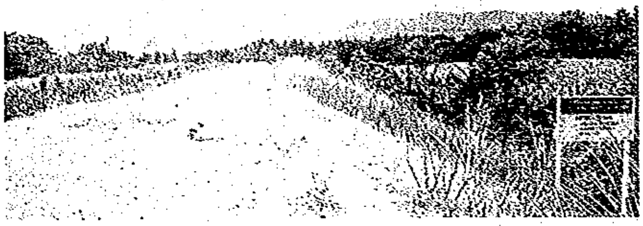
In order to further up grad the sabo technology in the future it is necessary to continue bringing sabo-engineers to VSTC.



Instruction scenery in VSTC (Second Progresive Course; 21 February – 30 March, 1989)

• **Progress of sabo technology**

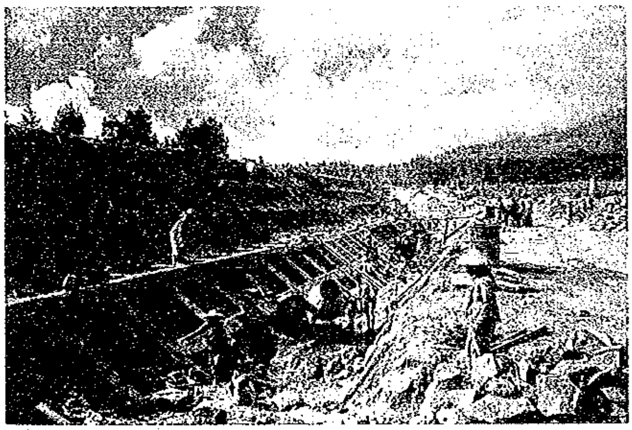
It is necessary that research on the basis of quantitative investigation in the field should be promoted so as to develop some more effective sabo technology for the disaster prevention.



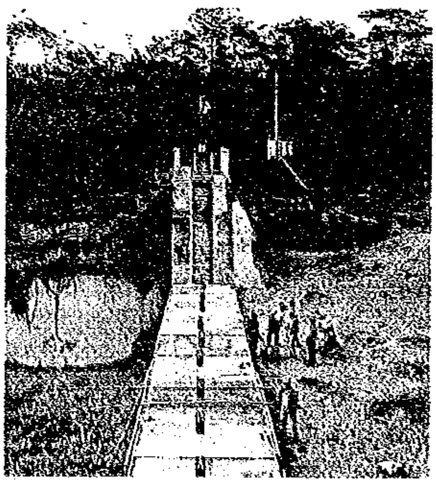
Trial planting on the slope of a sandy levee at the Simping river in the Mt. Merapi area.

• **Formulate standard for sabo techniques**

It is necessary that two kinds of standards for sabo technique, such as an all-Indonesian one and a practical manual for each project to use the standard, should be made to implement sabo works effectively.



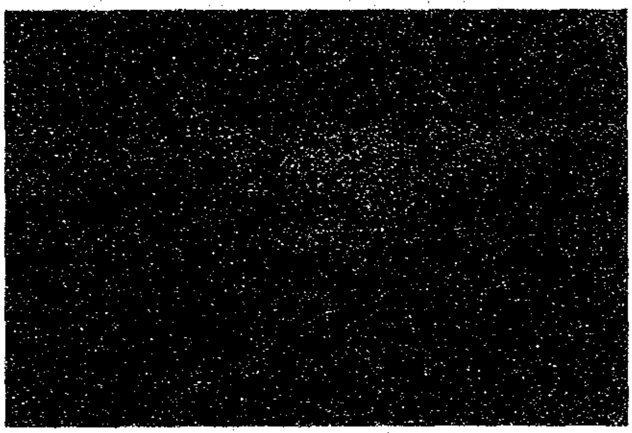
Training dyke under construction in the Mt. Merapi area.



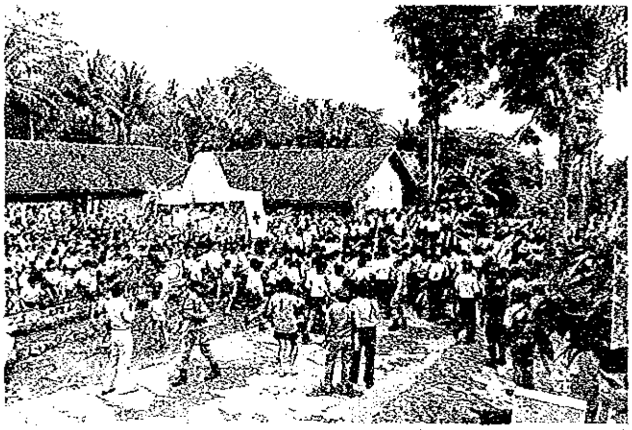
Trial test on concrete abrasion at Mranggen dam in the Mt. Merapi area

• Promote integrated countermeasures against sediment disaster

It is necessary that not only the physical countermeasures such as construction of check dams but also the non-physical countermeasures such as warning and evacuation systems for sediment disaster and the management of sabo project areas should be conducted integratively under a unity with the central government, local government and inhabitants.



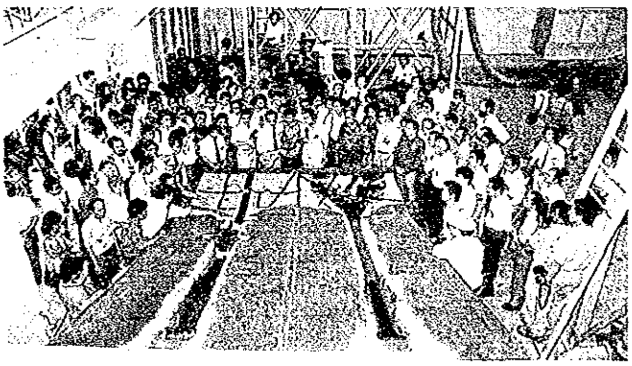
Enlarged to show the intensity of radar rainfall.
The mark ▲, quadrangle □ and blue line show the top of Mt. Merapi, the observation stations concerned and the rivercourse, respectively



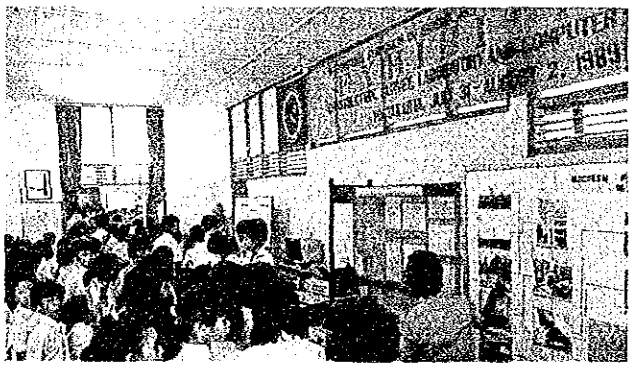
Evacuation drill against lahar in the Mt. Merapi area. (12 January, 1989).

• Promote publicity of activities of sabo projects

In order to up grade the disaster prevention knowledge of inhabitants and elementary and junior high school students in the area in danger of sediment disaster and to deduce the damage due to sediment disaster as much as possible through up grading a self-security consciousness, it is necessary to promote the publicity of activities of sabo projects positively.



Demonstrational experiment to show the effect of sabo works (VSTC).



Exhibition of VSTC activities for junior high school students.

• Prospect of Sabo Works

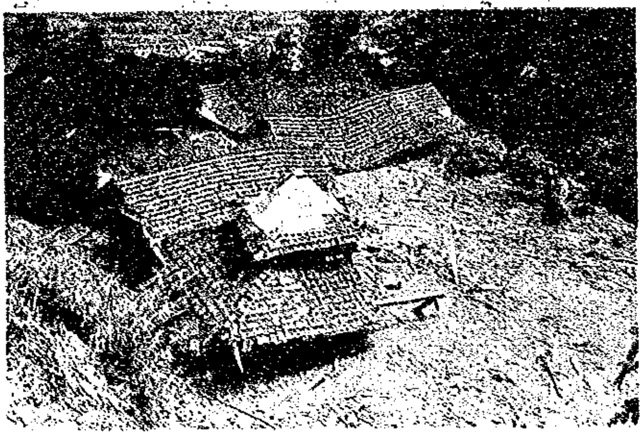
It may be alright to say that natural disaster, particularly due to debris/mudflows and landslides will tend in the near future to occur much more with lapse of time; because the land in this country is now rapidly developing and will be intensively exploited at places in accordance with the increase of population as well as the promotion of industry. In general, it is greatly difficult that development programmes, whether governmental or private, are accompanied by deliberate measures providing for natural disaster such as development programme to focus its point at merely the given development purpose.

This is the origin of disaster prevention works which cannot be helped but properly implemented by the governmental authorities. Sabo-works cannot be independent from this fact; still more, the principle of sabo-works consists in this fact.

From such an essential point of view, sabo-works in this country can not be negligible in the Ministry of Public Works. Besides the countermeasures to cope with occasional eruptions of volcanoes and their sequential disasters, we still have a lot of components entangled in sabo-works. Here, some of them can be introduced as follows :

1). Countermeasures against landslides

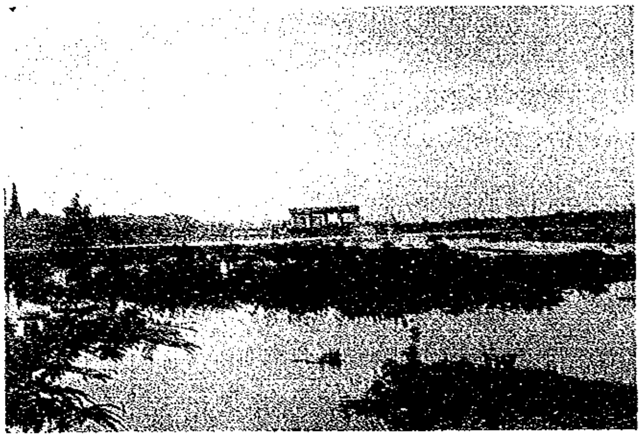
Various kinds of landslides are tend to increase these days in this country. Among them, it is impossible to leave untreated those landslides that directly hit the infrastructures. As a matter of fact, applicable technology of sabo-engineering is not yet brought into practise much. While the countermeasures against small-scale landslides in remote mountainous ranges are not always the objectives of sabo-engineering implemented by the Ministry of Public Works, they are to be managed by the Ministry of Agriculture or the Ministry of Forestry. On the contrary, such landslides as blocking up main roads and desposed by dint of the Ministry of Public Works which are competent authorities for the application of sabo-technology. It is predicted that the more industrialized the land of a nation, the more seriously damaged the facilities; the phenomena of landslide cannot be taken as an exceptional.



Temanggung landslide (Central Java)
Irreplaceable human lifes of 31 persons were lost in an instant due to landslide occured in Temanggung village. on 26 January, 1990.

2). Countermeasures for sedimentation in reservoirs

Some of the rather big-scale reservoirs of multi-purpose dams constructed in the last twenty years are currently suffering from excessive sedimentation. Shortened working-life of those reservoirs means the deficit of expected profits, necessarily. For instance, the situation of reservoirs provided by the Wonogiri dam or the Wlingi dam cannot be optimistic to us. The experienced and usual method of sabo-works should be extended to the small streams flowing into reservoirs, based upon a certain overall plan. In practice, those may consist of a few low-dams and a series of groundsills; and the cost will be reasonable as compared with total investment.



A big sedimentation in Wlingi Reservoir (Brantas river).

3) Embarkation on systematic sediment control throughout a basin

Apart from the sedimentation in reservoirs, we also suffer from sediment accumulation in the river channel which is called "aggradation" as well as lowering of riverbeds called "degradation", even in the same river depending upon the place and the time. The phenomena of riverbed fluctuation at a certain point or in a certain specific section of a river course might be physically discussed and analyzed to some extent and actually we have a few kinds of mathematical expressions, though they are of little use in terms of practical application. The problem, however, might not be solved in the end without incorporating the concept of "sediment supply or inflow" from upstream to the section in question. In this respect, we should remember the principle of propagation of degradation from upstream to downstream — up to estuary — on the condition that there is no newly-yielded supply of sediment in the headwaters.

In a practical sense, although the problems involved are not easy to figure out, it is essential to set up the fundamental policy and to materialize some pragmatic measures, even provisionally. Degradation in the lower reaches of the Brantas river and aggradation in the upper reaches of the Solo river (K. Dengkeng or K. Madiun) exactly exemplify the problems on which we should embark.

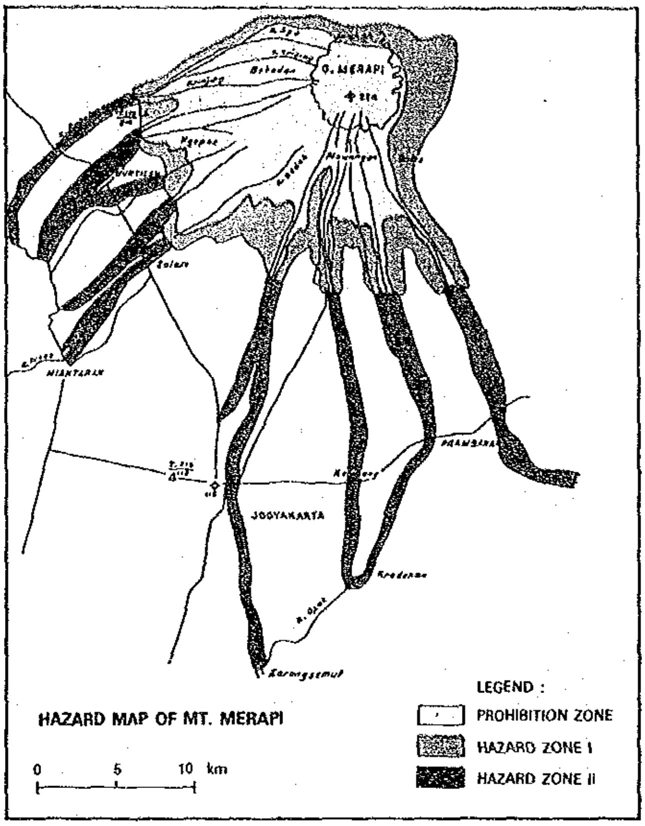
The establishment of a united and systematic method for sediment control will call for a better comprehension by river-engineers and irrigation-engineers.

4) Approach to hazard-zoning/designation of areas

All the countermeasures for sediment control are not composed of application of civil-engineering methods, as a matter of course. The significance of hazard zoning or the areal designation of hazards against a probable occurrence of debris/mudflows and landslides should be deliberately taken into account because the land utilization is rapidly developing in this country. Experienced specialists in this field and geologists or geomorphologists are needed to be mobilized to the purpose. Such tasks may be impossible to extend to all the areas. Identified areas of importance in terms of socio-economy may be chosen towards the formulation of technical criteria applicable to other areas.

For the hazardous areas at the foot of active volcanoes it is apparent that the effort of VSI (Volcanic Survey of Indonesia) over tens of years has already produced kinds of hazard maps for almost all the volcanoes and actually they are publicized. However, in accordance with the progress of scientific study as well as social development, it seems that all of them are not proper to the current situations. New approachs may be necessary and some modifications of them will meet the demands of the community.

In this respect, radar-raingauge and telemeterized lahar-observation systems which are now trially in operation at the foot the Merapi volcano, is naturally expected to contribute further to other areas.



Source : Directorate of Volcanology, Ministry of Mining and Energy, Basic data on active volcanoes in Indonesia, 1979, Jakarta

5). Application of erosion-control technology to environmental issues

So long as the erosion-control aims at providing the supporting base of reforestation/afforestation with which we could protect the space of human-living, it has a close relationship with so-called environmental issues on which those concerned are focussing their viewpoint on a global scale. The more dense the population is, the more intensive is the use of hilly suburban areas near the industrialized cities and towns. If we want to maintain a better environment for the place of human activities and living, we cannot but apply the erosion/sediment-control technology. This is entirely parallel to a direction of keeping the ecological environment well around the human-living space. It is believed that there is still a wide room of application of erosion/sediment control technology capable of contributing to environmental issues.

Thus, the prospect of erosion/sediment-control technology is promising as well as should be delivered from a far sighted point of view, even in difficulties of governmental finance.

12 August, 1978

28 July, 1985

Before Mt. Galunggung eruption of 1982 (S = 1/500,000)

After Mt. Galunggung eruption of 1982

Comparing with two pieces of satellite photographs, it is clear that the big scale of sedimentation occured on the eastern fun of Mt. Galunggung after eruption.

Offered by : REMOTE SENSING ENGINEERING PROJECT PHASE II, MINISTRY OF PUBLIC WORKS

Published in 1990 by Volcanic Sabo Technical Centre (VSTC)
Directorate of Rivers,
Directorate General of Water Resources Development,
Ministry of Public Works;
Under the auspices of Japan International Cooperation Agency (JICA)

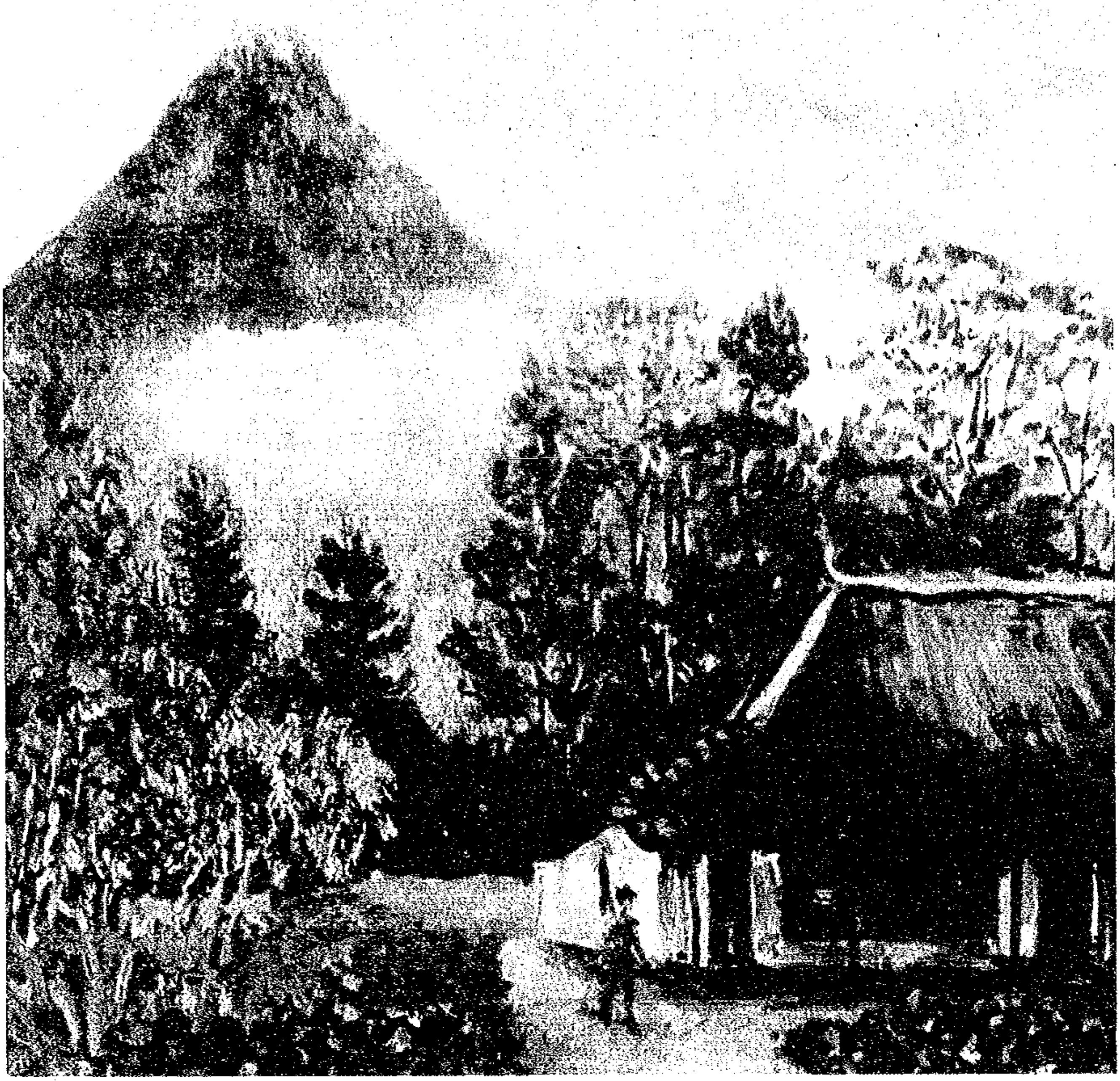
Covering photograph shows a nuee ardente occured
in Mt. Semeru on June, 1989

附属資料9.

VSTC

VOLCANIC SABO TECHNICAL CENTRE

Organization & Functions
1989



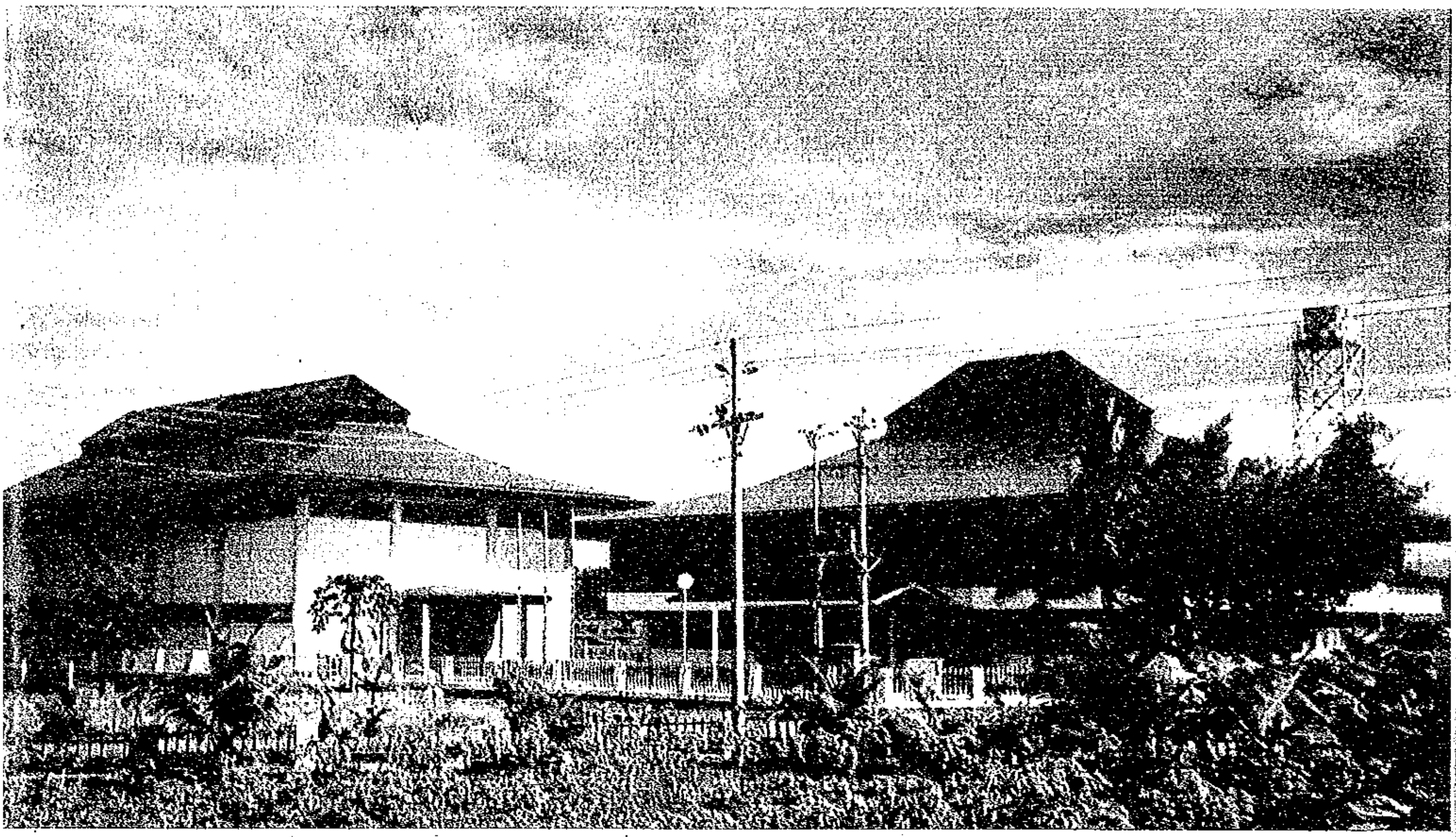
Simple life, entrusting Nature with one's Fortune, on the slope of Mt. Merapi *Painted by : T. Hirozumi*
Chief Advisor of VSTC

Comment : Whatever severe and capricious sometimes the Providence may be, people have been living on the hazardous flank of active volcano with their forgetful mind as well as strong will of livelihood.

Meanwhile, the restoration of the nature, even after an eruption, is really marvellous in tropical climate but for accelerated activity of mankind. Besides, we have already learnt that most risky zone around volcano is unexpectedly small as compared to all the area of devastated land in general sense of the meaning.

It is true that sabo works dealt with us are deeply involved into those facts. I believe we should begin with the nature study despite of our powerful technique of engineering.

Foreword



The more intensively develops the land, the more carefully it should be conserved. This fundamental principle of land-use will be immutable so long as human beings live on the earth.

The significance of sabo works must be recognized in a real sense of this principle. It is quite obvious for us that the dense population, intensive land-use and the reinteration of disaster in this country are deeply related to each other.

Under such circumstances Volcanic Sabo Technical Centre has been established with a view to bring up executive sabo engineers as well as to introduce sabo technology proper to Indonesia. The fact can be said significant and commemorative.

Sabo engineering originally has two aspects of subjects, namely physical/mechanical and vegetative/sylvan way of construction. Both of the ways inevitably must be supported by a lot of basic lessons and various natural sciences such as mechanics, hydraulics, hydrology, geology, geomorphology, vegetation ecology, forestry and so on. This means that sabo works should be planned and implemented in such a direction as being orientated on better understanding of natural conditions involved.

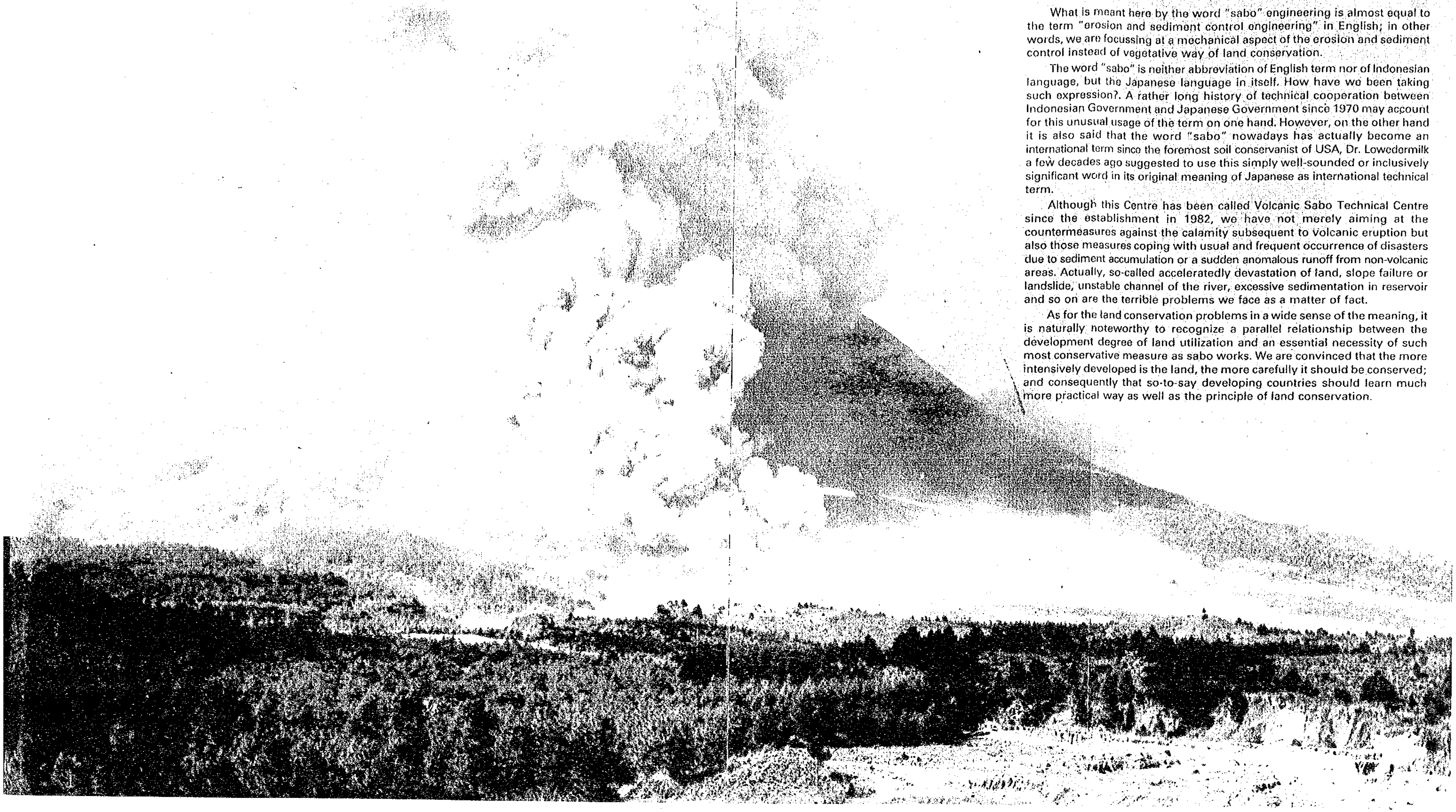
In this connection the role that Volcanic Sabo Technical Centre should play is thought to be big and grave.

The activities and functions of the Centre are really hoped to be superior to other similar ones.

Head of VSTC

Ir. Djoko Legowo, Dip.HE

Welcome to VSTC



Introduction

What is meant here by the word "sabo" engineering is almost equal to the term "erosion and sediment control engineering" in English; in other words, we are focussing at a mechanical aspect of the erosion and sediment control instead of vegetative way of land conservation.

The word "sabo" is neither abbreviation of English term nor of Indonesian language, but the Japanese language in itself. How have we been taking such expression?. A rather long history of technical cooperation between Indonesian Government and Japanese Government since 1970 may account for this unusual usage of the term on one hand. However, on the other hand it is also said that the word "sabo" nowadays has actually become an international term since the foremost soil conservanist of USA, Dr. Lowedermilk a few decades ago suggested to use this simply well-sounded or inclusively significant word in its original meaning of Japanese as international technical term.

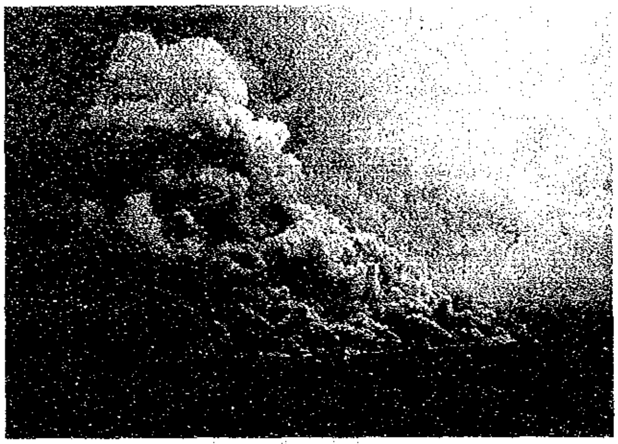
Although this Centre has been called Volcanic Sabo Technical Centre since the establishment in 1982, we have not merely aiming at the countermeasures against the calamity subsequent to volcanic eruption but also those measures coping with usual and frequent occurrence of disasters due to sediment accumulation or a sudden anomalous runoff from non-volcanic areas. Actually, so-called acceleratedly devastation of land, slope failure or landslide, unstable channel of the river, excessive sedimentation in reservoir and so on are the terrible problems we face as a matter of fact.

As for the land conservation problems in a wide sense of the meaning, it is naturally noteworthy to recognize a parallel relationship between the development degree of land utilization and an essential necessity of such most conservative measure as sabo works. We are convinced that the more intensively developed is the land, the more carefully it should be conserved; and consequently that so-to-say developing countries should learn much more practical way as well as the principle of land conservation.

Background of Establishment

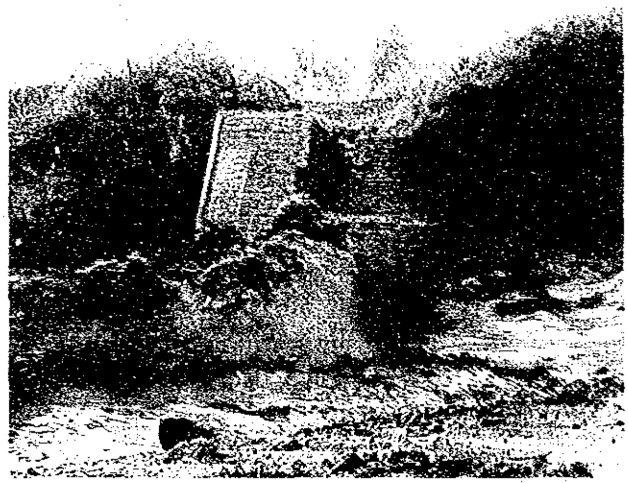
Indonesian archipelago is originally destined to suffer from occasional catastrophy of the nature because of parallel existence of so-called Circum Pacific volcanic belt. In this country there are a large number of historic records of volcanic calamity, and the deposit of volcanic efflux — even after the cease of eruption — affects badly on the environmental condition of the rivers downstream. On the top of that, some parts of this country have been consecutively troubled by the devastation of land because of intensive landuse coming from its dense population.

From the nineteen-sixties to nineteen-seventies there happened to occur a series of volcano eruptions at places and we were, as a matter of fact, faced to difficulties in setting out the effective countermeasure in those days. Thus, the Government of Indonesia commenced technical cooperation of sabo engineering with the Government of Japan in 1970. Through the practical and precious experience of the field works extending over ten years we had attained to a certain degree of technology, but at the same time we recognized the necessity of further study in view of the importance of problems involved.



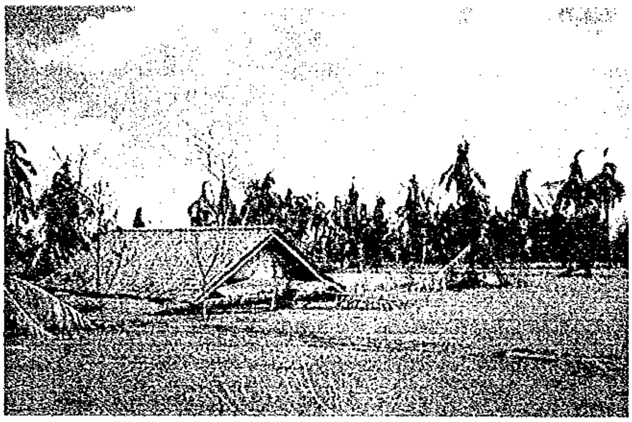
Eruption of Mt. Semeru (10 May 1988)

Hot lahar flow in the Besuk Bang River, Mt. Semeru



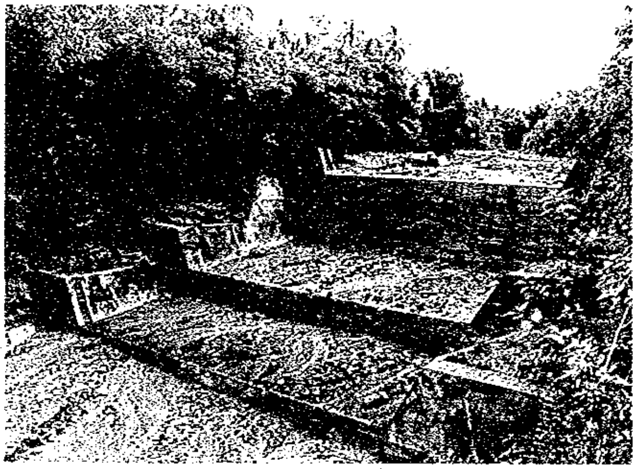
Leprak No. 1 Check Dam struck by lahar flow, Mt. Semeru (January 1986)

The Government of Indonesia established the Volcanic Sabo Technical Centre in 1982 as a link in the chain of technical cooperation with the Government of Japan with a view to develop her traditional way of erosion and sediment control technique. As matter of fact, it was motivated by the shortage of engineers specialized in sabo technology as well as the actual necessity for further application of technology. At that time we had five projects particular to sabo works and many other projects concerned to the similar works including those works executed in non-volcanic areas. Circumstances at this moment of the time are the same or much more.

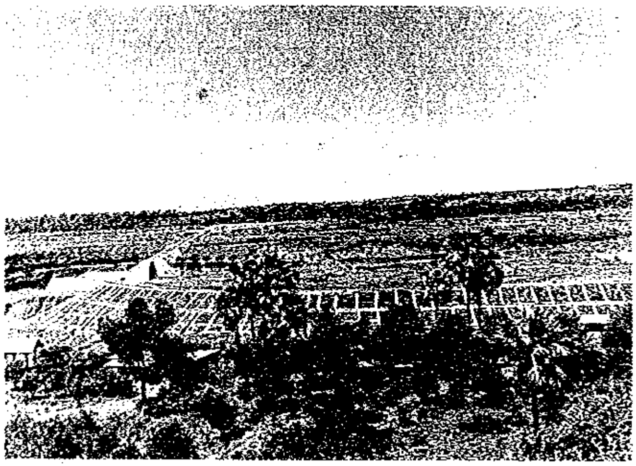


Buried houses due to lahar flow, Mt. Galunggung (1982)

Lost wing of check-dam due to a fierce clashing energy of lahar flow, Mt. Semeru



Check-dam in the Gendol River, Mt. Merapi



Daya River, Mt. Agung

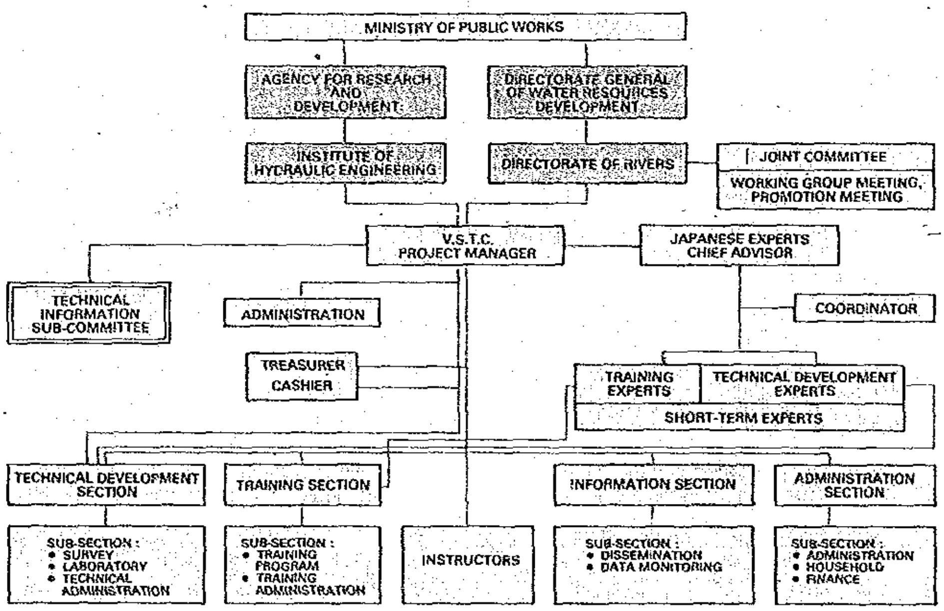
Organization

□ Organization Chart As of October 1, 1988

The VSTC is sub ordinated to Directorate of Rivers, Directorate General of Water Resources Development and at the same time belonging to Institute of Hydraulic Engineering. The former is called Training Centre Project of Countermeasure for Volcano (Proyek Pusat Latihan Penanggulangan Gunung Berapi), the latter is Research Centre for Sediment Control Works (Balai Penyelidikan Bangunan Penahan Sedimen). Despite of such apparently duplicated organization, the actual activities can be said to be smoothly practiced as a matter of fact.

The VSTC office consists of five sections that are in charge of such matters as mentioned below, under the surveillance of Directorate of Rivers (Jakarta) as well as Hydraulic Engineering Institute (Bandung).

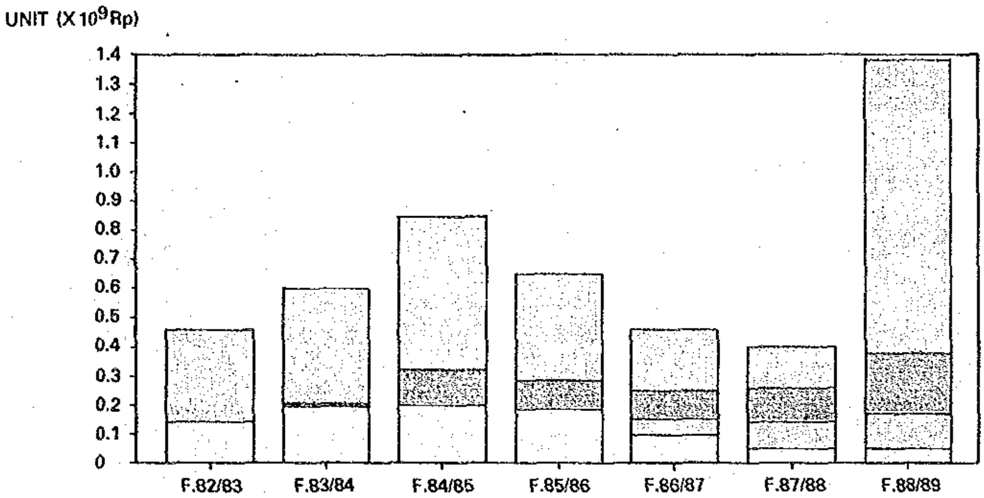
- Technical Development Section
  - Development of appropriate method of construction
  - Development of lahar forecasting and warning system
  - Maintenance of equipment
- Training Section
  - Periodical implementation of training program with two to three kinds of Courses
- Information Section
  - Dissemination of essential matters through publicity activities
  - Exchange of manifold technical information among those concerned to sabo engineering
  - Arrangement for data bank
- Administration Section
  - Managerial matters in general
  - Financial matters and budget allocation
  - General matters related to personnel welfare
- Treasure, Cashier
  - Account book-keeping
  - Receipts and Disbursement



Budget

□ Transition of VSTC Budget

Volcanic Sabo Technical Centre budget consists of Project budget from Directorate General of Water Resources Development, Routine budget from Agency for Research and Development, Project and Equipment budget from JICA (Japan International Cooperation Agency).



REMARKS :

- PROJECT BUDGET FROM DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
- ROUTINE BUDGET FROM FOR RESEARCH AND DEVELOPMENT
- PROJECT BUDGET FROM JICA
- EQUIPMENT BUDGET FROM JICA

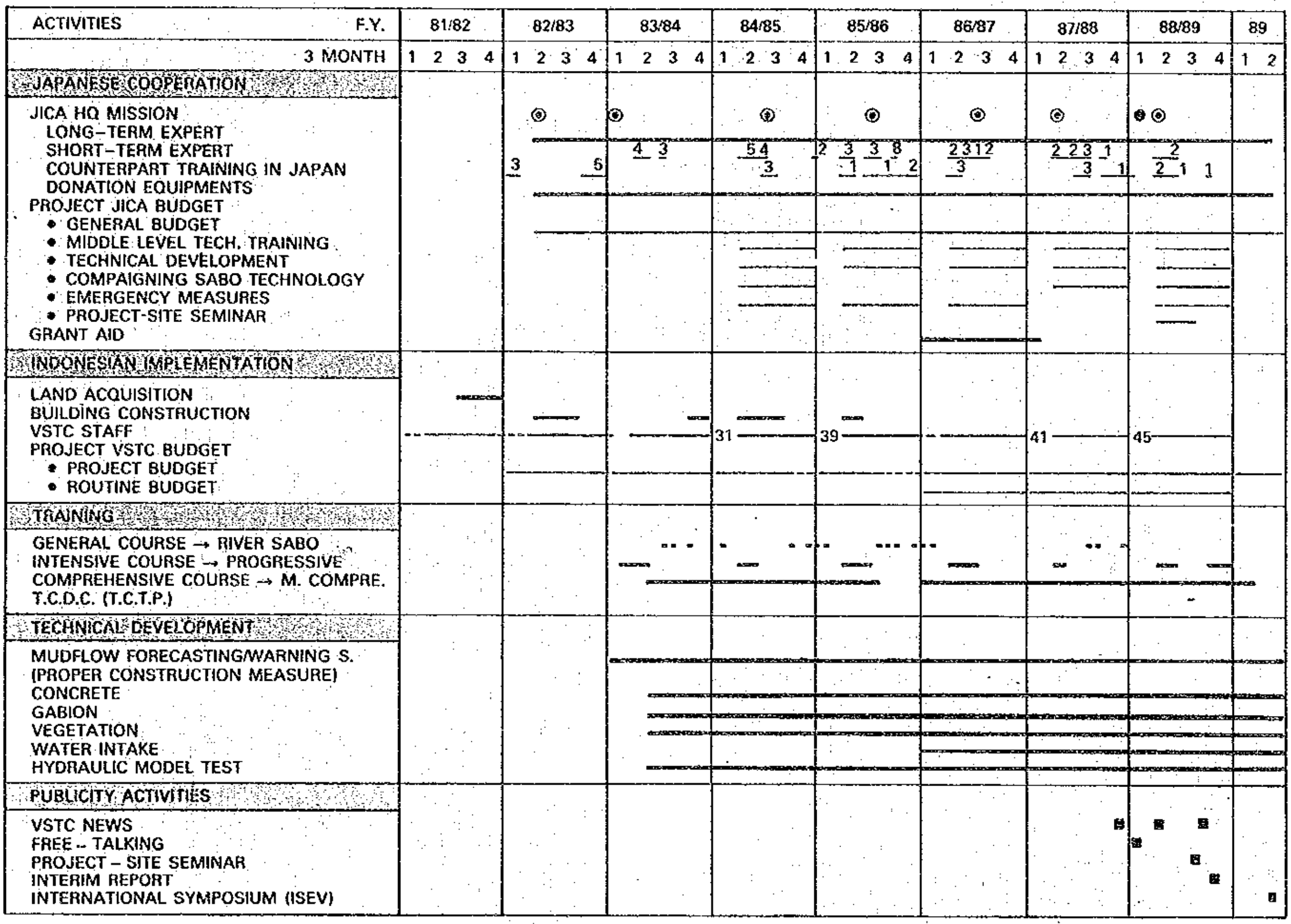
TRANSITION OF VSTC BUDGET — UNIT: Rp.X1000

	F.Y.82/83	F.Y.83/84	F.Y.84/85	F.Y.85/86	F.Y.86/87	F.Y.87/88	F.Y.88/89
PB VSTC	142.160	195,850	195,480	174,461	93,000	47,634	47,000
RB VSTC	0	0	0	0	50,700	85,700	120,305
LB JICA	2,528	9,643	124,542	106,446	97,184	113,942	206,087
EB JICA	315,943	397,556	533,785	356,224	210,394	147,200	1.012,970
TOTAL	460,631	603,049	853,807	637,131	451,279	394,476	1,386,362
1 Yen = Rp.	3.80	4.00	4.30	4.40	7.14	11.50	13.00
Grant Aid from JICA						9.630.000	

Functions of VSTC

The VSTC has three of the functions: training, technical development program and publicity activity. Training activity has been consecutively conducted since 1983/1984 until it enable the implementation of TCTP in the frame of TCDC. Meantime, for the consequence of the technical development program it is hardly possible to express briefly because of complicated and sophisticated components involved in. In short, it can be said the program has just started from long-term point of view. The subjects of program are shown below.
As for the publicity activity it is full of the schedule all the time in spite of less personnel in number as well as little experience.

□ Activity and Schedule of VSTC Project



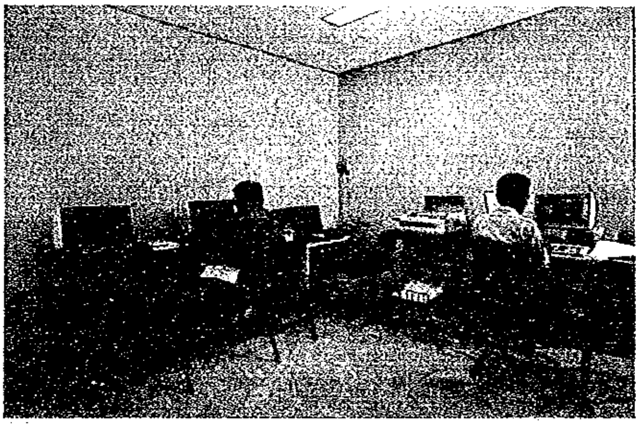
Progress of Activities

□ Training Programme

We have been running three sorts of domestic training courses since 1983. They are : General Course for one month to give the participants fundamental knowledge and wider understandings of sabo works; Intensive Course for four months to train executive engineers capable of solving actual problems concerned; Comprehensive Course with the duration period of two years for the purpose of training those promising participants who will be able to formulate overall plan and working out detail design. The result of domestic training activities so far can be tabulated as follows :

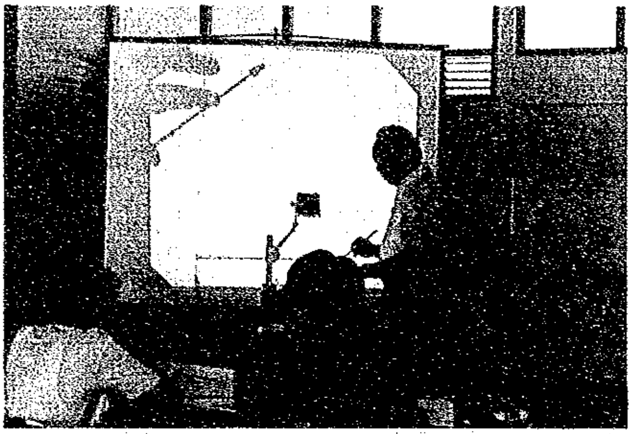
COURSE	IMPLEMENTATION RESULT (AT THE END OF MARCH 1988)			
	PERIOD	TOTAL TIMES	TOTAL NUMBER OF PARTICIPANTS	REMARKS
GENERAL (SABO)	1 month	12	Ir : 30 BE : 120 STM : 77	Two to three times a year
GENERAL (RIVER & SABO)	1 month	2	Ir : 8 BE : 32	Combined course with river-engineering
INTENSIVE	4 months	5	Ir : 66 BE : 4	Once a year
COMPREHENSIVE	2 years	2	Ir : 12	
			Ir : 116 BE : 156 STM : 77 Total : 349	

Notes:
Ir : qualified engineers graduated from universities
BE : engineers graduated from collages or equivalents
STM : experienced technicians after finishing high schools



Computer Room

Throughout the implementation of the courses, we have been impressed with their eagerness and positive attitude, especially for practices and exercises of the lessons. At any rate, it can be said that they must have attained to a basic level or applicable standard of sabo technique as well as its fundamentals.



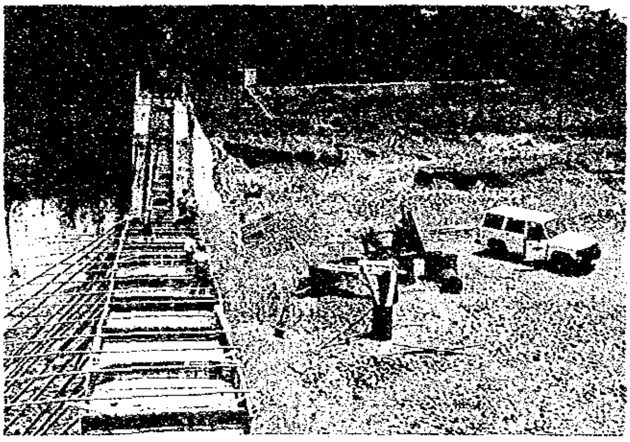
Lecture activity

Field observation

□ Technical Development Programme

With a view to expand or level up the applicability of technology and to set up an appropriate technique to Indonesia, we have been conducting the following study by the name of Technical Development Programme in parallel with the abovementioned training activities.

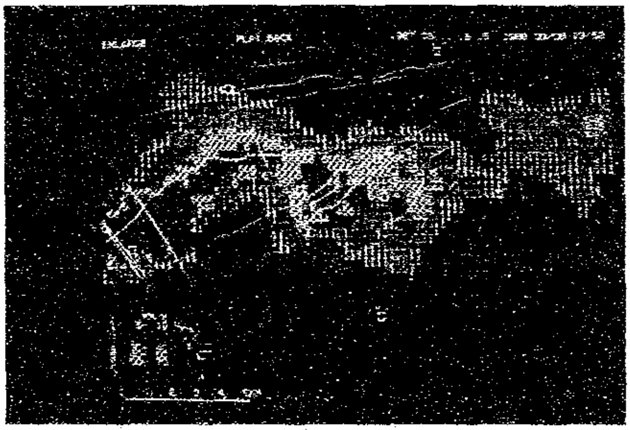
- Special mix-proportion of concrete for the protection of sabo-dam spillway from a fierce abrasive force of debris/mudflow
- Manifold application of gabions as an example of low cost and flexible way of construction in the stream channel
- Introduction of vegetation into levee or dyke for the purpose of reinforcement of earth-work
- Bilateral utilization of low dam for both purpose of water intake and sediment control
- Analysis of hydrological data given by radar-telemetering equipments for the establishment of mudflow forecasting and warning system, as a pilot project



Under construction of concrete field test at the Mranggen Dam in the Putih River (F.Y. 1987/1988)

Measurement of vegetation growth in the Simping River, Mt. Merapi

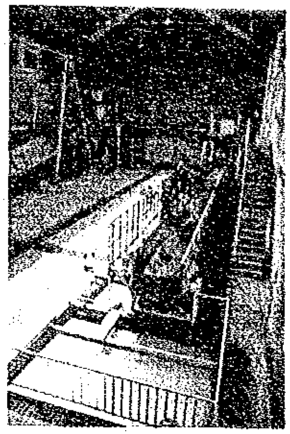
Gabion mesh used Chaznlink Machine



Radar Display

- Hydraulic model test, especially of the torrential flow accompanied by sediment load.

Because of limitation of available equipment as well as less appropriation of the necessary budget, it is natural that we have not accomplished the final purpose of these study items yet. However, it might be safe to say that we have already made a little of approach for each item and we hope that those obtained results might be presented in near future. We are convinced that these activites could grade up the level of training itself, on the other hand.



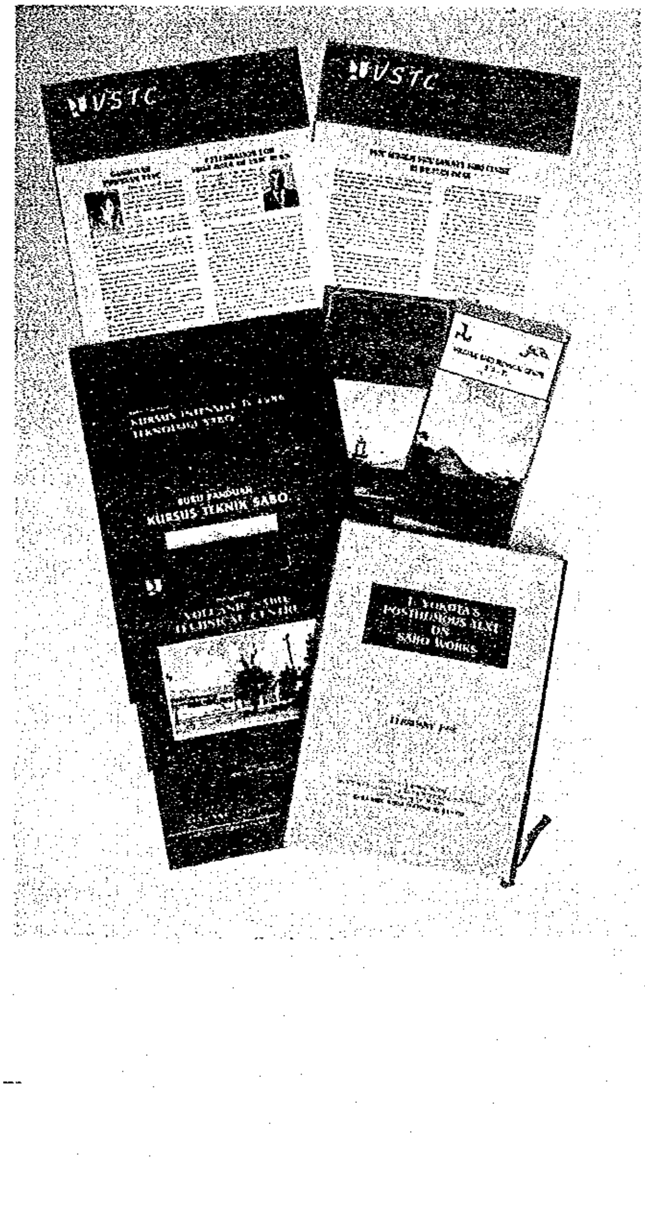
Model Flume 20 m in length

□ Information Programme

Taking the point that sabo works are apt to be left behind the other beneficial development works into our consideration, we also have been trying to make a chance of public relations so as to publicize our situations as well as rejuvenate our works. Such activities as publishing an organ (VSTC News) and holding a discussion meeting (Free Talking on Sabo) have been realized already. We think that it is greatly significant to find a response in the consequences of our activities.

Within this year it is scheduled for us to organize a seminar on the land conservation matters by way of inviting a considerable number of professors or scholars from universities and institutes, those officials concerned from the governmental agencies, some of representatives of international cooperation agencies. We are anxious for discussion together with them and at the same time for listening to their explicit opinions.

Meanwhile, it is also scheduled to establish the International Symposium on sediment control problems at this Centre, in July-August 1989. We are now providing for the details of schedule and expecting a fruitfull result.

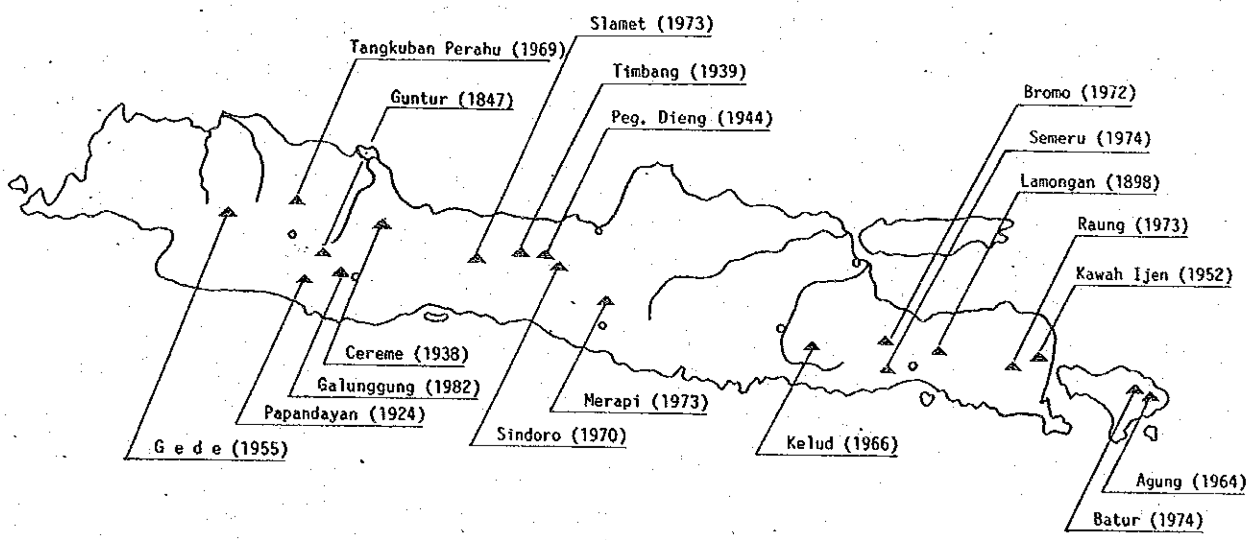


□ Collaboration with other Universities and Institutes

Since the sabo technology essentially has a remarkable aspect that it is integrated or synthetic technique of those various science as extending from forestry, geology, geomorphology, geophysics, agriculture up to general civil engineering, we always endeavour to invite those influential lecturers from leading universities and institutes besides the routine acceptance of several experts dispatched from the Government of Japan through Japan International Cooperation Agency (JICA). Gadjah Mada University in Yogyakarta has been dispatching a large number of lecturers besides the lecturers from within Directorate of Rivers. Lecturers come from Faculty of Science, Forestry, Agriculture and Engineering in the main. Also Mt. Merapi Laboratory of Volcanology (Yogyakarta), Institute of Hydraulic Engineering (Bandung) and Hydraulic Experimental Station for River Improvement (Solo) always support our activities not only in the lecture room but also in the field survey.

On the other hand, we keep in touch with those institutes overseas such as International Institute of Environmental and Hydraulic Engineering (Delf, Netherland); Public Work Research Institute, Ministry of Construction (Tsukuba, Japan) and others through official as well as private channel. So as to exchange the information and to figure out how to solve the problems, their support has been playing the important role and will be much more when we treat manifold and extensive problems relevant to the land conservation on top of matters of volcanic sabo

□ Main Active Volcano in Jawa and Bali Islands



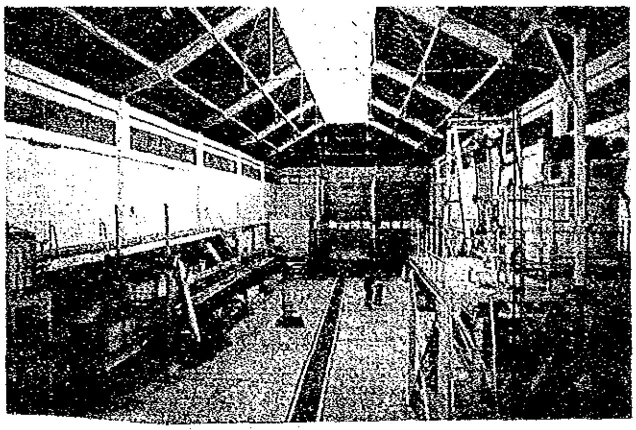
Volcanic Basic Data in Indonesia

Equipment

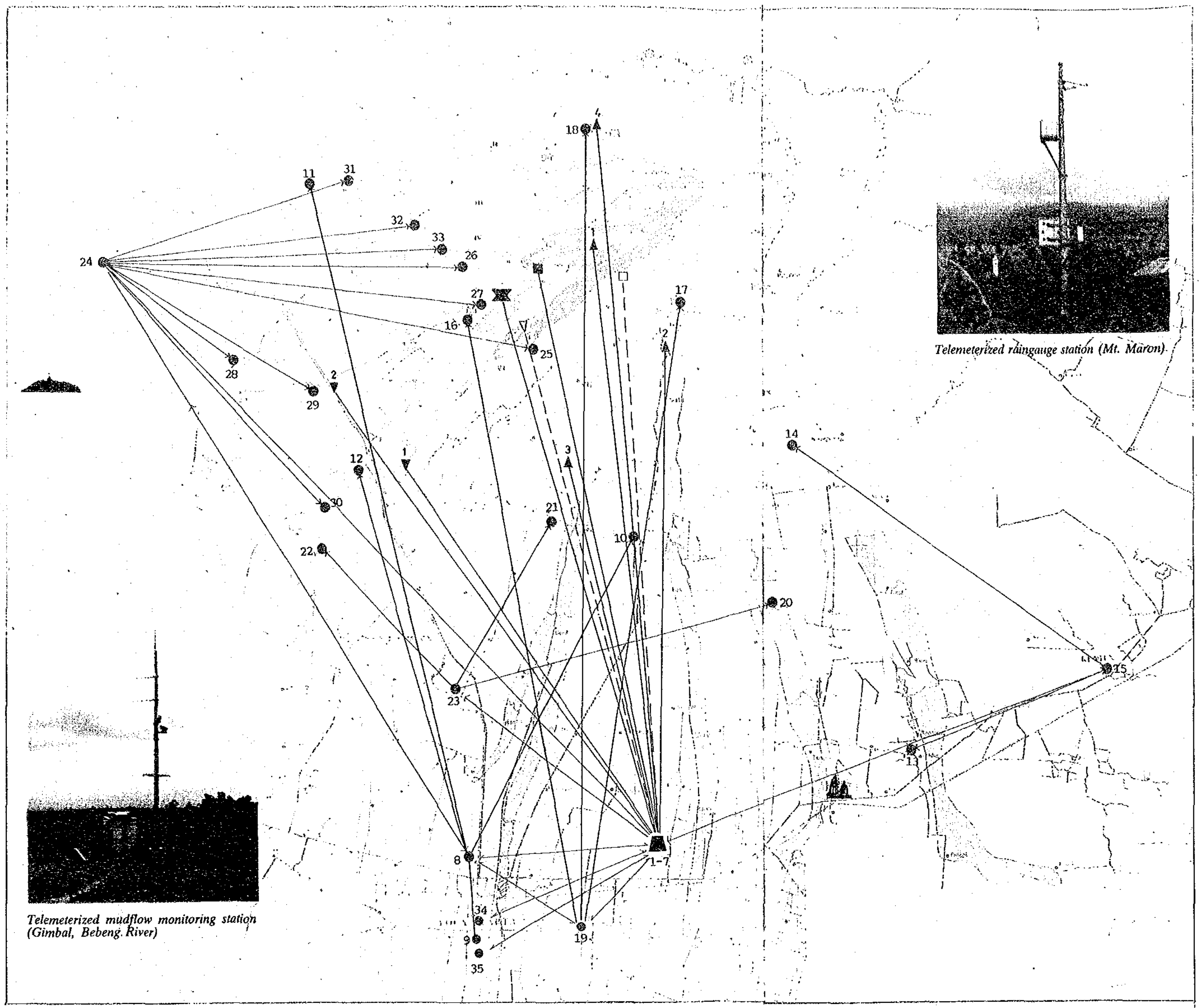
The major equipment and apparatus available to the purpose of training as well as programme for appropriate technique development can be enumerated up as follows :

- Hydrological equipments such as radar-raingauge set, telemeterized water-level gauge, telemeterized rainfall gauge, wire and vibration-sensor, automatic rainfall recorder, computerized display of rainfall distribution, video set for lahar observation, artificial rainfall apparatus.
- Hydraulic equipments such as model-flume channel, mudflow generator apparatus, riverbed height gauge, video for experiment, measuring instruments
- Geodetic and geotechnical survey equipments such as theodolite, transit, auto-level, pocket-compass, plain-table set, seismic perspective instrument, binocular, altimeter, penetration apparatus, hand-auger, core-drilling machine.
- Soil test and landslide measurement apparatus such as shearing test machine, constant and variable head permeability test apparatus, specific gravity test machine, groundwater prospecting equipment, pipe strain gauge, strain meter in soil, earth pressure and pore-pressure gauge, tiltmeter, hydrometer, Swedish-type penetration apparatus
- Concrete testing apparatus such as compression test machine, Los Angeles test machine, Schmidt hammer, aggregate soundness test apparatus, cement specific gravity test apparatus, aggregate specific gravity apparatus, mortar-flow test apparatus, concret ecore drilling machine, abrasion-test machine, shock-test for concrete.
- Audio visual educational apparatus such as overhead projector, slide projector, 16 m/m film projector, mini personal computer, video tape recorder, micro-filming and micro-reader, copy machine, twin-stereo-scope for aerophotograph
- Miscellaneous equipments for transportation and field test such as various vechicles, belt conveyor, gabion-knitting machine, water pump, power generator, radio communication apparatus

Radar tower

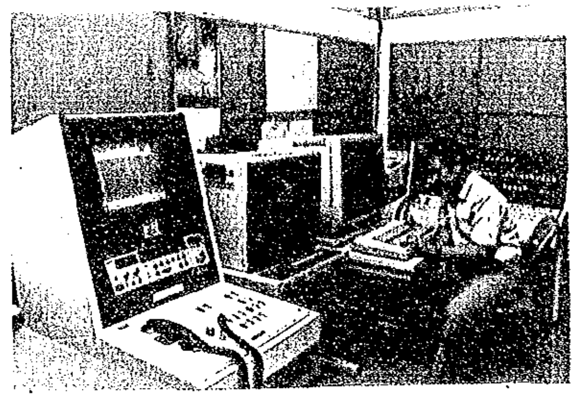


Mudflow Generating System



Telemeterized raingauge station (Mt. Maron)

Telemeterized mudflow monitoring station (Gimbal, Bebeng River)



Master station of mudflow forecasting and warning system

Radar raingauge / Master station :
VSTC, Sopalan, Maguwoharjo

Telemeterized raingauge station :
1. Gn. Maron
2. Plawangan
3. Girikerto
4. Babadan Duwur

Automatic water-level gauge station :
1. *Puntuk*

Telemeterized water-level gauge station :
1. Kopen
2. Tegalsari

Telemeterized raingauge & water-level gauge station (combined) :
1. Mranggen (Ngepos)

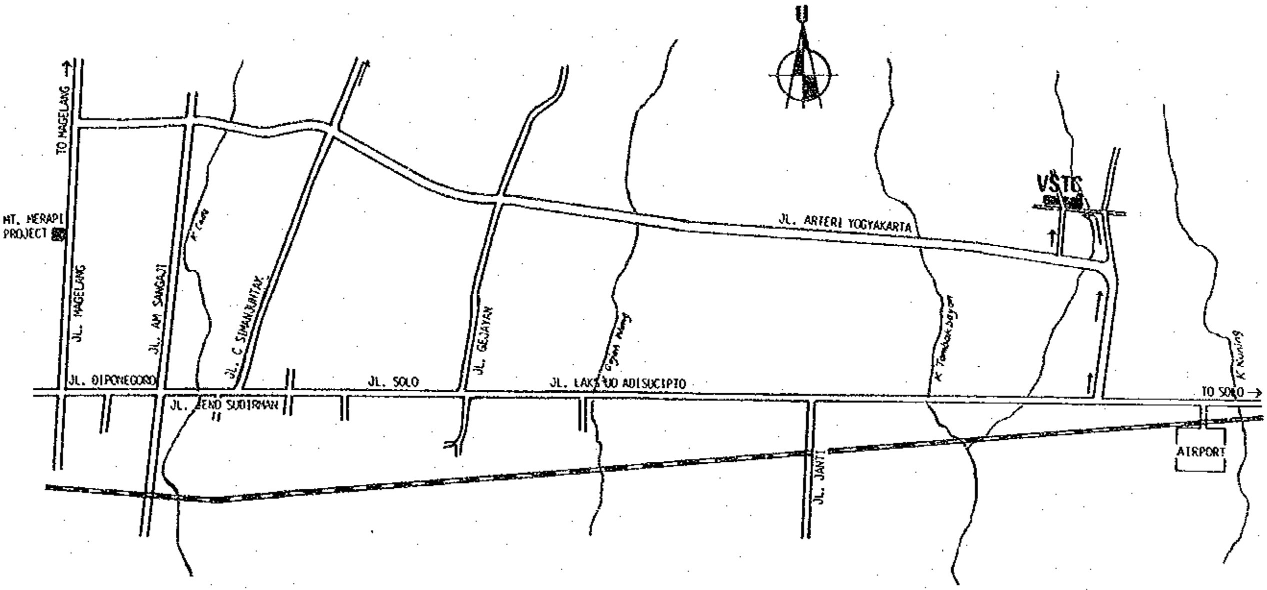
Mud flow sensor station :
1. Jurangjero

Telemeterized mudflow monitoring station :
1. Gimbal

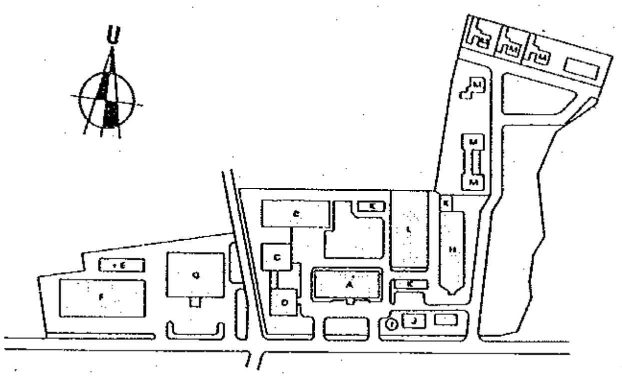
Radio Communications :
1– 7 VSTC
8 Merapi Project Office
9 Suronatan
10 Pakem
11 Sawangan
12 Salam
13 Brajan, Prambanan
14 Plosokerep
15 Government Office (Klaten)
16 Ngepos
17 Plawangan
18 Babadan
19 Volcanology Office: Yogyakarta
20 Sindumertani
21 Purwobinangun
22 Pondokrejo, Tempel
23 Government Office (Sleman)
24 Government Office (Magelang)
25 Kaliurang Cepit
26 Tegalrandu
27 Mranggen
28 Gunung Pring
29 Tegalsari
30 Jarean Kidul
31 Local Government of Sawangan
32 Local Government of Dukun
33 Ketunggeng
24 Ngadiwinatan
35 Kadipaten

□ Location Map of VSTC Project

The VSTC is located at Sopalan, Maguwoharjo, Depok, (P.O. Box 128) Yogyakarta. It has a good access to airport, shopping street and by-pass road of the city.

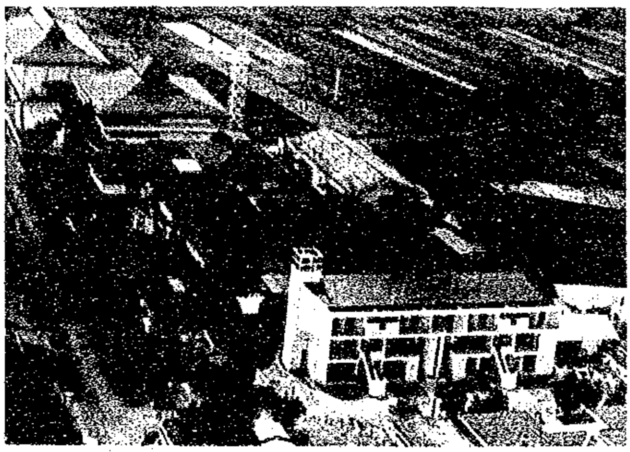


□ Campus of the Volcanic Sabo Technical Centre



REMARKS :

A. Administration Building
B. Hydraulic Laboratory
C. Technical Development Building
D. Soil & Concrete Laboratory
E. Gabion Work Shop
F. Lahar Laboratory
G. Sabo Information Centre
H. Dormitory
I. Radar Tower
J. Meeting Room
K. Garage
L. Tennis court
M. Official House



General view of the VSTC Project

Published in 1990 by Volcanic Sabo Technical Centre (VSTC)
Directorate of Rivers,
Directorate General of Water Resources Development,
Ministry of Public Works;
Under the auspices of Japan International Cooperation Agency (JICA)

Covering photograph shows a nuee ardente occured
in Mt. Semeru on June, 1989

JICA