2.4 Frequency of Damage

2.4.1 Periodicity of Volcanic Eruptions

In order to determine the frequency of damage, a study as been made of the periodicity of the volcanic eruptions on the basis primarily of those eruptions since 1800 that have been most damaging. (see Table 2)

Assuming a normal distribution with an average reoccurrence period of μ and a standard deviation of σ_n, 95% of the distribution is in the range $\mu - 1.96\ \sigma/n \sim \mu + 1.96\ \sigma/n$. With a reliability of 95%, the periodicities are as follows: one eruption even 3-6 years and a large eruption every 9-16 years.

	n	μ	σ	Interim Period
Eruption	32	4.5	5.0	3 ∿ 6 years
Large Eruption	11	12.5	5.8	9 ∿ 16 years

List of Large Eruptions Since 1800

No.	Eruption Year	Interim Period	No.	Eruption Year	Interim Period
1	1822	-	7	1920	16
2	1832	10	8	1930	10
3	1849	17	9	1954	14
4	1872	23	10	1956	2
5	1888	16	11	1961	5
6	1904	16	12	1969	8

Table 1 Record at Damage and Volcanic Eruption (1)

Year	Month	Day	River	Location	Damage			Eruption
					Deaths	Houses	Fields	
1672	Apr.	8	-	Borobudur Magelang	3,000	-	-	-
1822	Dec.	-	K. Pabelan K. Blongkeng	"	100	-	-	Jul. 22~31,1822
1832	Dec.	25	-	-	32	-	-	-
1837	-	-	K. Blongkeng	Magelang	-	-	-	-
1849	Sept.	-	-	-	800	-	-	Nov. 16~18,1845
1872	Apr.	-	-	-	200	-	-	Aug. 29, 1954 Oct. and Nov. 1954 Dec. 1954 Apr. 1861 May, 1863
1888	Sept.	-		-	-	-	-	Aug. 1876, June, 1977 Dec. 1883, Nov. 1885 May, 1886, Mar. 1888

Table 1 Record at Damage and Volcanic Eruption (2)

Year	Month	Day	River	Location	Damage			Eruption
					Deaths	Houses	Fields	
1904	Jan.	30	-	-	16	-	-	Mar. 1889 Apr. 1904
1920	Oct.	12	K. Blongkeng K. Batang and K. Senowo	-	35			Nov. 1905, Dec. 1907 Nov. 1911, July, 1913 Jul. 1914, May - June 1916, Jun. 1917, Sept. 1917 Sept. 1917, Mar. 1918 Aug. 1918, Feb. 1919
1930	-	-	-	-	1,369	1,109	-	Feb. and Apr. 1927, Nov. 1930

Table 1 Record at Damage and Volcanic Eruption (3)

Year	Month	Day	River	Location	Damage			Eruption
					Deaths	Houses	Fields	
1933	-	-	K. Kuning, K. Trising and K. Senow	Sendang tirto, Slm.	-	-	5 (ha)	Dec. 1930, Jan. 1931 Feb. 1932, Apr. 1934 Apr. 1943
1954	Jan.	18	K. Apu	Borobudur, Magelang	64	144	-	Nov. and Apr. 1953 Jul. 1958 Jan. 1954
1956	Jan.	3	K. Apu	Borobudur, Magelang	5	2	-	Jan. 1956
1961	May	8	K. Blongkeng K. Batang	Magelang		3	109	-
1967	Oct.	7-8	K. Blongkeng and K. Krasak	Magelang	-	-	-	Sept. and Oct. 1967 Jan. 1969

Table 1 Record at Damage and Volcanic Eruption (4)

Year	Month	Day	River	Location	Damage			Eruption
					Deaths	Houses	Fields	
1969	Jan.	6	K. Krasak	Magelang	-	5	20.8	Jan. 1969
			K. Bebeng		-	275	25.0	
		8	K. Putih	Magelang	-	2	-	
			K. Bebeng	Magelang	-	-	25	
			K. Gendol	Sleman	-	20	156	
	Mar.	15	K. Putih	Magelang	-	7	28.2	
		21	K. Putih	Magelang	-	-	0.5	
		24	K. Putih	Magelang	-	4	11	
		29	K. Putih	Magelang	-	20	77	
	Apr.	5	K. Bebeng	Magelang		31	41.5	
			K. Putih	Magelang		39	5	

Table 1 Record at Damage and Volcanic Eruption (5)

Year	Month	Day	River	Location	Damage			Eruption
					Deaths	Houses	Fields	
1969	Apr.	20	K. Putih	Magelang	-	1	0.9	
1973	Sept.	23	K. Gendol	Sleman	-	-	38.5	
	Oct.	3	K. Gendol	Sleman	-	-	0.3	
	Nov.	10	K. Gendol	Sleman	-	-	0.5	
		12	K. Gendol	Sleman	-	-	0.7	
		16	K. Gendol	Sleman	-	-	2.5	
1974	Oct.	1	K. Bebeng	Magelang	-	-	72	
	Nov.		K. Bebeng	Magelang	-	-	18.9	
1975	Mar.	5	K. Gendol	Magelang	-	-	9.1	
			K. Krasak	Magelang	-	26	46	
			K. Bebeng	Srumbung, Magelang	-	102	15.4	
			K. Putih	Magelang	-	4	33.5	

Table 1 Record at Damage and Volcanic Eruption (6)

Year	Month	Day	River	Location	Damage			Eruption
					Deaths	Houses	Fields	
1975	Mar.	22	K. Bebeng	Srumbung, Magelang	-	1	3	
			K. Putih	Srumbung, Magelang	-	1	0.9	
1975	Oct.	3	K. Krasak	Magelang	-	-	62	
1976	Nov.	25	K. Krasak	Ngluwar, Magelang	29	277	282.0	
			K. Bebeng	Srumbung, Magelang				

Table 2 List of Past Eruptions (1)

No.	Year and Date of Eruptions			Remarks
(1)*	1822	July,	23 - 31	K. Pabelan, K. Blongkeng, Lahar
	23			
2	1845	May,	16 - 18	-
	10			
3	1954	August,	29	-
	1			
4	1855	Dec.,	9	-
	6			
5	1861	Apr.,	-	-
	2			
6	1863	May,	23	-
	8			
(7)*	1871	Apr., Sept.		1872 K. Blongkeng, Lahar
	5			
8	1876			
	7			
9	1883	Dec.		
	2			
10	1885	Nov.,	12	
	1			
11	1886	May,	3	
	2			
12	1888	Mar.		
	1			
13	1889	Mar.		
	15			
14	1904	Apr.,	18	
	1			
15	1905	Nov.,	1	
	2			
16	1907	Dec.,	17	
17	1911	Nov.,	2	
	2			
18	1913	July		
	1			
19	1914	July,	1	
	2			
20	1916	Jun.		
	1			
21	1917	Jun.	16 - 18	
	1			
22	1918	Aug.,	18	
	1			
(23)*	1919	Feb., March		1920 K. Blongkeng, K. Batang, K. Senow, Lahar
	8			
24	1927	Feb.,	5 - 11	
	3			

(No.) * large éruption

Table 2 List of Past Eruptions (2)

No.	Year and Date of Eruptions	Remarks
(25)*	1930 May - June 25	1930 - 31 Nuée Ardente
26	1 1931 Jun., Apr.	
27	1 1932 Feb.	
28	2 1934 Apr.	
29	9 1943 Apr.	
(30)*	10 1953 Apr.	K. Trising, K. Senowo, Nuée
31	1 1954 Jan.	K. Apu
(32)*	2 1956 Jan.	K. Apu.
33	11 1967 Oct., Sept.	
(34)*	2 1969 Jan.	K. Blongkeng, K. Krasak

(No.) * large eruption

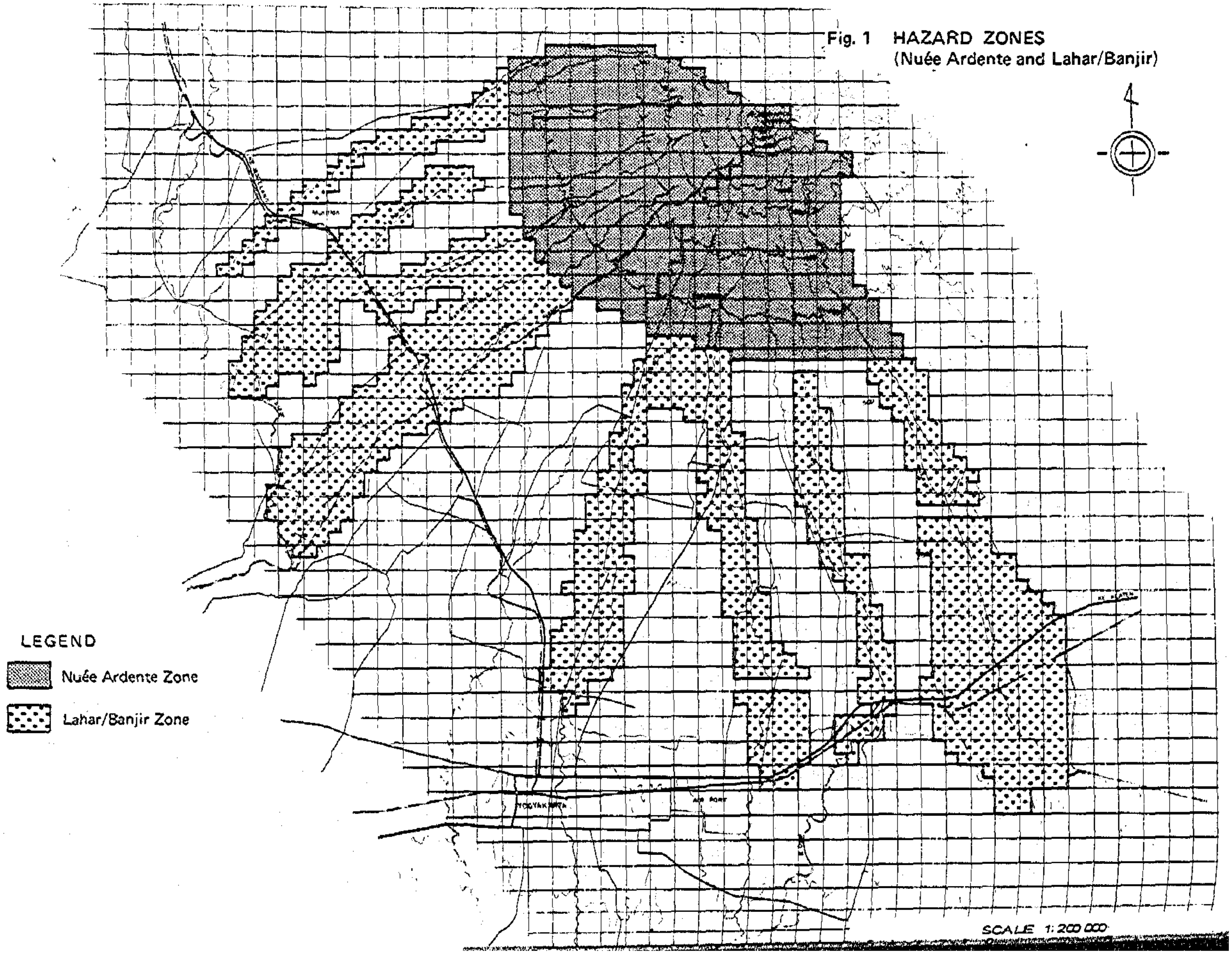


Fig. 1 HAZARD ZONES
(Nuée Ardente and Lahar/Banjir)

Fig. 2 The Range of Flow of Nuée Ardente, Lahar and Banjir (1) 1961 1969

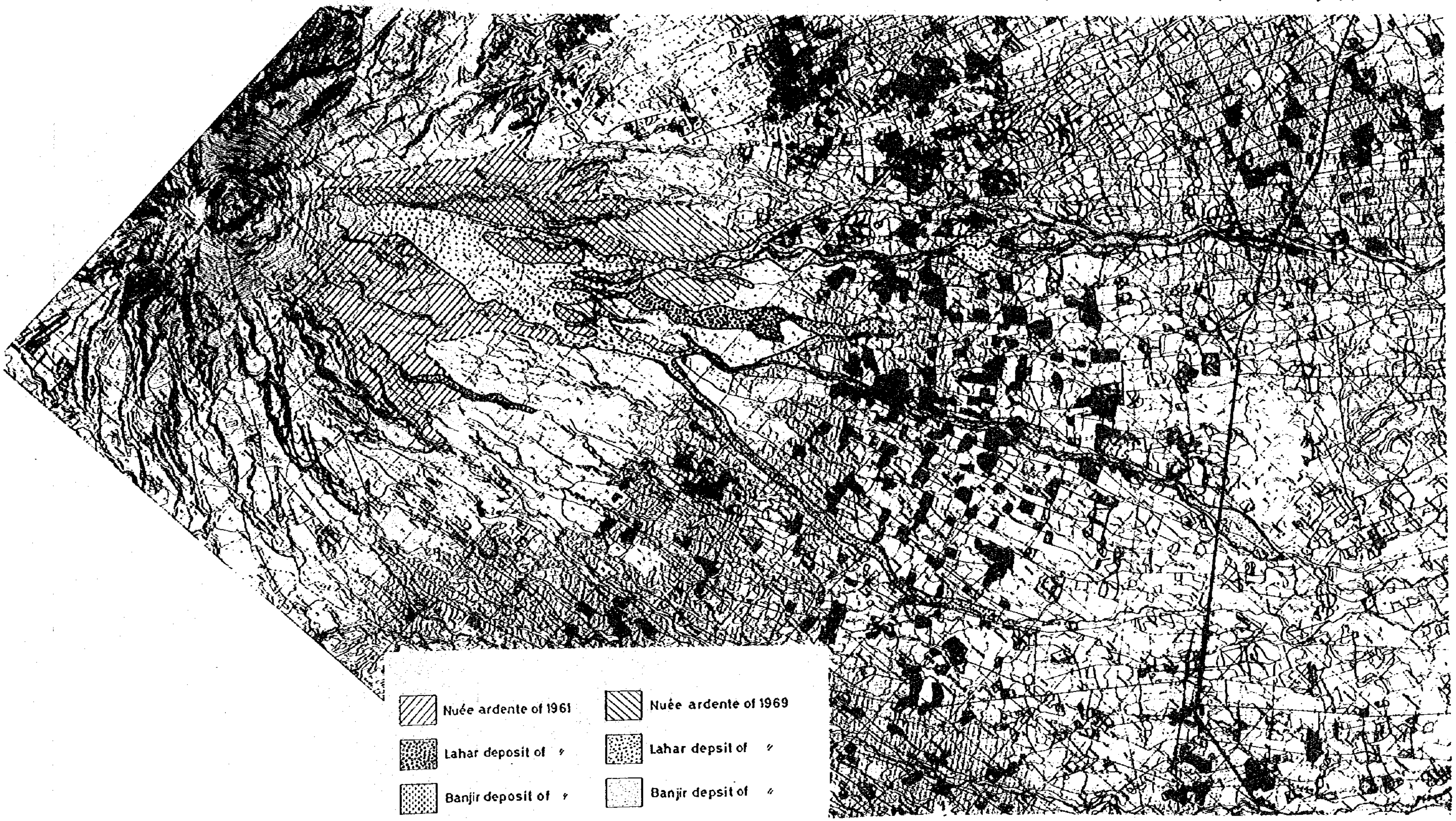
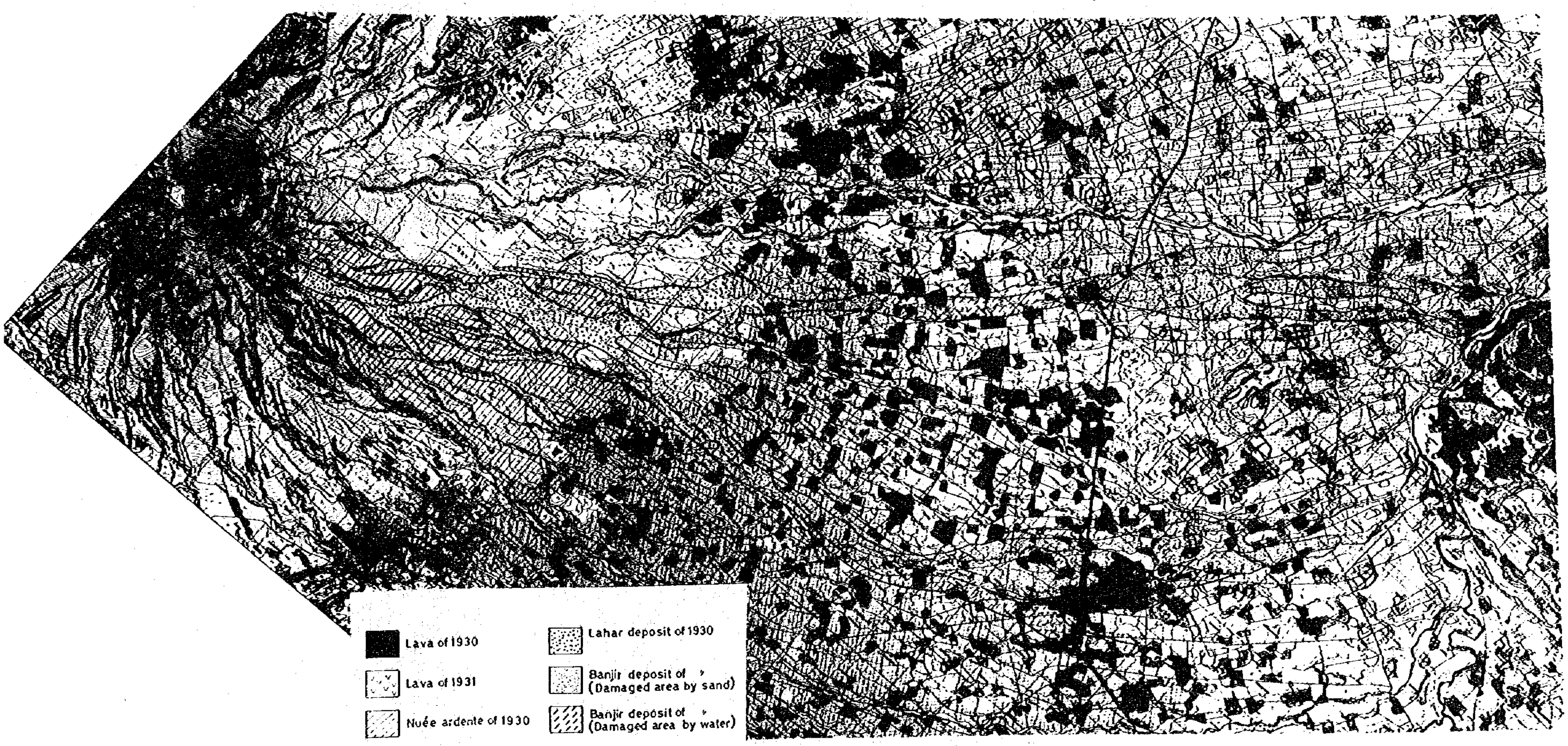


Fig. 2 The range of flow of Nué Ardente, Lahar and Banjir (2) 1930 1931



3. HAZARD ZONES

Fig. 1 shows the hazard zones for each of the types of disaster damage in the area covered by the plan: nuée ardente, lahar, banjir, and sediment deposits.

(1) Hazard zones on the slopes of G. Merapi.

(a) Areas directly affected by nuée ardente.

(b) Areas affected by lahar and banjir.

(2) River area (K. Progo and K. Opak) hazard zones .... Areas subject to flooding because of sediment deposits in river courses.

3.1 Area Classification for Nuée Ardente, Lahar, and Banjir

3.1.1 Nuée Ardente Areas

1) Nuée Ardente Areas

As determined on basis of existing information and data and field surveys, the only recorded information available with respect to nuée ardente flows is that concerning the southwest slope of the mountain (Type-I areas). According to it, the nuée ardente reached a point about 9 km from the crater or an elevation of about 700 m at the time of the 1930 and 1969 eruptions. (See Fig. 2) Judging from the land use pattern and the results of geological studies, nuée ardente reached to the vicinity of elevation 500 m some 11 km from the crater on the southeast side of the mountain in past times of greatest volcanic activity.

2) Nuée Ardente Areas as determined on basis of topographical analysis

a) Considering elevation and distance from the peak of the mountain, Nuée Ardente areas in which gravity movements are predominant are the following:

West slope (Type I areas): Above elevation of 900 m.
South and south east slope (Type II and III areas): Above elevation of 700 m.

b) Considering riverbed gradient and length of flow course, the Nuée Ardente areas in which gravity movements are predominant are (See Fig. 3):

West slope (Type I areas): Above elevation of 900 m.
South and south east slope (Type II and III areas): Above elevation of 800 m.

3) Nuée Ardente Area

On the basis of the above considerations, the extent of the nuée ardente area has been defined as follows:

West sloDe: Above elevation of 700 m.
South and south east slope: Above elevation of 600 m.
K. Woro area: Above elevation of 550 m.

The limits on the south and south east slope and in the K. Woro area have been defined based on the fact that the volcanic activity has become somewhat less vigorous in recent years than the distance reached by nuee ardente on the west side.

3.1.2 Lahar Areas

(1) Lahar area as determined on basis of existing information and data and field surveys.

Table 3 lists clear points where lahar has stopped in recent years:

From past experience it would seem that lahar with a considerable content of volcanic ash and other fine particles flowed still further downstream.

(2) Lahar areas as determined on basis of topographical analysis

It is known that the form of movement of sediment changes at points where there is sudden change in the riverbed gradient. Table 4 and Fig. 4 show the boundaries between lahar and banjir based on this fact. The highest elevation of the boundary is 570 m, at K. Pabelan, and the lowest is 370 m, at K. Woro and K. Gendol. The largest riverbed gradient at the boundary is 0.05 (2.9°), at K. Boyong, and the smallest is 0.026 (1.5°), at K. Blongkeng, the average being about 2°. Furthermore, as determined by a survey, the characteristics of boulder deposits change at an elevation of about 500 m in the case of K. Krasak.

3.1.3 Bajir Areas

The banjir area is defined as all areas downstream of the lahar area.

3.2 Lahar/Banjir Flooding Hazard Zones

3.2.1 Relationship of the Landform and Lahar/Banjir

When Lahar and Bajir are regarded as geomorphic stages of geological processes on the slope of G. Merapi, probable damage areas from lahar or banjir can be estimated by the geomorphic analysis. The danger areas of lahar and banjir were determined from the geomorphological land condition map that was prepared using photo interpretation (map: 1/25,000, photos: 1/40,000) and field surveys.

According to geomorphological study, there is quite close relationship between the landforms and lahar/banjir occurence.
Rivers generally overflow at the places where they turn sharply or stream gradients change and become more gentle. These topographical changes correspond to the geological/lithological differences on the slope of G. Merapi. The landform of the volcanic slope is the result of the volcanic activity. (See Fig. 4 in Supporting Report A)

Usually lahar/banjir follow old river courses, and small and shallow valleys. Today's landforms suggest the possible flooding area of lahar and banjir. The isoclinal slope map, drainage system and flow direction map have been prepared as the supplementary information. By field survey, flooding areas and the sand deposits distributed with them were studied.

According to the survey of the Lahar and Banjir in 1975 and 1976, the Landform overflow points and flooding area resulting from Lahar/Banjir are described as follows:

<u>Overflow points</u>

1) The point where the gradient of the riverbed becomes gentle (downstream of the breaking zone)

2) The point where the river course crosses a former river course.

3) The point where the riverbed is raised by sedimentation.

4) The river terraces

5) The point where the discharge area decreases sharply.

6) The point where the river course bends sharply.

Flooding areas

1) Topographical small undulations and streams become the boundary of the flooding area.

2) The flood flows into a small channel or former river course after flooding.

3) In case the small channel or former river course does not have enough capacity to handle all the volume, the flood overflows these boundaries again.

4) A lot of sand transported by the flood remains along the small channel.

5) Houses are damaged and livelihoods disrupted in the sediment deposit area.

3.2.2 Distribution map for degree of danger of Lahar and Banjir flooding

The results of the field surveys have given a rough idea of the relationship between lahar and banjir disasters and topographical conditions. A map has therefore been prepared which shows the degree of lahar and banjir flooding hazard in different places on the basis of a land conditions index and the relative height of banks (see Fig. 6 in Supporting Report A).

Five degrees of flooding danger have been determined based on the relative heights of river banks. Where there was overlapping of area, the higher degree of flooding danger was given priority. Particularly hazardous points and old river courses and terraces have been marked on a map.

Degrees of Flooding Danger as based on River Bank Height

Degree of Damage	Probability of Flooding	River Bank Height (m)
5	Very High	0 - 5
4	High	5 - 10
3	Medium	10 - 20
2	Low	20 - 30
1	Very low	over 30

In addition, three Degrees of Flooding Damage have been determined as follows.

Degree of Damage	Amount of Damage	Kind of Flooding Damage
3	Large	Damage from a lot sand and gravel
2	Medium	Damage from less sediment
1	Small	Damage from inundation

The extent of the lahar areas has been defined on the basis of above considerations follows in Table 5 and as shown in Fig. 4.

3.3 Hazard Map

On the basis of records of past eruptions and damage the Indonesian Government has prepared a map of the following hazard zones on the slopes and fringes of G. Merapi (see Fig. 5):

(1) Off-limits zone (daerah terlarang)

(2) Type-I hazard zone (daerah bahaya I)

(3) Type-II hazard zone (daerah bahaya II)

The off-limits zone, where no one is permitted to live, is those parts of the upper slopes of the mountain directly affected by nuée ardente,; the Type-I hazard zone is where there would be considerable influence from falling debris, but no direct influence from nuée ardente, and the Type-II hazard zone is where damage can be expected from lahar along the rivers.

The main problems are as follows:

(a) On the basis of the topographical analyses and field surveys it can be concluded that although the off-limits zone is perhaps somewhat more extensive than necessary, the Type-II hazard zone tends to be too small.

(b) Not enough public information regarding the hazard zones or administrative guidance in connection with them are provided the residents of such zones.

Table 3 Elevations where Lahar has stopped in recent years

Year	River	Elevation (above the sea level)
1930	K. Batang	570 m
1930	K. Blongkeng	530 m
1961	K. Batang	660 m
1969	K. Bebeng	500 m
1969	K. Putih	650 m

Table 5 Lahar Areas of Tributaries

No.	River	Elevation (m)
1	K. Pabelan	570
2	K. Blongkeng	420
3	K. Putih	420
4	K. Batang	420
5	K. Krasak	420
6	K. Boyong	420
7	K. Kuning	410
8	K. Gendol	370
9	K. Woro	360

Table 4 Characteristics of Sediment Locations

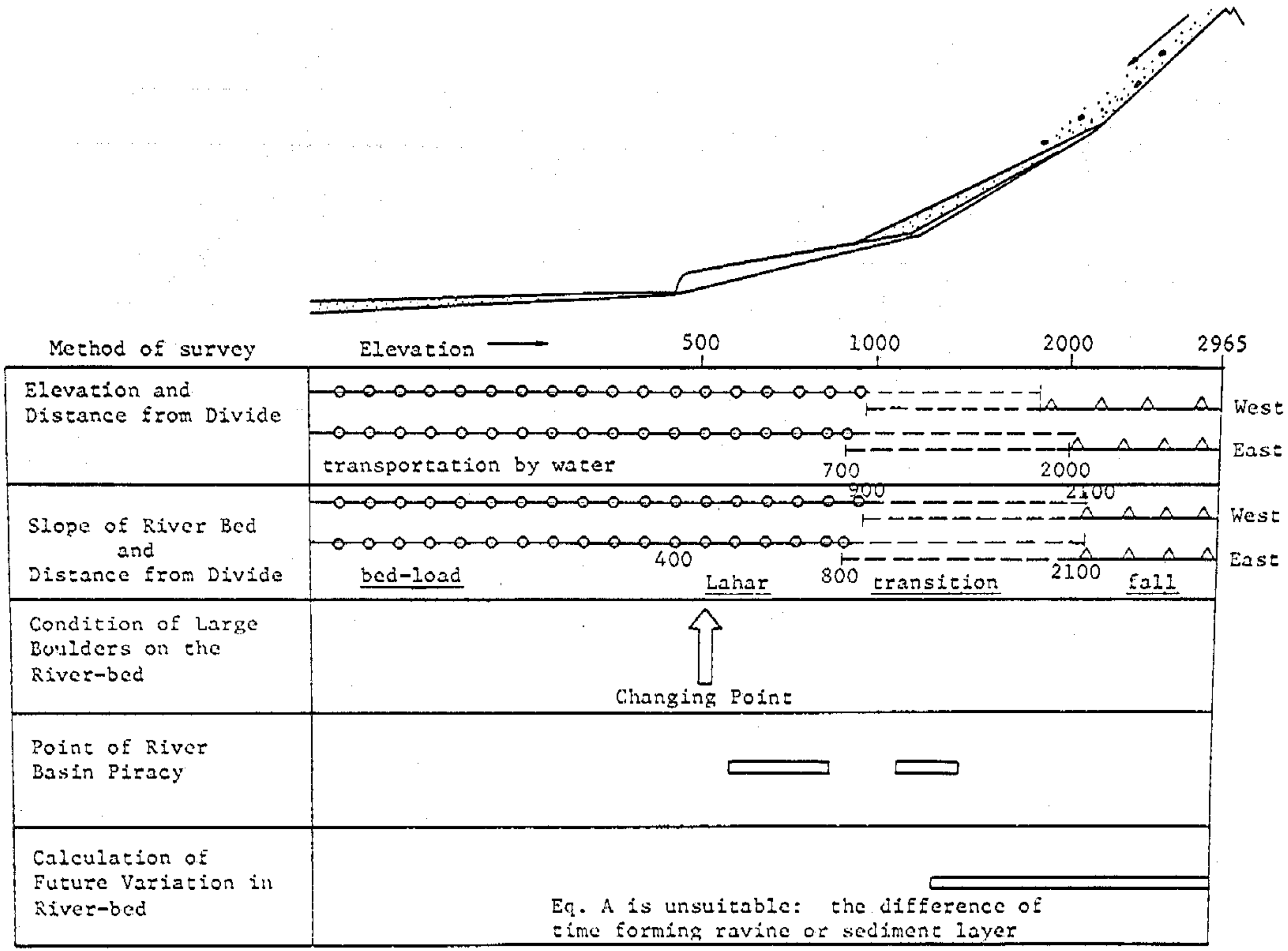


Fig. 3 Relation between Riverbed Gradient and Stream Length

I: Mean Slope of River Bed
L: Distance from Divide (Km)
$I = KL^{-\beta}$
( ): Elevation

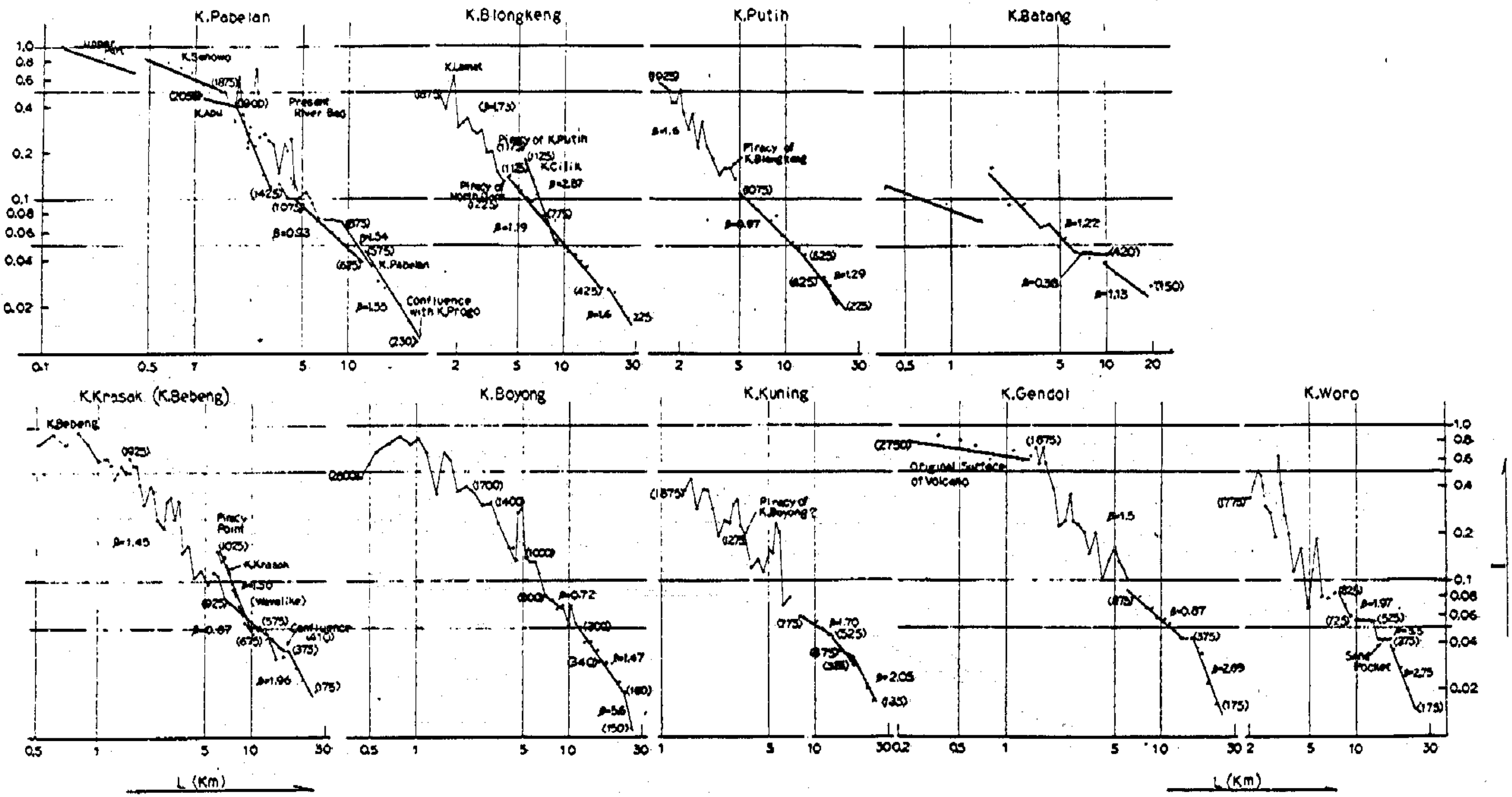
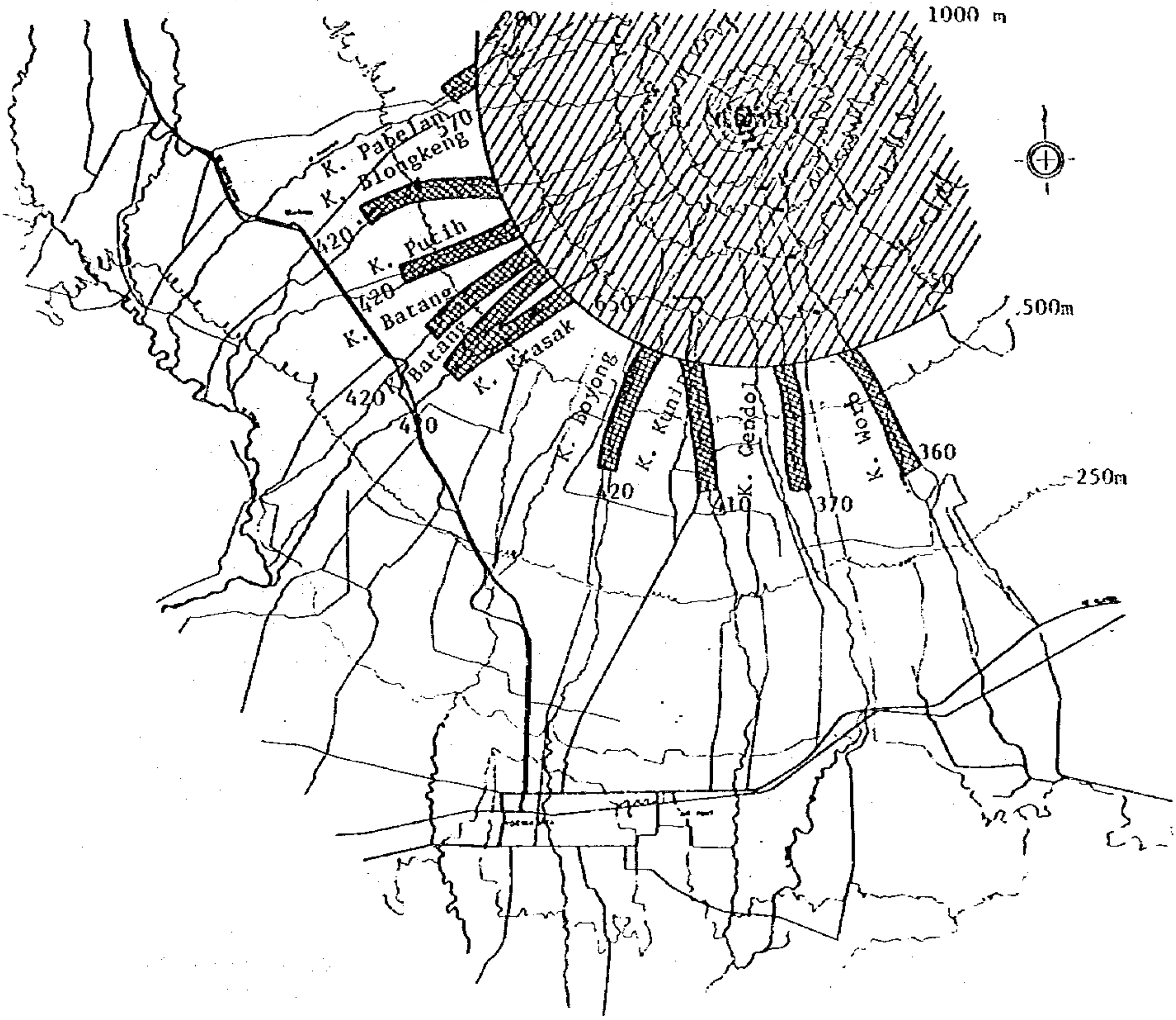
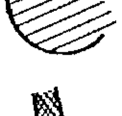


Fig. 4 Distribution Map of Nuée Ardente, Lahar and Banjir



Legend


: Nuée Ardente Zone


Lahar Zone

Banjir Zone

Scale: 1:250000

4. COUNTERMEASURES

The measures that have already been taken to mitigate and prevent damage due to flow of volcanic debris from G. Merapi are the designation of hazard zones, establishment of a warning and evacuation system, and implementation of land erosion and volcanic debris control works. The following is a description of these measures.

4.1 Warning and Evacuation System

As a result of long years of observation and research on volcanic activity, and with designation of the hazard zones, it is now possible to a certain extent to cope with abnormal volcanic activity based on a lahar/banjir warning and evacuation system and the monitoring system which are described in the paragraph below.

4.1.1 Coping with Abnormal Volcanic Activity

1) Monitoring Volcanic Activity

The monitoring of volcanic activity at the volcanic observation posts is based on directly observation and seismometer measurements. The following are considered signs of abnormal volcanic activity:

(1) Successive earthquake readings on the seismometer.

(2) Frequent collapses at the crater.

(3) Rising of the peak of the mountain.

(4) Rumbling of the earth.

(5) Minor eruptions.

(6) Rise in temperature of eruption gases.

(7) Occurrence of nuée ardente.

Whenever any of these abnormal phenomena are observed, an alarm is sent out by telephone from the volcanic observation posts as indicated in Fig. 6.

When the volcanic activity gets to be very active, the volcanic observation posts issues a "Merapi alert" through the nearest telephone bureau. It is the provincial government, however, that issues formal evacuation orders.

2) Nuée Ardente Warnings

If nuée ardente is observed, the residents of the hazard zone are immediately notified. The warnings are in three stages, depending on the proportions of the nuée ardente: "Caution", "Alert", and "Evacuation". The warnings are made chiefly by siren, tom-tom, or other traditional means of communication. The criteria for the three warning stages are as follows:

1) "Caution" .... Nuée ardente flow of 3.5 km/5 min.

2) "Alert" .... Nuée ardente flow of 5.0 kg/5 min.

3) "Evacuation" .... Nuée ardente flow of 6.0 km/5 min.

4.1.2 Coping With Lahar

1) No definite criteria have been established for predicting the occurrence of lahar. In the past the schmidt oroposal set the rainfall criterion for occurrence of lahar at 70 mm/35 min, but the provincial government and the residents of the hazard zones are now notified of a possible lahar hazard under the following circumstances:

(1) Hourly rainfall of over 60 mm at the Plawangan observation post.

(2) Thunderstorms or other heavy rainfall in Type-I lahar occurrence areas (elevation 1,000-2,000 m) or further upstream.

(3) Actual observation of lahar.

2) Observation System

Table 6 and Figs. 7 and 8 indicates the existing lahar observation posts and the observation system now in effect. Besides the lahar observation posts at Plawagan, Babadan, Ngepos, Puntuk, and Salam, there are rain guages at two other places in Type-II areas.

It is desirable that lahar warnings be based on the amount of rainfall and the rainfall pattern, but in the area in question the rainfall as determined on the basis of hydrological analysis is over very small area of maximum 30 - 50 km^2.

Since it is important in a warning and evacuation system that the forecasts be accurate and timely so as to allow ample time for the necessary action, it is necessary that the existing observation system and network, which is not entirely adequate with respect to determination of the amount and pattern of rainfall, be improved by, for one thing, increasing the observation density.

3) Warning System

The present warning system for lahar, which is indicated in Fig. 8, centers on Type-I areas, where most of the damage occurs.

Normally the warnings are communicated to the G. Merapi office and the provincial government by the observation posts, the provincial government then taking whatever action is necessary, including notification of the residents of the hazard zones.

In emergencies, however, besides this communication route, the residents are also warned by tom-tom, siren, or other direct means of communication. At the present time it is chiefly this latter route that is depended on.

4) Lahar and Rainfall in the Past

Table 1 and Fig. 9 (1)-(9) shows the amount of rainfall and the rainfall pattern for the nine instances of occurrence of lahar during the period 1973 - 1976. It was assumed that the time of occurrence of the lahar coincided approximately with the sharp rise in the curve of the accumulated amount of rainfall. Tables 8 - 10 shows the frequencies of hourly rainfall, daily rainfall, and two consecutive days of rainfall in 1976, 1977, and 1978 at the Plawagan and other observation posts in order to get an idea of the frequency of occurrence of rainfall of lahar triggering proportions. The following can be said concerning the relationship between rainfall and the occurrence of lahar on the basis of such information:

(1) In two of seven recent instances of lahar damage (Mar. 5, 1975, and Nov. 25, 1976) the daily rainfall was abnormally heavy, the heaviest in 50 years in the first instance and the heaviest in 200 years in the second instance.

(2) When there are considerable unstable deposits of volcanic debris as after eruptions, 90 mm of rainfall or more can give rise to lahar. At Plawagan in the 3-year period mentioned

5) Advanced Warning Time-

The following are the estimated amounts of time for the different stages of the warning process:

1)	Collection and checking of data for forecast of Lahar	30 min.
2)	Official consultation	10 min.
3)	Communication of warning	30 min.
4)	Evacuation	30 - 60 min.
	Total	100 - 130 min.

Since there is a short amount of time for the lahar to make its way down the mountain 30 - 50 min. and a considerable amount of time for the warning and evacuation process to be completed, the forecasting system must be a very efficient one. Under the present system, the data collection need for timely forecasting is inadequate; hence additional observation posts and facilities are critical.

6) Main Warning System Problems

1) Since there are only three main observation posts for lahar warnings (Plawagan, Babadan, and Ngepos) at the present time, it is hard to get a good idea of the amount and pattern of rainfall in lahar hazard areas. There are also automatic rain gauges operating at two other points in upper Type-I areas,

but both are below elevation 700 m. Considering the rainfall characteristics of the area in question, this observation network is inadequate for highly accurate determination of the amount and pattern of rainfall and therefore ought to be improved.

2) Considering the need for speedy communication of information, a possibility that should be studied is telemeters and other advanced equipment in connection with increasing observation facilities and establishment of additional main observation posts in lahar occurring areas.

3) Considering the present data system, observation system, and warning system, it will be necessary to establish a new warning and evacuation system for the area covered by the plan in stages.

Table 6 Present Observation Posts and Information Centers

Observation Post	Equipment			
	Radio-Telephone		Telephone	Rain-gauges
	of Merapi project	of Kab. Magelang		
1. *Babadan	o		o	o
2. *Plawangan	o		o	o
3. *Ngepos	o		o	o
4. **Salam	o		o	o
5. ***Puntuk (Temporary Post)	o			o
6. @Kec. Ngluwar		o	o	o
7. @Kec. Kukun		o	o	o
8. @Kec. Srumbung		o	o	o
9. Kab. Magelang	o	o		
10. Merapi project office	o			o

Note: 1. * Belongs to Volcanology office

2. ** Belongs to Merapi project office

3. *** Belongs to Merapi project office: Temporary post in rainy season.

4. @ Belongs to Kab. Magelang

Table 7 Duration of Rainfall and Rainfall Pattern at Lahar (From 1973 to 1976)

Year	Month	Day	Duration of rainfall	Daily rainfall	CR*	ER*	t*	ER/t*	CR-1*	CR-2*	t_o*
1973	Sept.	23	98.8	20.8	98.4	20.0	1.0	20.0	18.4	78.4	9.00
"	Nov.	10	94.9	76.1	75.9	54.8	4.0	13.7	46.9	35.9	17.00
"	"	12	109.0	26.0	101.4	17.0	2.0	8.5	86.4	84.4	15.00
1974	Nov.	22	96.6	30.9	87.7	22.0	2.0	11.0	77.7	65.7	16.00
1975	Mar.	5	232.0	200.0	230.0	198.0	3.0	66.0	150.0	121.0	16.00
"	Oct.	1	75.0	75.0	75.0	75.0	6.0	12.5	60.0	55.0	20.00
"	"	3	90.3	72.0	70.7	53.0	2.0	26.5	21.7	17.7	16.00
1976	Nov.	17	172.5	166.9	146.7	129.8	3.0	43.2	79.2	21.7	16.00
"	"	25	281.2	241.6	233.6	193.6	3.0	64.5	158.4	102.0	16.00

* Notes : CR - cumulative rainfall amount
ER - effective rainfall amount
t - effective time preceeding Lahar
ER/t - rainfall intensity
CR-1 - cumulative rainfall 1-hour prior to Lahar
CR-2 - " " 2-hours "
t_o - estimated time of Lahar occurance

Table 8 One Day Hourly-Rainfall for Three Years from 1976 to 1978

Degree (mm)	Times		
	Babadan	Plawangen	Ngèpos
0 - 10	29	22	23
10 - 20	91	99	89
20 - 30	35	71	52
30 - 40	14	25	22
40 - 50	4	16	12
50 - 60	4	6	7
60 - 70	-	2	3
70 - 80	1	1	3
80 - 90	-	-	1
90 - 100	-	-	-
100 - 110	-	-	-
110 - 120	-	-	-
120 - 130	-	-	1
Total	178	242	213

Table 9 Two Days Daily-Rainfall for Three Years from 1976 to 1978

Degree (mm)	Times		
	Babadan	Plawangen	Ngepos
90 - 110	6	16	7
110 - 120	5	10	5
130 - 150	-	7	8
150 - 170	2	3	3
170 - 190	-	4	2
190 - 210	1	1	1
210 - 230	-	-	1
230 - 250	-	-	-
250 - 270	-	-	-
270 - 290	-	1	-
290 - 310	-	-	-
310 - 330	-	1	-
330 - 350	-	-	1
Total	14	43	28

Table 10 One Day Daily-Rainfall for Three Years from 1976 to 1978

Degree (mm)	Times		
	Babadan	Plawangen	Ngepos
0 - 20	54	51	62
20 - 40	74	115	88
40 - 60	38	34	32
60 - 80	9	17	16
80 - 100	5	13	7
100 - 120	2	3	3
120 - 140	-	4	4
140 - 160	-	1	-
160 - 180	-	2	1
180 - 200	1	-	1
200 - 220	-	-	-
220 - 240	-	-	1
240 - 260	-	1	-
Total	183	241	215

Fig 5 HAZARD MAP

(Published in Indonesia)

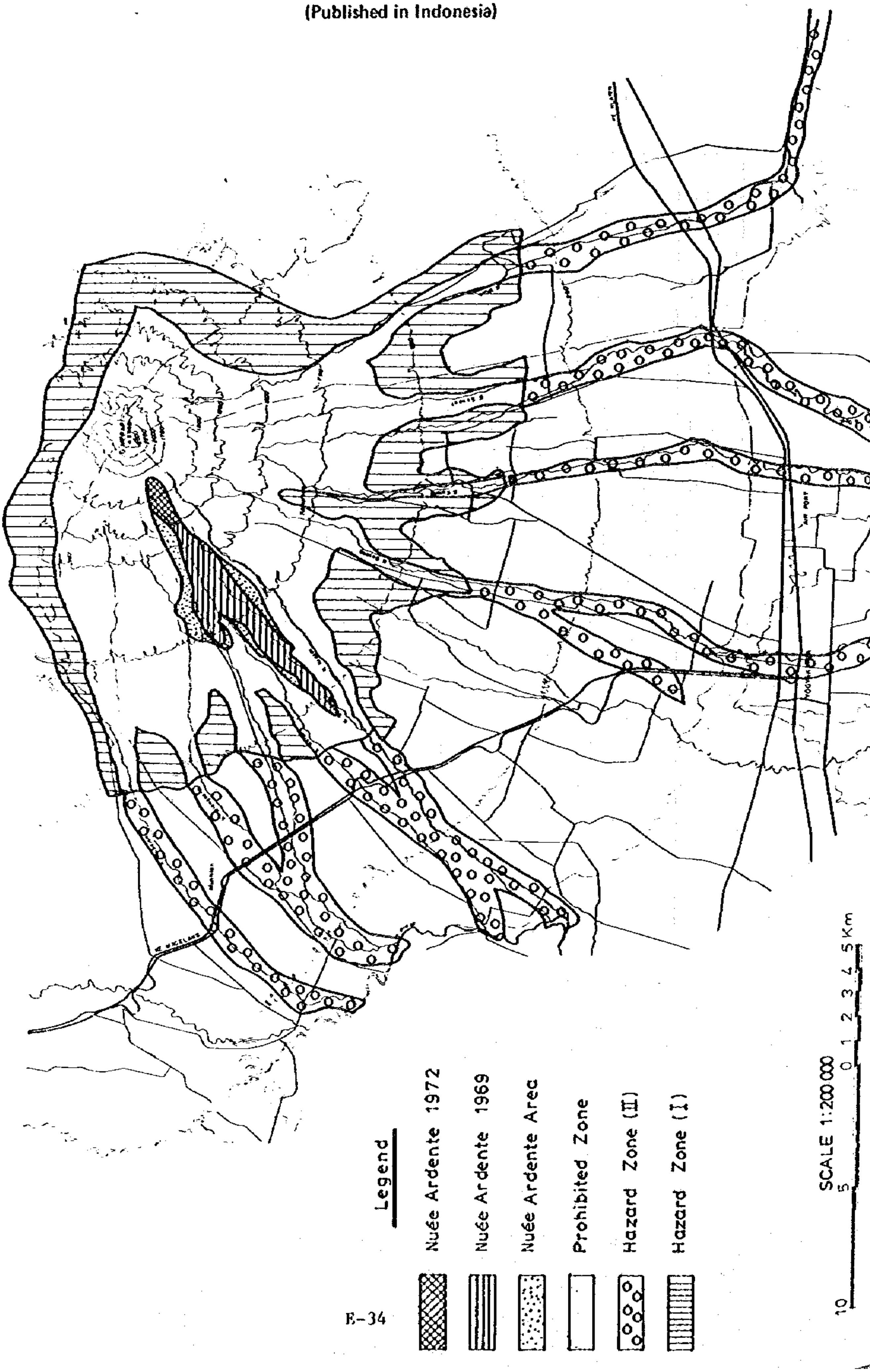


Fig. 6 Existing Volcanic Activity Warning Service Network

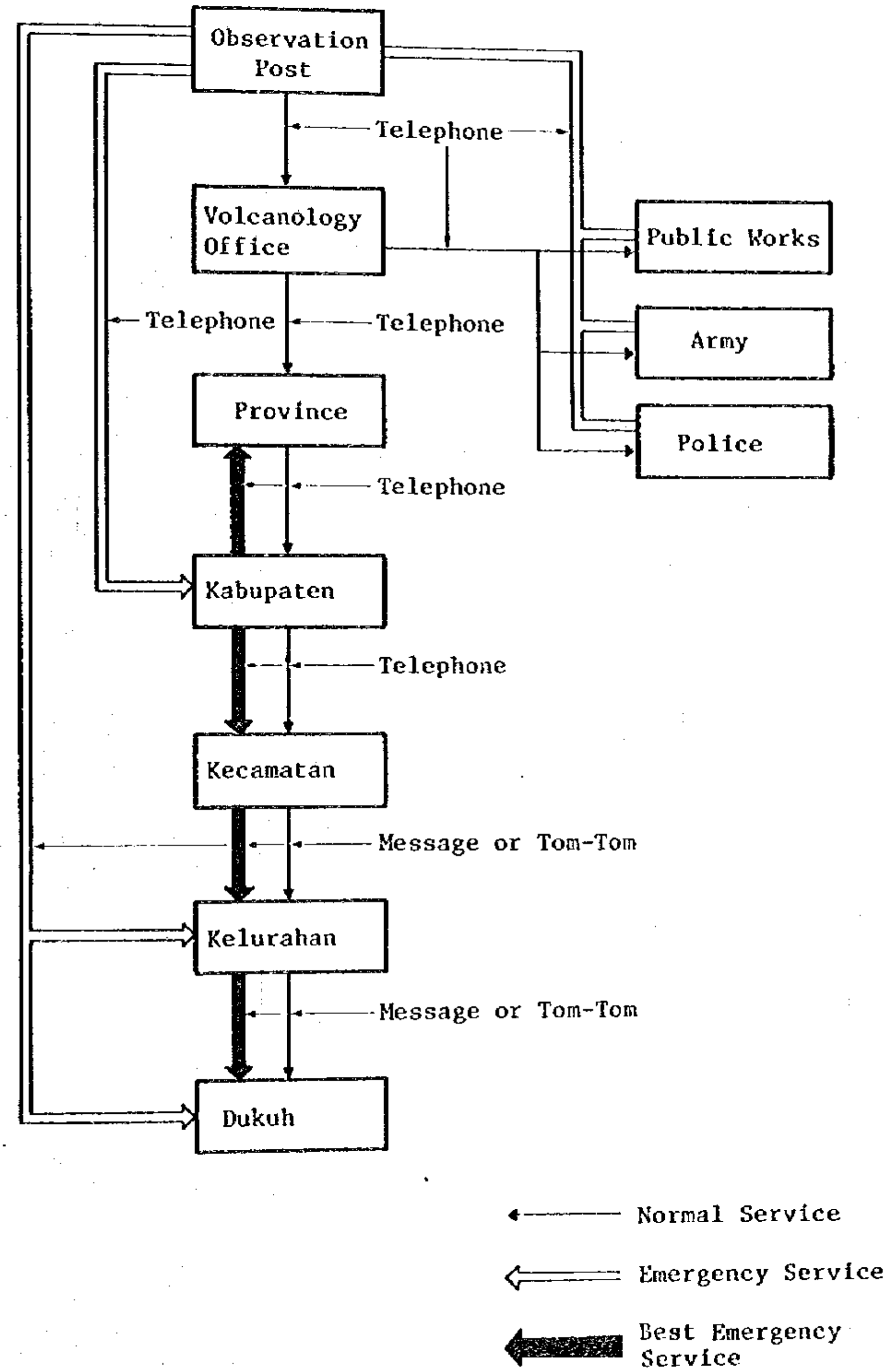


Fig. 7 Map of Present Observation Posts, Raingage and Information Centers

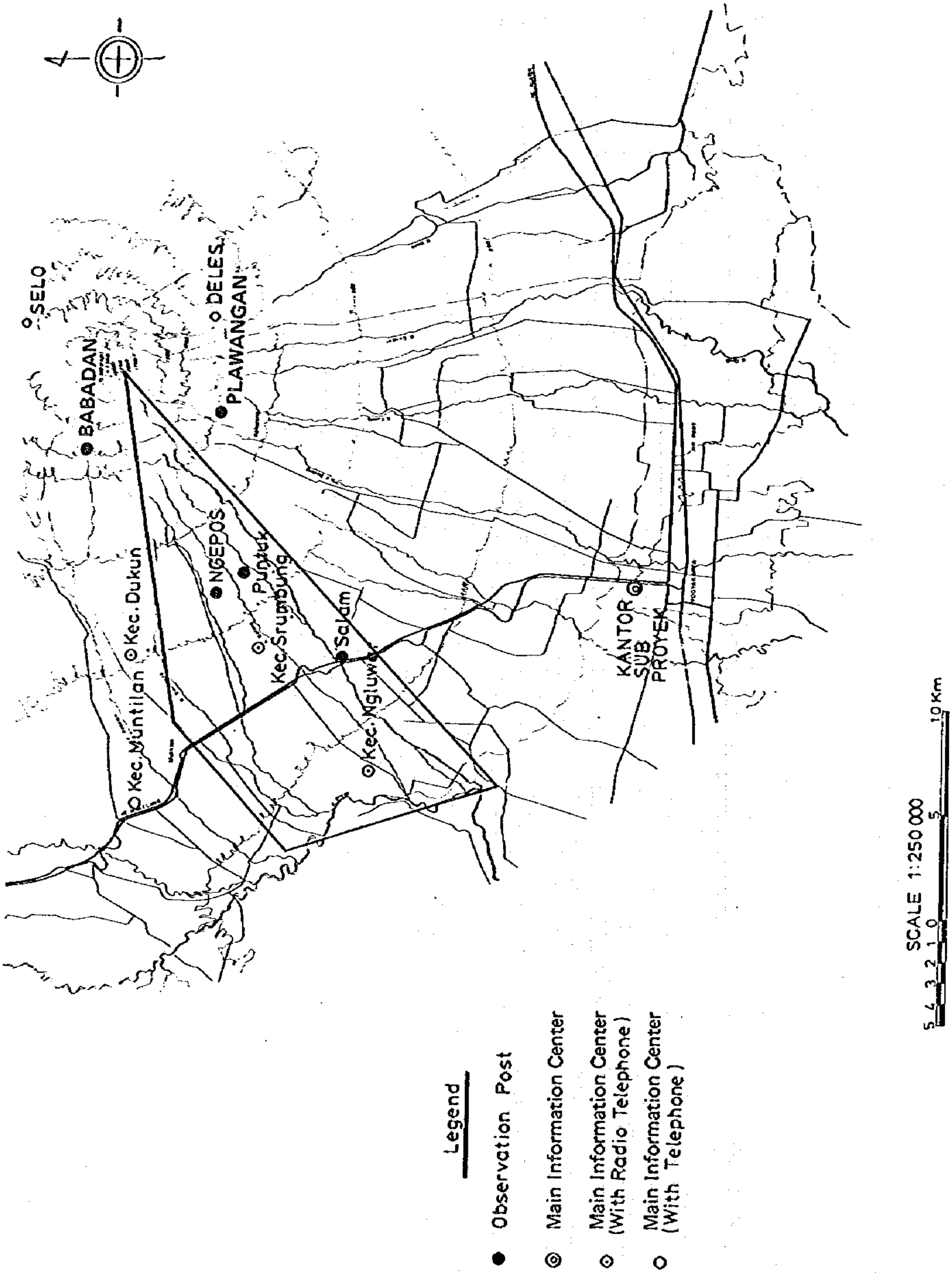


Fig. 8 Existing Lahar Warning Service Network

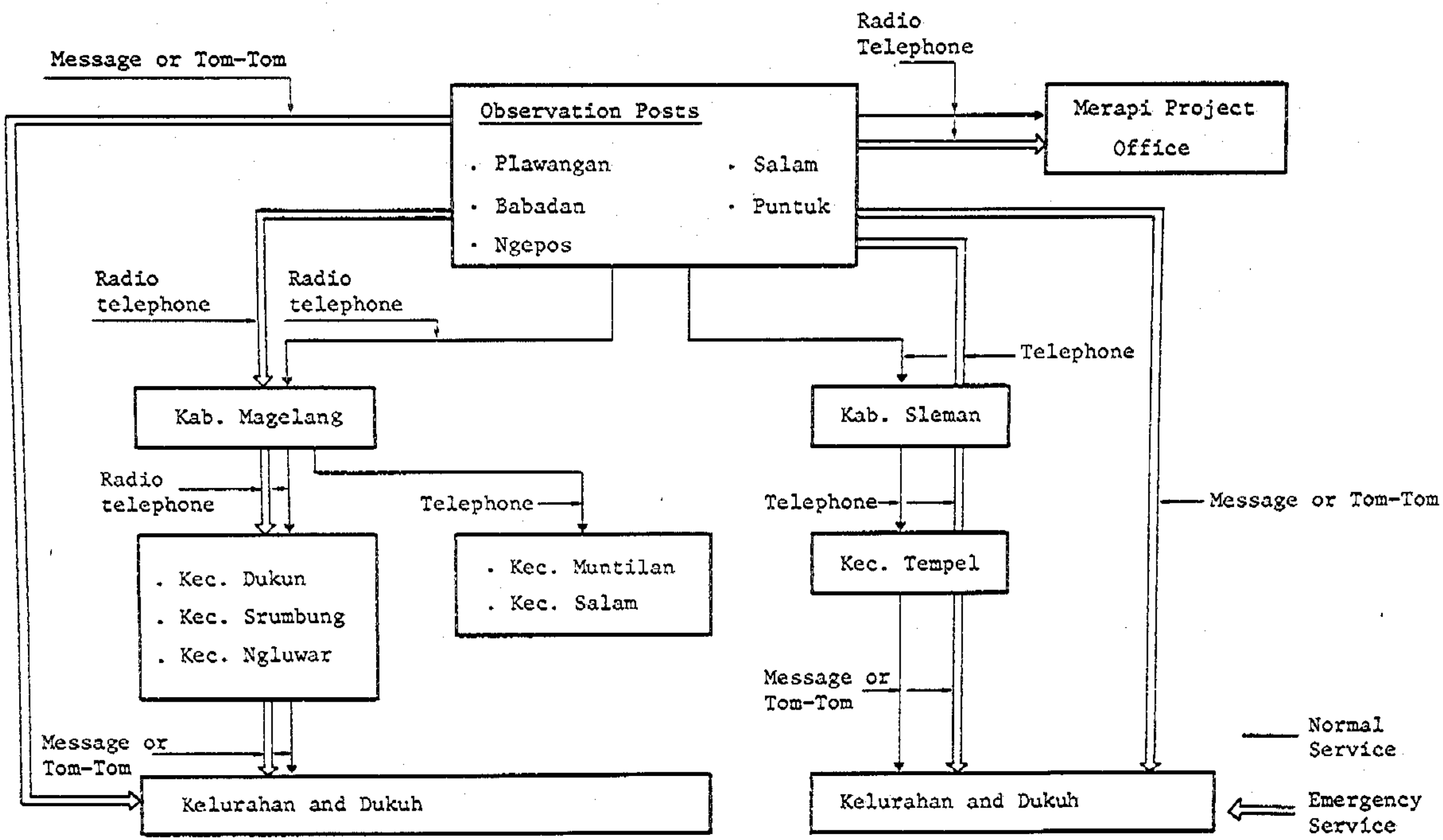
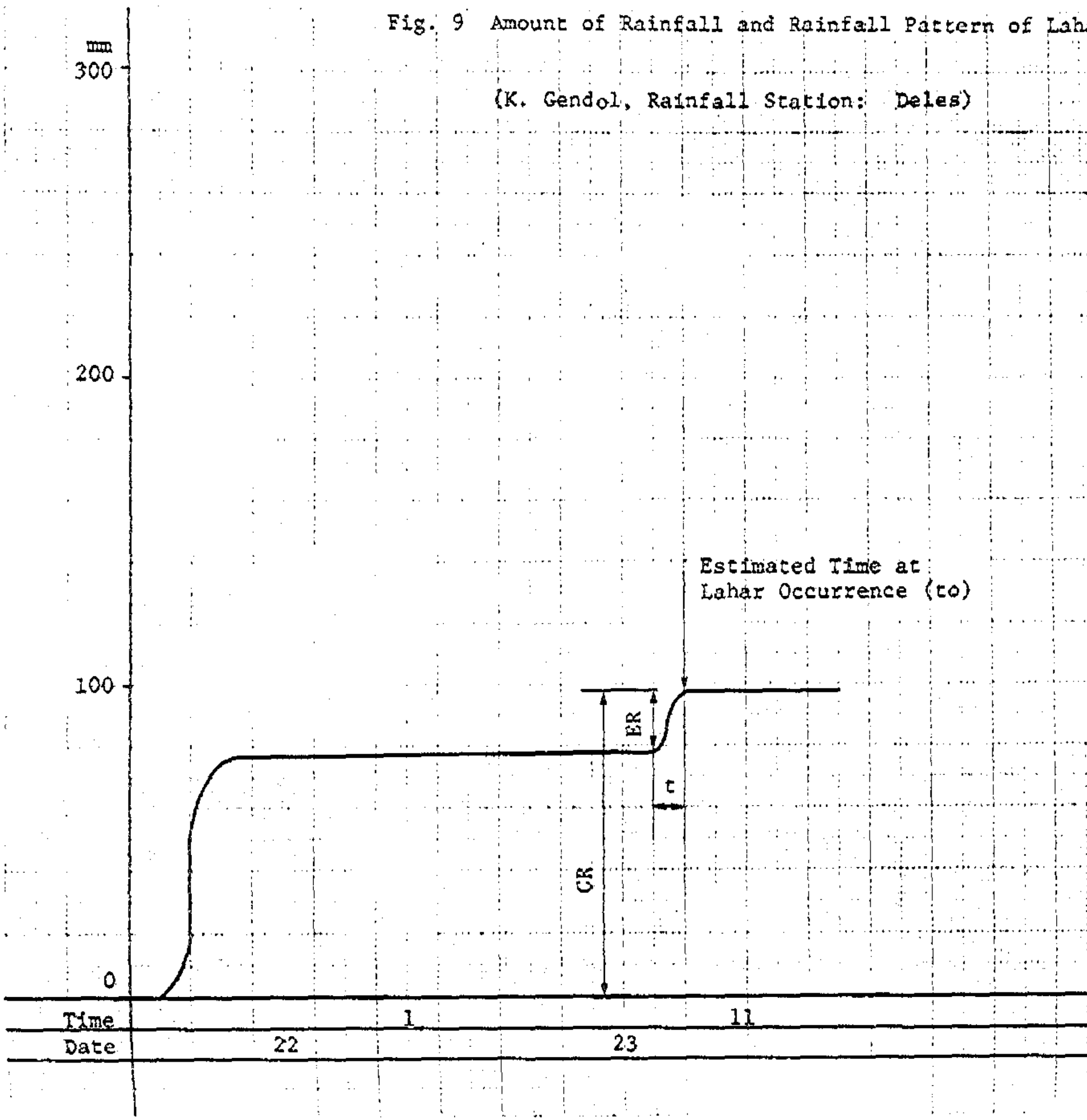


Fig. 9 Amount of Rainfall and Rainfall Pattern of Lahar (1)

(K. Gendol, Rainfall Station: Deles)

Sept.	22.23	1973



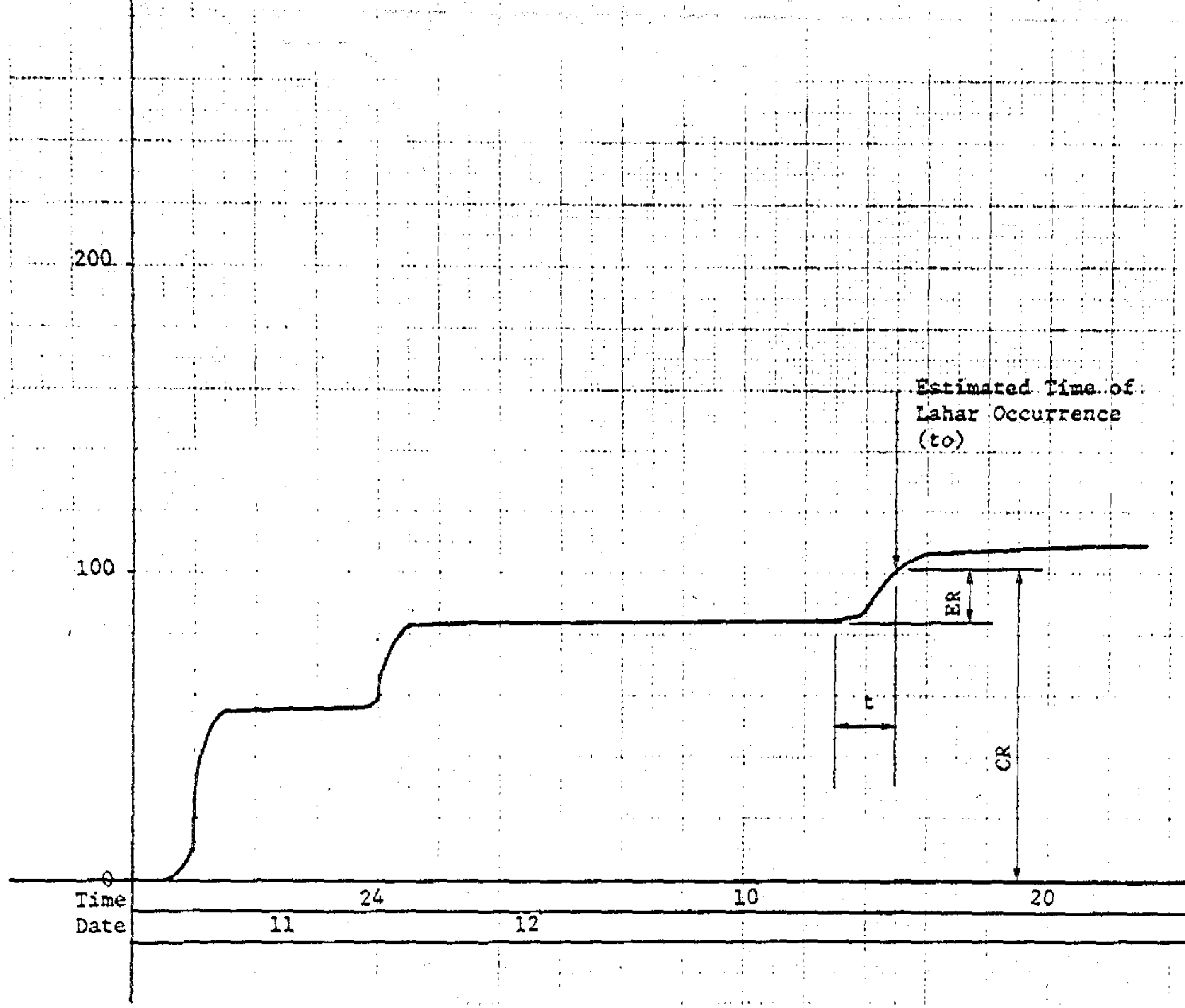
Duration of Rainfall	98.8 mm
Daily Rainfall	20.8 mm
Cumulative Rainfall Amount (CR)	98.4 mm
Effective Rainfall Amount (ER)	20.0
Effective Time Preceeding Lahar(t)	1.0"
Railfall Intensity (ER/t)	20.0 mm/h

Damaged Area	
Paddy Field	38.5 Ra

Fig. 9 Amount of Rainfall and Rainfall Pattern of Lahar (2)

(K. Gendol, Rainfall Station: Deles)

Nov.	11.12	1973



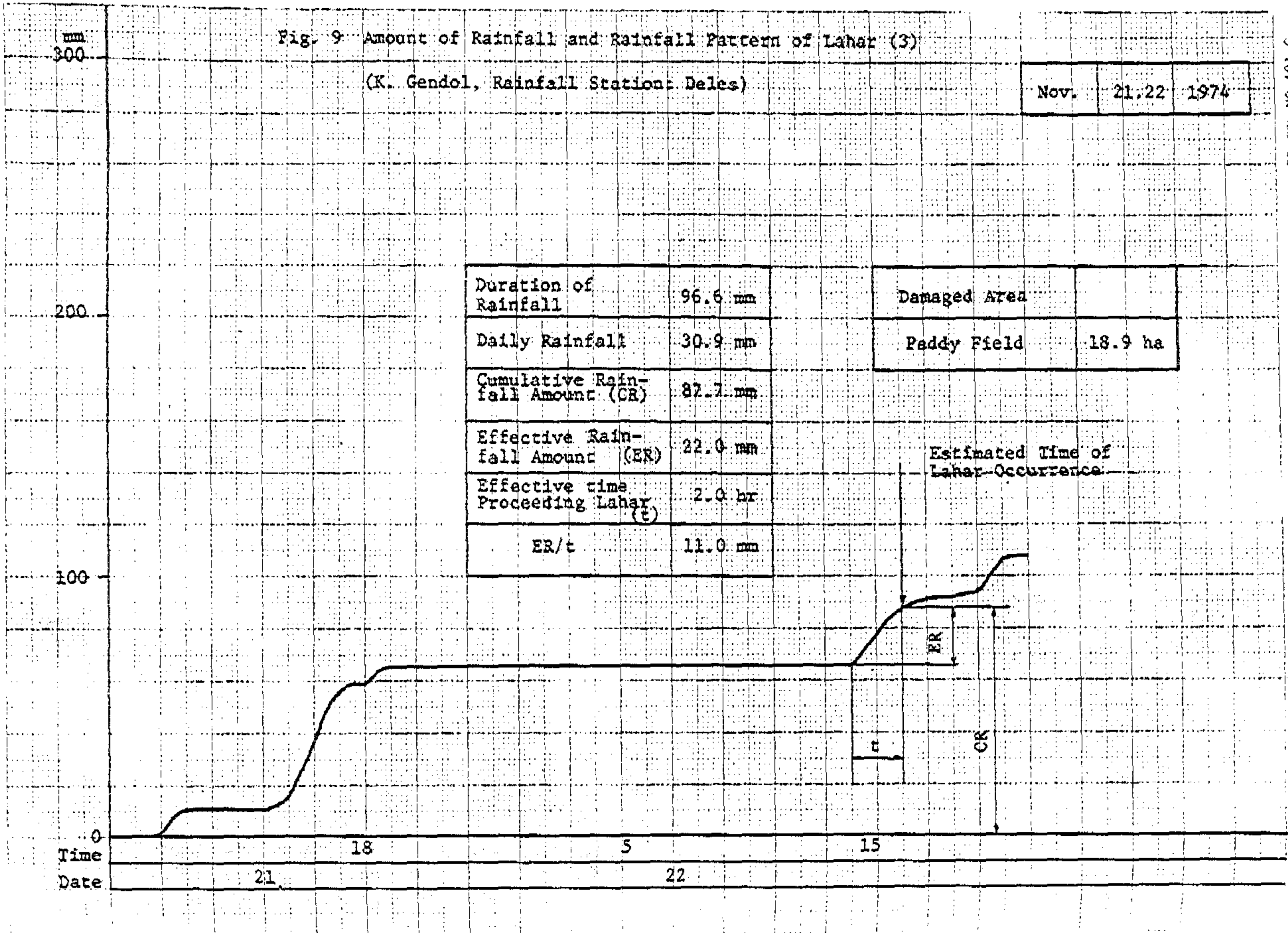
Duration of Rainfall	109 mm
Daily Rainfall	26 mm
Cumulative Rainfall Amount (CR)	101.4 mm
Effective Rainfall Amount (ER)	17.0 mm
Effective Time Preceeding Lahar (t)	2.0 hr
ER/t	8.5 mm

Damaged Area	
Paddy Field	0.7 ha

Fig. 9 Amount of Rainfall and Rainfall Pattern of Lahar (3)

(K. Gendol, Rainfall Station: Deles)

Nov.	21.22	1974



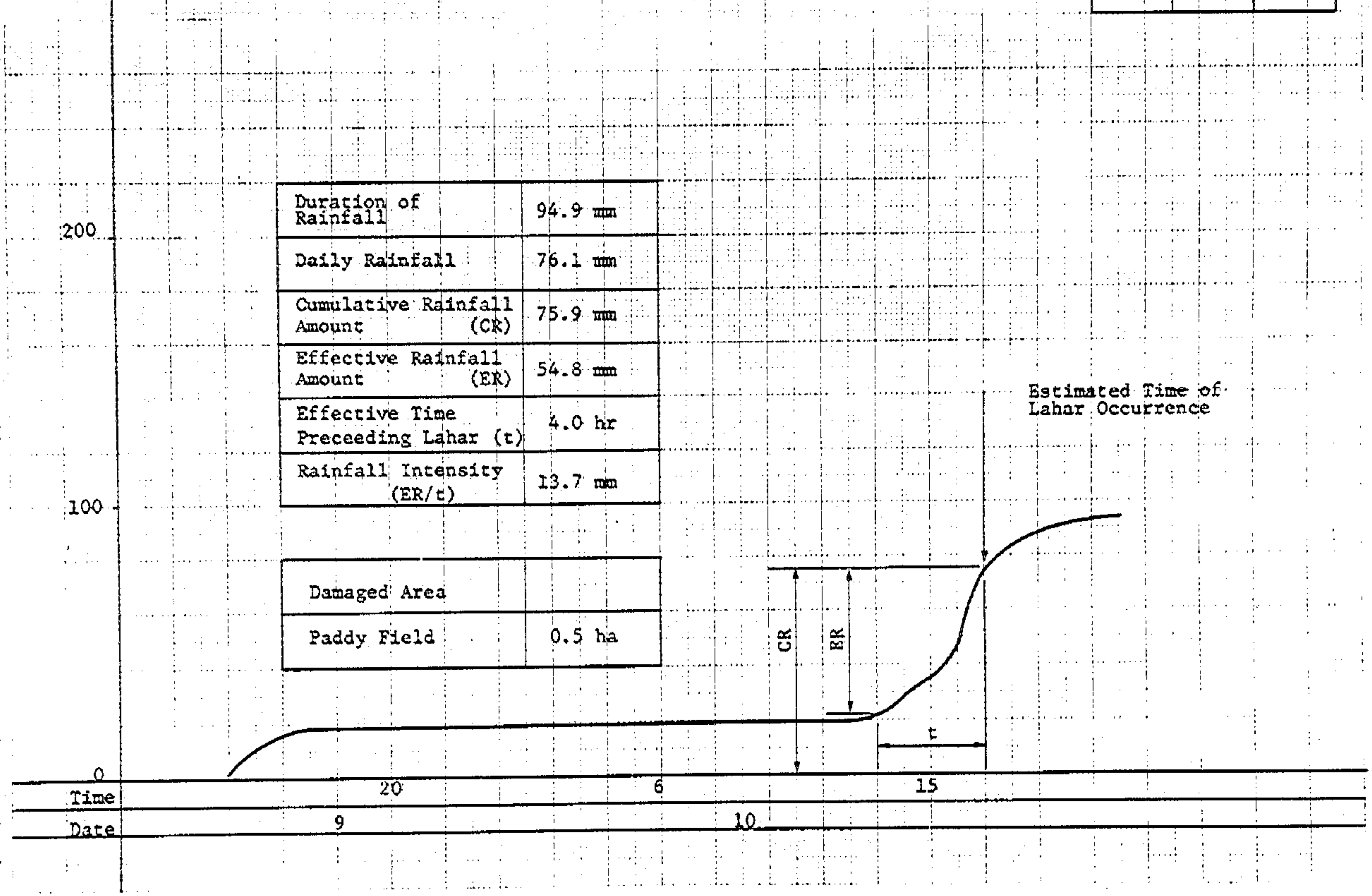
Duration of Rainfall	96.6 mm
Daily Rainfall	30.9 mm
Cumulative Rainfall Amount (CR)	82.7 mm
Effective Rainfall Amount (ER)	22.0 mm
Effective time Proceeding Lahar (t)	2.0 hr
ER/t	11.0 mm

Damaged Area	
Paddy Field	18.9 ha

Fig. 9 Amount of Rainfall and Rainfall Pattern of Lahar (4)

(K. Gendol, Rainfall Station: Deles)

Nov.	9.10	1973



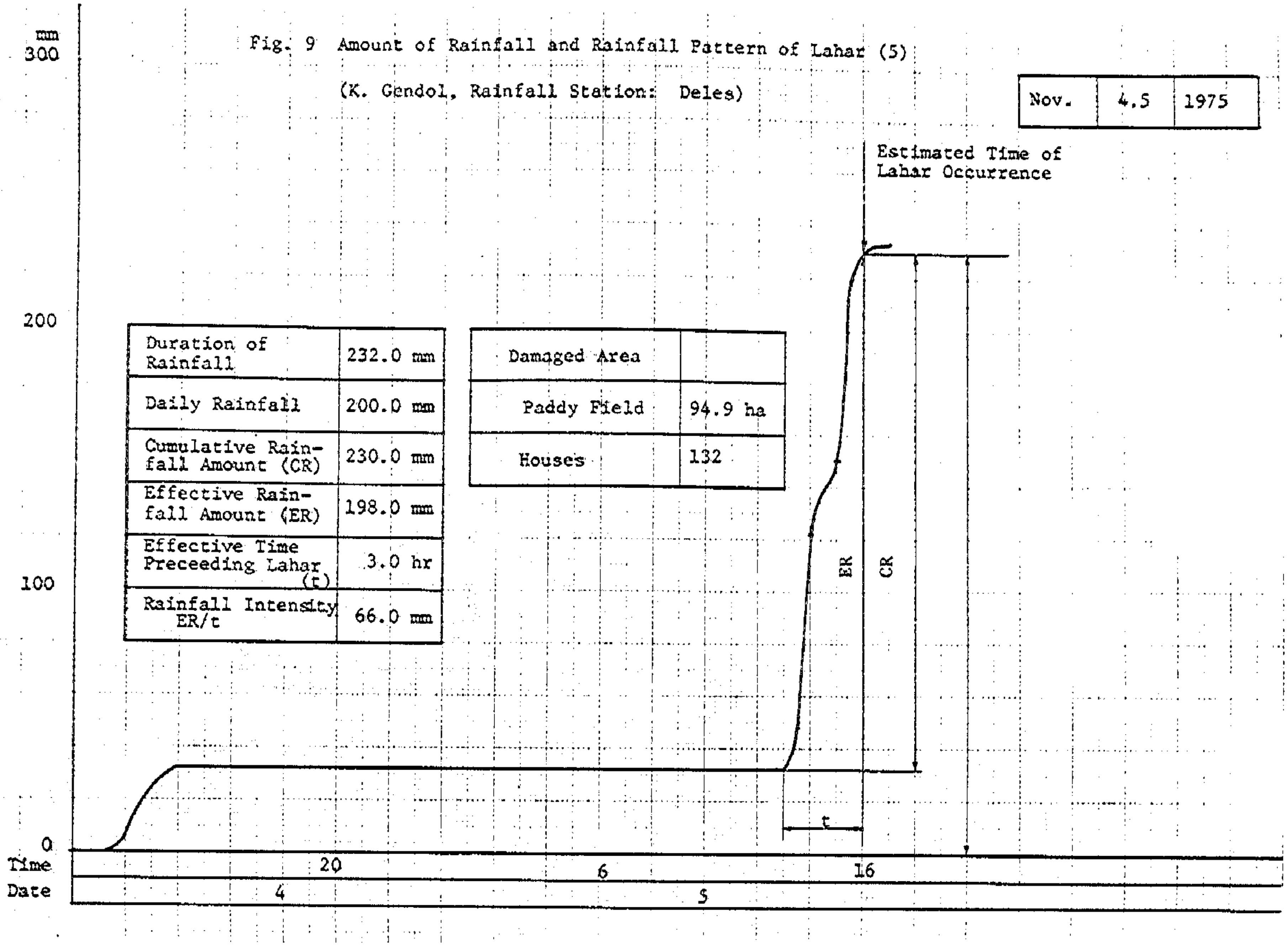
Duration of Rainfall	94.9 mm
Daily Rainfall	76.1 mm
Cumulative Rainfall Amount (CR)	75.9 mm
Effective Rainfall Amount (ER)	54.8 mm
Effective Time Preceeding Lahar (t)	4.0 hr
Rainfall Intensity (ER/t)	13.7 mm

Damaged Area	
Paddy Field	0.5 ha

Fig. 9 Amount of Rainfall and Rainfall Pattern of Lahar (5)

(K. Gendol, Rainfall Station: Deles)

Nov.	4.5	1975



Duration of Rainfall	232.0 mm
Daily Rainfall	200.0 mm
Cumulative Rainfall Amount (CR)	230.0 mm
Effective Rainfall Amount (ER)	198.0 mm
Effective Time Preceeding Lahar (t)	3.0 hr
Rainfall Intensity ER/t	66.0 mm

Damaged Area	
Paddy Field	94.9 ha
Houses	132

Fig. 9 Amount of Rainfall and Rainfall Pattern of Lahar (6)

(K. Gendol, Rainfall Station: Deles)

Nov.	1.2	1975

Duration of Rainfall	75.0 mm
Daily Rainfall	75.0 mm
Cumulative Rain-fall Amount (CR)	75.0 mm
Effective Rain-fall Amount (CR)	75.0 mm
Effective Time Preceeding Lahar (t)	6.0 hr
Rainfall Intensity (ER/t)	12.5 mm

Damaged Area	
	-
	-

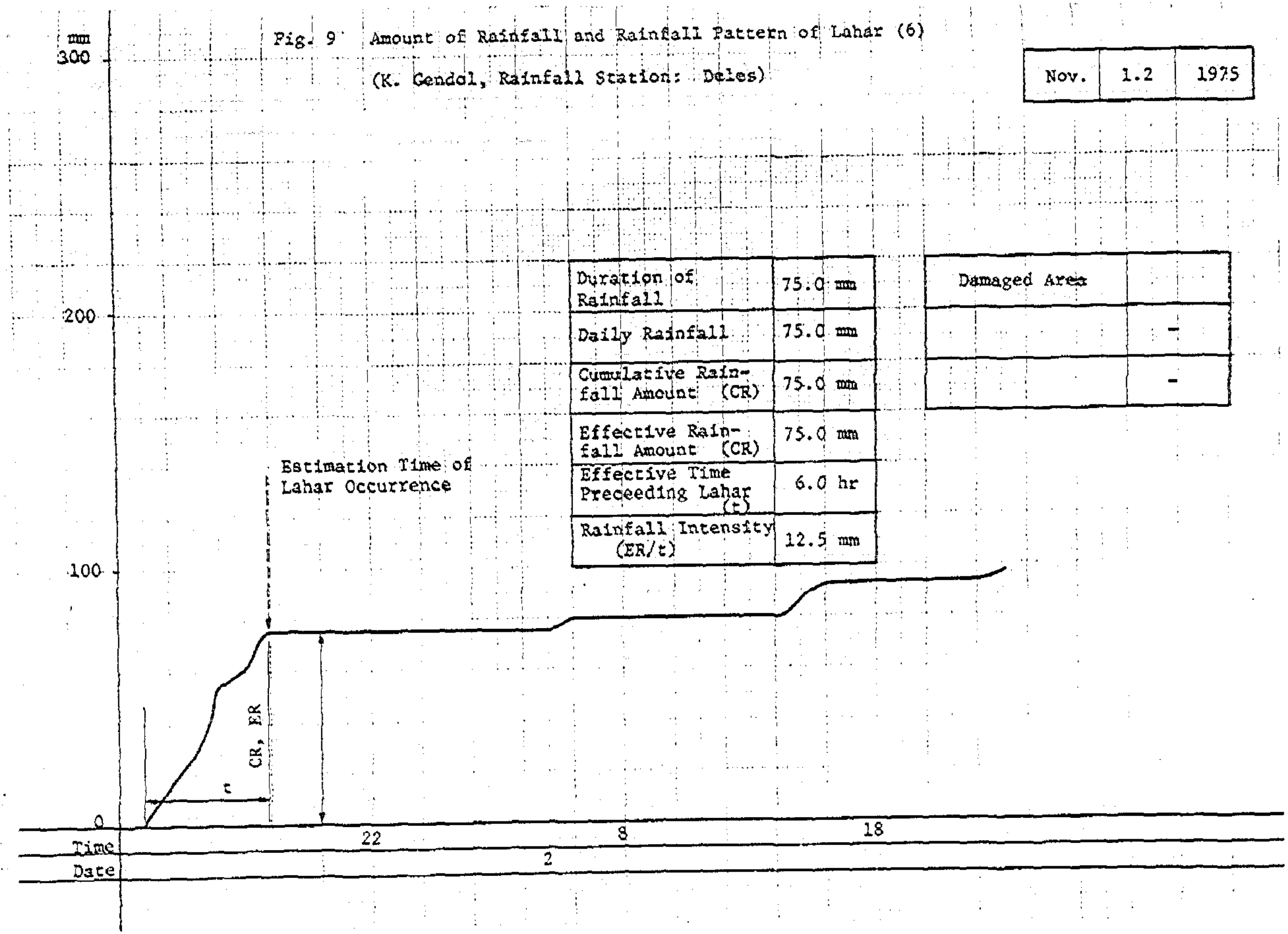


Fig. 9 Amount of Rainfall and Rainfall Pattern of Lahar (7)

(K. Gendol, Rainfall Station: Deles)

Oct.	2.3	1975

Duration of Rainfall	90.3 mm
Daily Rainfall	72.0 mm
Cumulative Rainfall Amount (CR)	70.7 mm
Effective Rainfall (ER)	53.0 mm
Effective Time Preceeding Lahar (t)	2.0 hr
Rainfall Intensity (ER/t)	26.5 mm

Damaged Area	

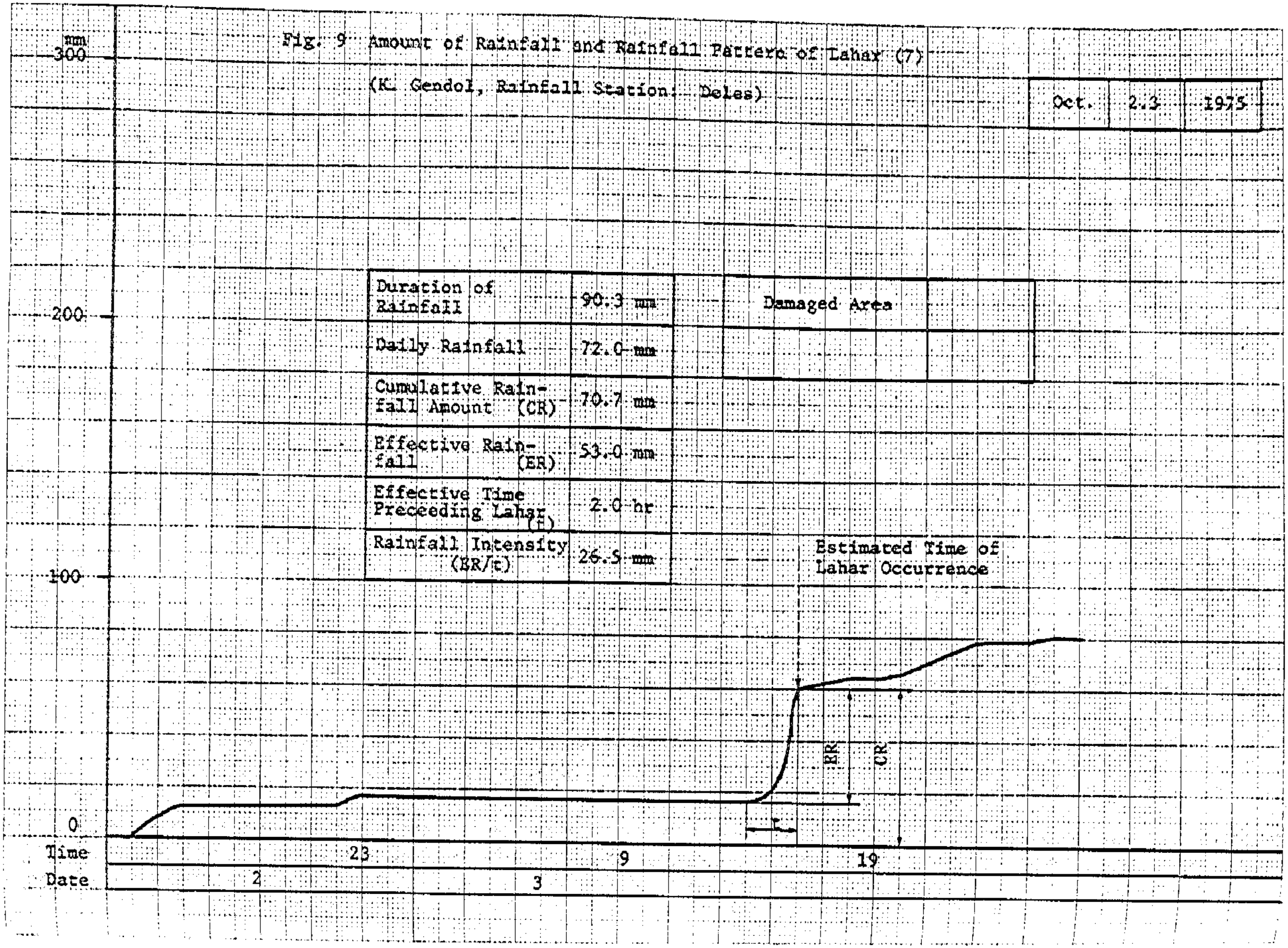


Fig. 9 Amount of Rainfall and Rainfall Pattern of Lahar (8)

(K. Gendol, Rainfall Station: Deles)

Nov.	16.17	1976

Duration of Rainfall	172.5 mm
Daily Rainfall	166.9 mm
Comulative Rain-fall Amount (CR)	146.7 mm
Effective Rain-fall Amount (ER)	129.8 mm
Effective Time Preceeding Lahar (t)	3.0 hr
Rainfall Intensity (ER/t)	43.2 mm

Damaged Area	
Jurangjero	

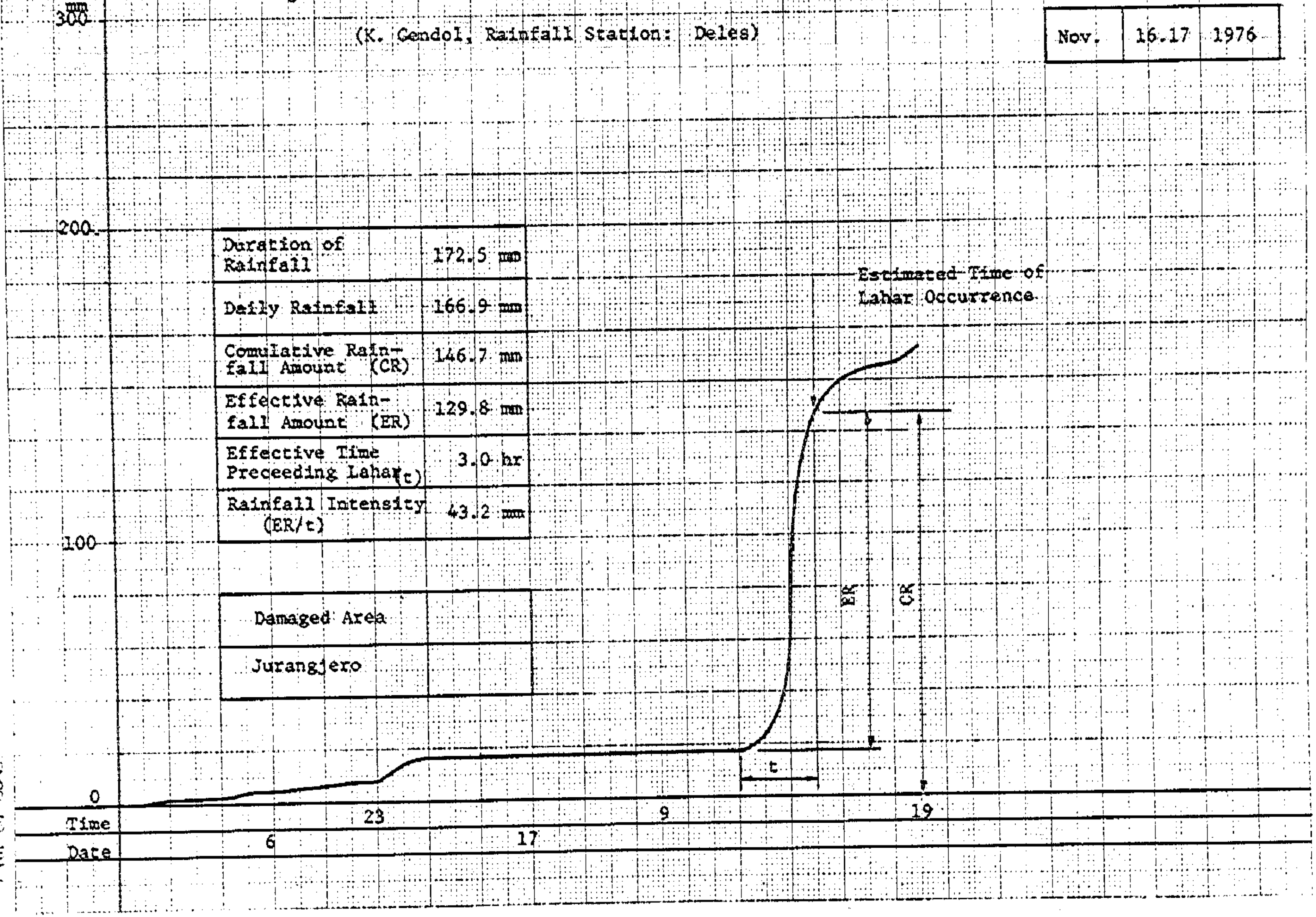
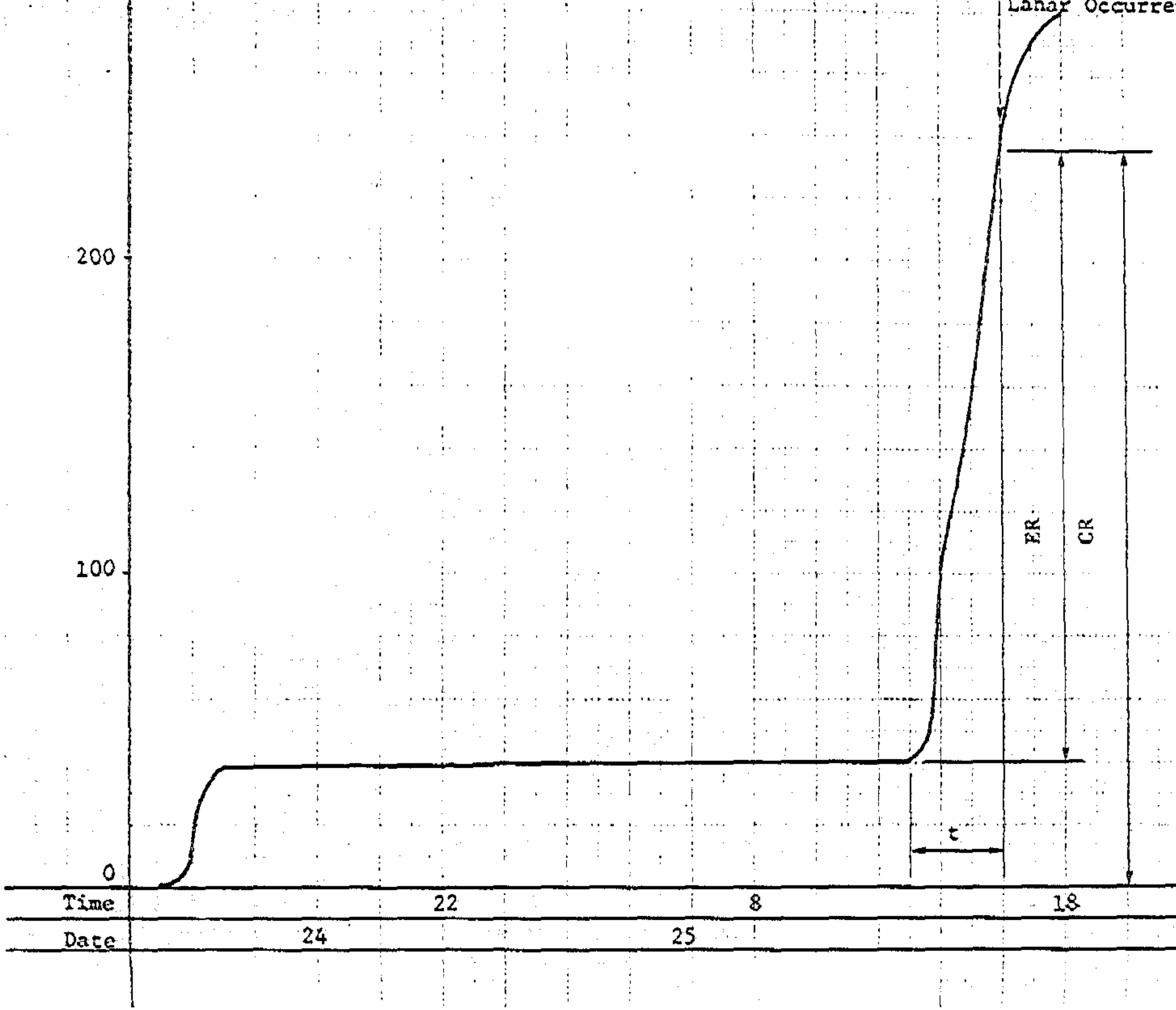


Fig. 9 Amount of Rainfall and Rainfall Pattern of Lahar (9)

(K. Gendol, Rainfall Station: Deles)

Nov.	24.25	1976



Duration of Rainfall	281.2 mm
Daily Rainfall	241.6 mm
Cumulative Rainfall Amount (CR)	233.6 mm
Effective Rainfall Amount	193.6 mm
Effective Time Preceeding Lahar(t)	3.0 hr
Rainfall Intensity (ER/t)	64.5 mm

Damaged Area	
Paddy Field	298.5 ha
Houses	277

4.2 Existing Disaster Prevention Facilities

4.2.1 Summary of Existing Disaster Prevention Facilities

(1) Tributaries' Existing Facilities

In the tributary areas, present disaster prevention facilities have been provided in a rather makeshift fashion, treating, so to speak, the symptoms rather than the causes. Before 1969, sand pockets and downstream embankments and revetment works were provided in the case of K. Woro, but it was not until that year that facilities began to be provided for the other tributaries (see Table 11 and Fig. 10).

(2) K. Progo's Existing Facilities

Approximately 4 km of embankments were provided along the left bank downstream of Srandakan Bridge, which is about 8 km from the river mouth.

(3) K. Opak's Existing Facilities

Embankments were provided all along the right bank and at places along the left bank downstream of approximately the 17 km point from the river mouth after the flooding of 1966.

(4) K. Dengkeng's Existing Facilities

The embankments of K. Dengkeng were required have been completed since it is a river with a riverbed that is higher than the ground base of the surrounding land.

4.2.2 Comments on the Existing Facilities

Although the existing facilities were no doubt well designed for the conditions that were present when they were constructed, they now need to be improved or supplemented as a result of riverbed variation and other factors. The following are comments on what improvement and supplementation is needed.

1) Required Disaster Prevention Facilities for the Tributaries

(1) Embankments and bank protection works are needed upstream of the downstream check dam of K. Krasak to prevent bank collapse and flooding as a result of the sediment depositing at the dam.

(2) The embankments and bank protection works downstream of approximately the 3 km point of the national road on K. Krasak were planned in such a way as to enclose a flooding area where there is a great deal of depositing of sediment. Under present circumstances this cannot be helped since it is necessary to decrease the amount of sediment discharge into K. Progo, but in the future it will be necessary to lower the riverbed at

section because as things are now it will continue to rise, threatening not only this section but also that in the vicinity of the national road as the rising riverbed progresses back upstream. Remedial work will entail reduction of the width of the river at this section by removal of the old intake weirs and provision of groin works, embankments, and revetment works.

(3) Since the sediment load works on K. Putih in the vicinity of the national road present a bottleneck for flood waters owing to the small cross-sectional area of the river and the fact that there is a sharp bend there, a shortcut and other improvements are necessary.

(4) Although there are two shortcuts at sharp bends on K. Putih, the river is narrow at these shortcuts, and this has the effect of adjusting sediment storage upstream. It also increases the danger of flooding because there is little difference in height between the riverbed and the river banks upstream. For this reason it will be necessary to get rid of the bottleneck in the vicinity of the national road, lower the riverbed to the vicinity of Ngepos, and improve the lines of the river course.

(5) Although there are flow course works on K. Gendol to about the 13 km point from the summit making for a stable river course, there is considerable danger of flooding further downstream for lack of preventative facilities. It is therefore urgently necessary to provide temporary works all the way to the point of confluence with K. Progo.

(6) Since river fluctuation is very important, river variations must be fully ascertained after temporary works have been constructed and before proceeding with permanent works. In this sense it is very appropriate that the temporary works should be done with gabion and for concrete lining to follow later. The check dam works on K. Boyong should be temporarily suspended upon completion of the foundation in view of the present situation with respect to sediment discharge.

2) Required River Facilities for K. Progo and K. Opak

(1) The embankments at downstream sections of K. Progo and K. Opak where there is danger of flooding should be adequate for coping with flood waters of the proportions of those of 1966 and 1969. However, it is advisable that improvements such as fixation of low river courses and provision of river mouth training levees in order to cope with the threat of flooding due to future riverbed rise and river mouth blockage be planned.

3) Structure of the Facilities and Methods Employed in Their Construction

(1) Many of the facilities downstream of check dams and consolidation dams are subject to the Scouring action by the river waters. This is inevitable in view of change in the sediment

load, the effect of falling water, and other factors. Rivers characterized by a great deal of sediment discharge have high riverbeds with steep gradients, and as the discharged sediments decreases in the future, their riverbeds will get lower and scouring action will be particularly pronounced in areas such as this where the riverbed materials consist of fine particles. For this reason, it is necessary that check dams and other works for prevention of scouring be adequately planned for from the outstart.

(2) Stone mosonry and other top protective works are needed for check dams and consolidation dams because of the considerble damage that they have sustained.

(3) Since there is considerable danger of damage to the wings of check dams from the inpact of the lahar flow, it is advisable that protective works such as banking and bank protection works be planned.

(4) Since there have been cases of destruction of revetment works by secouring action, it is necessary not only to give such works adequate foundations, but also to provide foot protection works. Moreover, at places where the river course is pronouncedly unstable, gabion and similar flexible structures are preferable.

(5) Water regulation works in the downstream section of K. Woro are to be palings made of bamboo; in other places, rock basket, stone pitching, and concrete blocks should be used. Bamboo and similar materials should be effective for downstream sections. The bamboo palings should not be made from split bamboo, but rather from whole bamboo poles and wood for greater strength. There is also damage to groin works by scouring action at the front extremes and at where they are connected to embankments. In the case of nonpermeable groin such as those with stone pitching, it will be necessary to provide foot protection works around them as well as revetment works beside the embankments. Furthermore, it will be necessary to provide bank protection works at the stone masonry groin works upstream of the national road on K. Blongkeng because these works are long in compalison with the river width and also very strong, forcing the river water to flow in the direction of the opposite bank.

(6) Since the attachment part of the arch-type check dams on K. Pabelan bear the brunt of the force of the river's flow and is in danger of collapse, bank protection works are needed.

(7) The surfaces of the embankments downstream of the national road on K. Woro are made of sand and embanked earth and therefore are apt to collapse quite easily. Presently tests are being carried out with respect to the kind of vegetation that might be planted as covering at the higher parts of the embankment if the slope there can be made more gentle by providing small terraces. Bank protection works for fixation of a low water

course are also necessary at this section.

(8) Intake facilities and bridges have also been planned in association with provision of disaster prevention facilities, and this has proven to be effective. Accordingly, this practice should be continued in the future.

(9) There have been cases of damage to embankments and bank protective works owing to the subsequent provision of passages for people and livestock. For this reason such passages, washing and bathing places, and the like should in the future be planned as integral parts of the design of such facilities.

(10) Planting experiements are being conducted in the upstream section of K. Krasak with respect to the legume plant, flemingia congesta. It is fast growing and ought to be very useful for ground covering to prevent surface erosion and reduce sediment discharge. It can also be mixed with pine and other trees to serve as fertilizer. Sengon (acacia) are also fast growing and could possibly be used for buffer purposes in the vicinity of sand pocket training levees.

4) Materials and Construction Methods

Stone and other materials available locally should be used as far as possible. The rock fill used for check dams are now cut to about 20 cm on a side. It would be better, however, to use larger rocks, which would be possible if better means could be found to transport them. Furthermore, adequate packing is necessary for close contact between the rock fill and the concrete; in this connection, it would be advisable to use vibrators.

5) Maintenance and Repairs

(1) At some places the facilities are in need of maintenance and repair work. Such work should be carried out as soon as possible if the facilities are to be expected to have a long effective life.

(2) In view of the great amount of riverbed fluctuation, the condition of the rivers should be inspected regularly and restorative repairs should include improvements when possible.

(3) There are cases in which local residents have taken away foundation stones of bank protection works or used the tops of embankments for cultivation purposes. It is therefore advisable that efforts be made to make local people aware of the purposes of these facilities and engender in them the desire to protect their rivers and disaster prevention facilties.

Table 11 Existing Sabo Facilities (Check dams and Consolidation dams) (1)

(Unit: m, m^3)

No.	Name of River	Location	Height (m)	Length (m)	Capacity (m^3)	Construction Period
1	K. Pabelan	Pendem	8.0	64	110,000	from 73 ∿ 74
2		Tlatar	7.0	64	72,000	72 ∿ 73
3	K. Pabelan (K. Trising)	Sukoguo	7.5	54	50,000	73 ∿ 74
4	K. Pabelan (K. Senowo)	Tutup	5.5	49.5	136,000	77 ∿ 79
5	K. Blongkeng (K. Lamat)	Banyurejo	3.0	16	3,930	73 ∿ 74
6	K. Blongkeng	Salamsari	10.0	93	128,000	78 ∿ 79
7	K. Putih (K. Jurangjero)	Salamsari	10.5	84.6	185,000	76 ∿ 77
8	K. Putih	Salamsari	7.7	50	45,000	73 ∿ 74
9	K. Krasak (K. Bebeng)	Puntuk	6.0	97.5	224,000	78 ∿ 79
10	K. Krasak	Kranggan	5.0	1,214	320,000	76 ∿ 77
11	K. Krasak	Kopen (Salam)	6.5	93	210,000	74 ∿ 75
12	K. Boyong	Kaliurang	5.5	97	580,000	75 ∿ 76
13	K. Code	Pogung	4.0	100	119,800	67 ∿ 70

Table 11 Existing Sabo Facilities (Check dams and Consolidation dams) (2)

(Unit: m, m^3)

No.	Name of River	Location	Height (m)	Length (m)	Capacity (m^3)	Construction Period
14	K. Kuning	Ngipiksari	16.5	60.5	360,000	from 74 ~ 75
15	K. Gendol	Kepuh	13.0	53.5	210,000	74 ~ 75
16	K. Gendol	Bronggang	6.0	30	150,000	71 ~ 72
17	K. Gendol	Tegaljetis	3.5	44	80,000	73 ~ 74
18	K. Gendol	Plumbon	3.5	60	100,000	73 ~ 74
19	K. Opak	Tulung	5.0	48	349,600	72 ~ 73
20	K. Woro	Junut	2.0	-	3,850,000	72 ~ 73
21	K. Woro	Sukorini	5.5	70	12,000	73 ~ 74
22	K. Woro	Kedusan	4.0	65	41,000	74 ~ 75
23	K. Woro	Jatirejo	4.0	83	20,000	73 ~ 74
24	K. Woro	Wono Boyo	3.5	69.5	38,160	77 ~ 78
25	K. Pusur	Selogringging	2.5	32	15,000	72 ~ 73
26	K. Pusur	Selogringging	3.25	30	10,000	72 ~ 73

Table 11 Existing Sabo Facilities (Embankment and Revetment) (3)

(Unit: m)

Final Year / Name of River	1969/1970	1970/1971	1971/1972	1972/1973	1973/1974	1974/1975	1975/1976	1976/1977	1977/1978	1978/1979
K. Pabelan										
Left	250									
Right	206.5									
K. Blongkeng										
Left					210				40	
Right	257									
K. Putih										
Left										
Right						12	50			
K. Krasak										
Left	300		91.4		31	1,186.5	2,459	325	739	3,599
Right	60	90	40		81	1,875	880	272.5	867	1,551
K. Gendol										
Left			1,200			40.5				
Right		1,100	1,200		100	40.5				
K. Woro										
Left		198	1,920	800	24					
Right		415	1,200	700	150					
K. Progo										
Left		130								
Right		34								
K. Code										
Left		225								
Right										

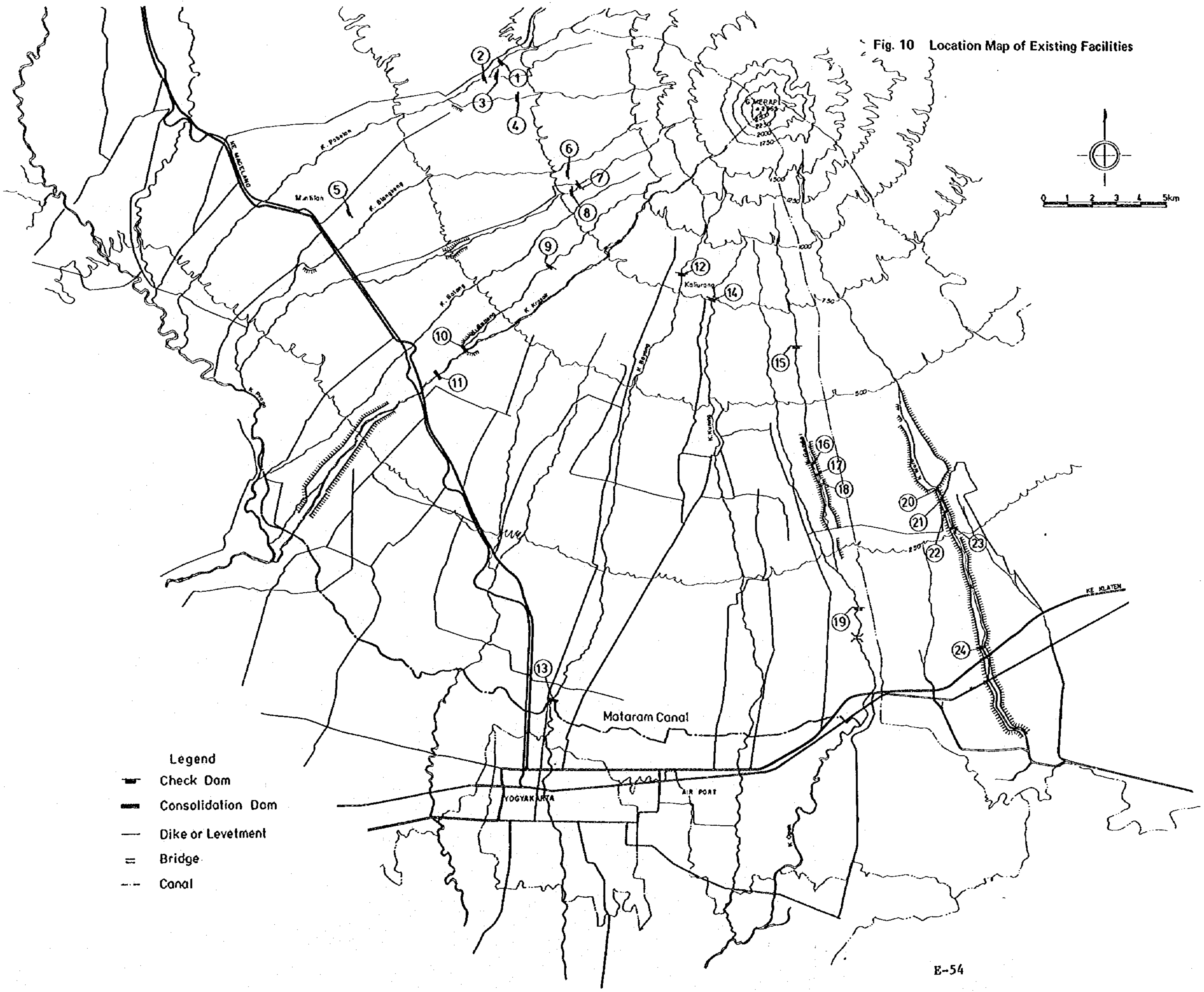


Fig. 10 Location Map of Existing Facilities

SUPPORTING REPORT F

SOCIO-ECONOMY

C O N T E N T S

List of Tables

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1. GENERAL

1.1 Purpose and Method of Study

The purpose of this study is to evaluate the erosion control plan by analyzing past and present socioeconomic conditions in the area covered and forecasting the socioeconomic impact that implementation of the plan will have.

Qualitative and quantitative analyses have been made regarding land use, infrastructure, population, labor force, agriculture, and assets on the basis of official national and regional statistics, and of information and data obtained during a door-to-door socioeconomic survey. With respect to agriculture in particular, which is and will continue to be, at least for the near future, the main production sector in the area covered by the plan. Items were studied from the standpoint of the structure of industry and employment in order to forecast future regional agricultural production and indicate the direction that agriculture will take in the area in question.

Furthermore, with respect to areas that have experienced disaster damage in the past and are therefore considered to be more problematic than other areas, a socioeconomic questionnaire was prepared in order to obtain information on the needs of the residents, their socioeconomic activities, the type of disaster damage they have actually experienced, and so on. A total of 19 kelurahan (villages or the smallest administrative unit) were selected at random for the purposes of this survey: 2-3 each from the upstream, middle stream, and downstream areas of the Type-I and Type-II river areas and from the middle stream area of the Type-III river areas. In each kelurahan a hamlet was again selected at random for door-to-door interviewing of all of the households in it, which represented 1.5-5% of all of the households in the particular kelurahan. The results were used for cross checking between the macro statistics and the other statistics and information to the extent that it was possible.

1.2 Economic Background

The area covered by the plan extends over parts of two provinces: Central Java Province and the Special District of Yogyakarta. It embraces 1 city, 4 kabupaten, 32 kecamatan, and 259 kelurahan. Table 1 gives GRDP figures for the two provinces. The rate of economic growth in real terms between 1971 and 1975 was 4.5% in Central Java Province, 9.6% in the Special District of Yogyakarta, and 8.0% in Indonesia as a whole. The interregional gap in per-capita income widened during that period and per-capita income in these two provinces, which had been 28% lower than the national average in 1971, fell to 45% below the national average in 1975.

Table 2 gives the per-capita GRDP figures for each of the four kabupaten in the area covered by the plan. Because of insufficient data, it was not possible to provide figures for the same years. It should be noted that the figure for Magelang, which is primarily located in the Type-I area, was particularly low.

1.3 Administrative Divisions

As already mentioned, the area covered by the plan extends over parts of Central Java Province including Kabupaten Magelang and Klaten and the Special District of Yogyakarta (D.I.Y.), including Kabupaten Sleman and Bantul. The administrative units from large to small are province, kabupaten, kecamatan, and kelurahan (village); the last is the smallest administrative unit. Each kelurahan, or village, is composed of hamlets (non-administrative units called dukuh) which are in turn composed of households. Table 3 summarizes the administrative units for the area covered by the plan.

Table 1 GRDP Comparison for Central Java, D.I. Yogyakarta and Indonesia

	1971	1973	1975
Central Java			
GRDP Current (Rp. Bill)	483	707	1,174
Per Capita Current (Rp.)	22,064	31,320	50,665
D.I. Yogyakarta			
GRDP Current (Rp. Bill)	55	78	132
Per Capita Current (Rp.)	21,969	30,551*	50,993*
Indonesia			
GRDP Current (Rp. Bill)	3,672	6,753	12,190
Per Capita Current (Rp.)	30,575	53,556	92,279

Note: * Estimated figure by the Study Team

Source: Java Regional Study; Central Java; JICA; 1977
Repelita III; D.I. Yogyakarta; 1979

Table 2 Per-capital GRDP for Comparison for Indonesia, Central Java and Selected Project Areas

Unit: Rupia

Per Capita GDRP in 1973		Per Capita GDRP in 1976	
Indonesia	53,560	Indonesia	114,800*
Central Java	31,320	D.I. Yogyakarta	61,070
Kab. Magelang	24,140	Kota. Yogyakarta	
Kab. Klaten	36,240	Kab. Sleman	65,700
		Kab. Bantul	62,200

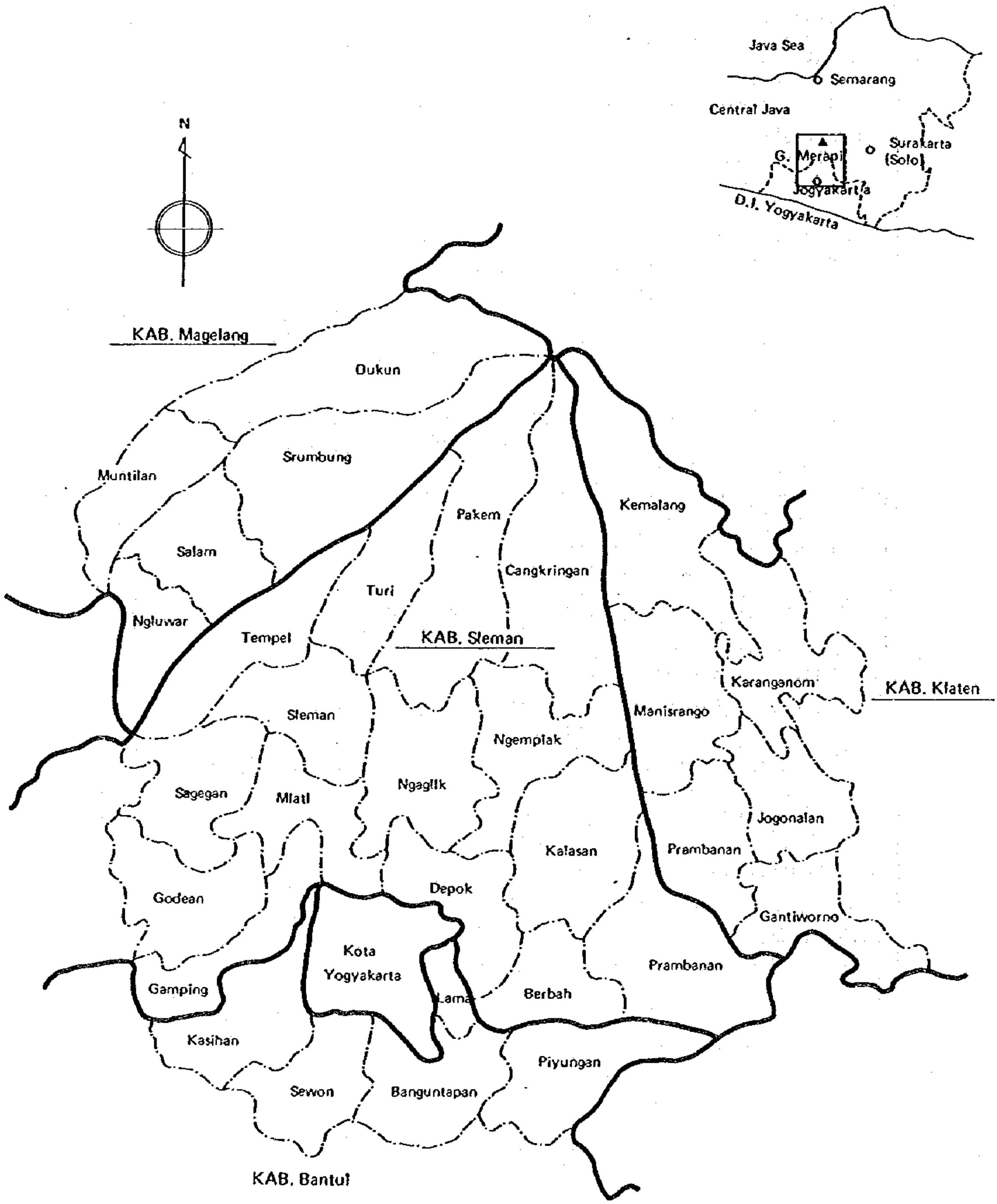
Note: * Estimated figure by the Study Team

Source: Repelita III; Central Java and D.I.Y.; 1979

Table 3 Administrative Units in the Area of the Plan

Province	Kabupaten	Kecamatan	Kelurahan
D.I. Yogyakarta	Kodya Yogyakarta	14	-
	Bantul	5	19
	Sleman	15	86
Central Java	Magelang	5	61
	Klaten	6	93

Fig. 1 Map of Kecamatan Administrative Units in the Project Area



2. POPULATION AND LABOR FORCE

2.1 Population

Table 4 gives average annual rates of increase in population and population densities for different parts of Indonesia, and Table 5 and 6 give similar figures for the kelurahan covered by the socio-economic survey mentioned above.

Approximately 1.3 million persons live in the area of about 800 km^2 covered by the plan. Although the rate of population increase in this area is lower than that for Indonesia as a whole, (under 1% in the case of more than 50% of the kelurahan in the area and under 2% in the case of over 80% of them), the population density is very high 1,584 persons/km^2.

The social importance of this area and the urgency of disaster prevention measures in it can be appreciated from the population densities of the nuée ardente danger zones which are 576 persons/km^2 and of Type-I parts of Zone-3, (where there is frequent lahar/banjir damage) of 1,381 persons/km^2.

Table 7 gives figures on population breakdown by age as based on kelurahan village official statistics. These figures indicate a basic statistical distribution shaped like Mt. Merapi, with a high birth rate, but they also show some signs of population outflow that is often to be observed in rural areas.

As for future population increase, the goal for D.I. Yogyakarta is to keep it below about 1.1% a year during the period covered by Repelita III; reduction of population pressure is also one of the main goals for Central Java Province during that period, since the rate of increase rose to 1.7% in 1977 after having been about 1.1% since 1971.

Although it should not be too difficult to keep the rate of population increase in the area covered by the plan within the limit set by provincial goals considering the present rate of increase, the high population density that has already been reached means that the increase in absolute terms will be large in any case. This is another factor emphasizing the growing importance of disaster prevention planning.

Tables 8 and 9 show the number of household members and the breakdown by level of education in the area covered by the plan. The average family size is 4.7 persons, with the largest distribution in the range 4-6 persons. A total of 54% of the persons have not attended school at all.

2.2 Structure of Employment

Table 10, which is based on statistics provided by the village offices, gives breakdowns by type of employment for the population aged 10 and over, and Table 11 gives breakdowns by type of employment for the heads of the households.

The overall percentage breakdown for the heads of households is 80% farming (70% farming exclusively), 5% commerce, and 7% wage earners; however the figures indicate considerable employment of surplus family labor in commerce and construction work.

2.3 Labor Force

The socioeconomic survey made in the area covered by the plan shows that almost all of the economically active population, i.e., those at least 10 years of age, work more than 200 days a year. A comparison of the necessary amount of labor as calculated on the basis of average labor input at the kabupaten level with the amount of labor that each of the 19 kelurahan can supply, however, shows that apart from 2-3 kelurahan which have a labor shortage and have to hire farm workers from neighboring villages, the rest have considerable labor surpluses of varying proportions.

The existence of unproductive surplus labor is also substantiated by statistics of the D.I. Yogyakarta which show that 40% of the residents fall below the living standard for rural communities of 240 kg of rice per annum per person. Furthermore, Repelita III of Central Java Province envisages the need to create new employment opportunities for 425,000 persons in the agricultural sector, 188,000 persons in the industrial sector, and 310,000 persons in the service sector in the next five years: another reason to expect considerable unemployment of both apparent and latent (see Table 12).

Creation of work opportunities will have to be put on a more permanent footing in order to be able to absorb the increase labor surplus that is expected. In the meantime, disaster prevention works in the area covered by the plan will help to a certain extent.

Table 4 Average Annual Rates of Increase in Population and Population Density

	Population Density (persons/km²)	Average rate of Population Increase per annum (%)
Indonesia	68 (1978)	2.3 (1974 - 1978)
Java.	644 (1978)	n.a.
Central Java	679 (1977)	1.15 (1971 - 1977)
D.I. Yogyakarta	828 (1976)	1.19 (1971 - 1976)

Source: Repelita III, 1979

Table 5 Area, Population and Population Density in the Project Area (1976)

Planning Zone	Area Type	No. of Kelurahan & M.P.P.	Area (km²)	Population	Population Density (Persons/Km²)
Zone 1 & 2	Nuée Ardente	26	136	78,298	576
Zone 3	Type I	27	78	107,689	1,381
	Type II	50	147	194,978	1,326
	Type III	8	71	56,900	801
Zone 4	-	114	414	902,000	2,179
Total or Average		225	846	1,339,865	1,584

Table 6 Average Annual Rate of Increase in Population (1966 ∿ 1976)

(Unit: No. of Kelurahan)

Zone	Type	∿-3.1	-3.0∿ -0.1	0∿ 0.9	1.0∿ 1.9	2.0∿ 2.9	3.0∿ 4.9	5.0∿	Total
Zone 1 & 2	Nuée Ardente	-	1	12	7	5	1	-	26
Zone 3	Type I	-	4	12	9	1	1	-	27
	Type II	2	13	14	8	3	2	1	43 1/
	Type III	-	-	6	1	-	-	-	7 1/
Zone 4	-	5	6	30	34	13	3	3	94 1/
Total		7	24	74	59	22	7	4	197

1/ data not available for all Kelurahans

Table 7 Population Breakdown by Age

Kelurahan / Sex / Age	Kemiren		Merdikorejo		Sukorini		Muruh	
	Male	Female	Male	Female	Male	Female	Mael	Female
0 ∿ 4	53	56	334	306	304	319	150	159
5 ∿ 9	46	52	312	308	151	162	143	145
10 ∿ 14	44	36	303	309	106	118	145	146
15 ∿ 19	40	41	262	302	169	115	147	145
20 ∿ 24	30	30	203	233	113	115	104	109
25 ∿ 29	45	49	183	197	105	110	103	106
30 ∿ 39	30	37	215	305	108	102	102	104
40 ∿ 49	25	19	225	246	121	120	100	103
50 ∿ 59	26	28	173	165	39	52	100	103
60 ∿	19	24	226	315	20	35	59	80

Table 8 Family Structure in the Hazard Area

Type	Location	Number of constituters	1	2	3	4	5	6	7	8	9	Over 10	No answers	Total
1	A	Number of answers	0	7	4	15	12	6	3	0	1	2	0	50
		%	0	14.0	8.0	30.0	24.0	12.0	6.0	0	2.0	4.0	0	100
	B	Number of answers	1	11	13	8	11	11	8	2	0	2	0	67
		%	1.5	16.4	19.5	11.9	16.4	16.4	11.9	3.0	0	3.0	0	100
	C	Number of answers	1	5	4	9	7	1	2	1	1	0	0	31
		%	3.2	16.1	13.0	29.0	22.6	3.2	6.5	3.2	3.2	0	0	100
2	A	Number of answers	0	3	4	14	10	7	5	3	1	1	0	48
		%	0	6.3	8.3	29.1	20.8	14.6	10.4	6.3	2.1	2.1	0	100
	B	Number of answers	1	8	16	18	12	19	15	5	4	3	1	102
		%	1.0	7.8	15.7	17.6	11.8	18.6	14.7	4.9	3.9	3.0	1.0	100
	C	Number of answers	0	1	2	9	7	17	6	5	2	1	0	50
		%	0	2.0	4.0	18.0	14.0	34.0	12.0	10.0	4.0	2.0	0	100
3		Number of answers	1	10	12	14	25	18	9	9	3	1	0	102
		%	1.0	9.8	11.8	13.7	24.5	17.6	8.8	8.8	3.0	1.0	0	100
Total		Number of answers	4	45	55	87	84	79	48	25	12	10	1	450
		%	0.9	10.0	12.2	19.2	18.7	17.6	10.7	5.6	2.7	2.2	0.2	100

(Note) A: Upper stream B: Middle stream C: Downstream

Table 9 Level of Education in the Hazard Area

Type	Location	Level of education	Non-educated	Graduated from Primary School	Graduated from Junior High School	Graduated from High School	Graduated from University	Doctor	No Answer	Total
1	A	Number of answers %	28	15	6	1	0	0	0	50
	B	Number of answers %	33	28	4	2	0	0	0	67
	C	Number of answers %	15	15	0	1	0	0	0	31
2	A	Number of answers %	36	11	0	0	0	0	1	48
	B	Number of answers %	61	35	2	4	0	0	0	102
	C	Number of answers %	24	20	4	1	1	0	0	50
3		Number of answers %	47	39	8	8	0	0	0	102
Total		Number of answers %	244 54.2	163 36.2	24 5.4	17 3.8	1 0.2	0	1 0.2	450 100

(Note) A: Upper stream B: Middle stream C: Downstream

Table 10 Types of Employment of the Population Aged 10 and Over in the Hazard Area

Employment \ Population	Kel. Sukorini		Kel. Muruh	
	prsns	%	prsns	%
Farmer	325	26.1	196	24.0
Agricultural Labourer	638	51.2	298	36.6
Industrial Labourer	5	0.4	52	6.4
Construction Labourer	-	-	150	18.4
Merchant	242	19.5	5	0.6
Transportation	-	-	56	6.9
Civil Servant/Military	30	2.4	56	6.9
Pensioner	5	0.4	2	0.2

Table 11 Vocation of Family Head

Type	Location	Vocation	Farming				Commercial business	Wage-earners	Others	No answer	Total
			Farming alone	Commerce	Wage-earners	Others					
1	A	Number of answers	45	1	1	0	0	3	0	0	50
		%	90.0	2.0	2.0	0	0	6.0	0	0	100
	B	Number of answers	43	1	1	4	5	6	7	0	67
		%	64.2	1.5	1.5	6.0	7.4	9.0	10.4	0	100
	C	Number of answers	28	0	0	0	2	1	0	0	31
		%	90.3	0	0	0	6.5	3.2	0	0	100
2	A	Number of answers	42	1	0	1	1	1	2	0	48
		%	87.5	2.1	0	2.1	2.1	2.1	4.1	0	100
	B	Number of answers	73	4	2	7	3	3	10	0	102
		%	71.6	3.9	2.0	6.9	2.9	2.9	9.8	0	100
	C	Number of answers	26	0	0	7	5	3	8	1	50
		%	52.0	0	0	14.0	10.0	6.0	16.0	2.0	100
3		Number of answers	62	2	4	5	5	16	5	3	102
		%	60.8	2.0	3.9	4.9	4.9	15.7	4.9	2.9	100
Total		Number of answers	319	9	8	24	21	33	32	4	450
		%	70.9	2.0	1.8	5.3	4.7	7.3	7.1	0.9	100

(Note) A: Upper stream B: Middle stream C: Downstream

Table 12 Estimation of Increase in Labor Force in Central Java Province (1979/80 ∿ 1983/84)

Age	Sex	1979/80 (%)		1983/84 (%)	
10 - 24	Male	2,164,326		2,277,950	
	Female	1,283,373		1,378,131	
	Total	3,447,699	35.7	3,655,262	34.5
25 - 39	Male	1,787,815		2,198,081	
	Female	977,813		1,054,697	
	Total	2,765,628	28.6	3,252,778	
40 - 54	Male	1,642,147		1,625,145	
	Female	908,366		985,834	
	Total	2,550,513	26.4	2,610,978	24.7
55 -	Male	620,362		744,554	
	Female	280,656		326,628	
	Total	901,018	9.3	1,071,182	10.1
Total	Male	6,214,650		6,845,738	
	Female	3,450,208		3,745,290	
	Total	9,664,858	100.0	10,591,028	100.0

Source: Repelita III of Central Java Province

3. SOCIOECONOMIC INFRASTRUCTURE

3.1 Production Infrastructure

3.1.1 Land

Land is an indispensable production factor. This erosion and volcanic debris control plan aims, for one thing, at protecting valuable land from lahar and banjir. Especially considering the fact that there is high population density and a high level of development of land use in the area covered by the plan and even in danger zones within it, the area will suffer a great loss if more land is lost to lahar. Approximately 11,400 ha of land are in fact more or less faced with this unpleasant possibility.

3.1.2 Irrigation Conditions

Irrigation on the periphery of G. Merapi has a long history. There are innumerable irrigation systems along the tributaries of the Progo, Opak and Dengkeng rivers, which receive water from that mountain. These irrigation facilities are particularly important because of the fact that agriculture and especially cultivation of paddy is the main industry of the area. The following points were revealed by a survey on the distribution of irrigation facilities in the area covered by the plan on the basis of information obtained from Magelang, Boyolali, Klaten, and Yogyakarta public works and the K. Progo irrigation project:

(1) Classification of Irrigation Areas

The irrigation areas within the area covered by the plan can be classified as follows according to their facilities, their organization and operation, and their functions:

a) Technical areas: areas in which the intake facilities and primary and secondary channels are constructed and managed by the national government and those on the tertiary or lower levels channels are managed by the villages (kelurahan).

b) Semi-technical areas: areas in which the intake facilities are constructed and managed by the national government, but all of the channels are managed by the villages.

c) Non-technical areas: areas in which the intake facilities and all channels are constructed and managed by the villages. A breakdown of the areas covered by such irrigation systems is given in Table 13.

(2) Distribution of the Irrigation Areas and Scale of Irrigation

The most important irrigation system of the area is the Mataram system, irrigating an area of 15,000 ha (see Table 14), which is divided into two parts that along the upstream part of the main channel and that along the downstream part.

Kab. Bantul and Kota Yogyakarta are located on the south side of the main channel of this system. The irrigation facilities there have been developed considerably, since most of the areas there are technical and semi-technical areas; only about 13% of the irrigation land in Kab. Bantul are still nontechnical areas.

This area is important in terms of agricultural production.

On the north side of the main channel of the Mataram system, located in the periphery of G. Merapi, the level of provision of irrigation facilities is still low as a whole; 58% of the irrigated land in Kab. Sleman, for instance, is still nontechnical areas. Consequently it is necessary to provide more irrigation facilities there. Since, however, as revealed by the results of the social survey, these nontechnical irrigation areas are very small, usually under 10 ha each, it would be better to give priority to potentially outstanding farming areas rather than to provide irrigation facilities evenly throughout.

As for the distribution of intake facilities, the main ones are on rivers with stable courses; those on rivers in Type-I areas with unstable courses due to lahar mud flows are primitive natural intakes except for those at erosion control dams. Therefore, as future disaster prevention works make the courses of these rivers more stable it should be possible to increase the number of intakes on them and stabilize the amount of water supply from such intakes.

3.2 Utility Infrastructure

Except for Kota Yogyakarta, there is no electrification or water supply or sewage networks in the area covered by the plan.

A survey of the sources of water of the 19 kelurahan indicates that 11 depend on wells and 5 on springs. In the upstream part of the Type-II area, people depend on rainwater for the water used in everyday life, and during the dry season some people have to travel a distance of several kilometers everyday to fetch water from reservoirs (see Table 16).

Nearby rivers and other waterways serve as sewage systems and are also important for washing clothes and bathing. When there are no rivers or channels nearby, ponds are dug in yards for such purposes. From the standpoint of both greater convenience and better sanitation, it is desirable that there be a more reliable way of providing the water that the people need in their everyday lives.

3.3 Transportation Infrastructure

The hierarchy of roads in Indonesian is as follows:

Road Hierarchy:

national	jalan negara
provincial	jalan propinsi
country	jalan kabupaten
town/village	jalan desa

The main roads in the area covered by the plan are: a national road linking Yogyakarta and Klaten via Prambanan in an east-west direction, another national road linking Yogyakarta and Magelang via Sleman and Tempel in a north-south direction, a provincial road running approximately 25 km from Yogyakarta to Kaliurang near G. Merapi via Pakem, and three other provincial roads running from Yogyakarta in the direction of Wonosari, Bantul, and Wates, respectively. In addition there is a road from Kalasan to Pakem via Ngemplak, a road between Yogyakarta and Turi via Ngaglik, and a road linking Muntilan and Dukun, all of which run in the direction of G. Merapi from the two national roads. The only road linking them crosswise is a road from Paken to Tempel via Turi.

Table 17 shows the results of a survey conducted June 12, 1978 by the the Ministry of Public Works on the amount of daily traffic on major roads, and Fig.2, based on the same results, shows in graphic form the relative volumes of traffic in both direction on the roads in question, 2-wheeled traffic excluded. As will be appreciated, the main roads in the area covered by the plan have quite a bit of traffic. This is because there are no good harbors near the area on the Indian Ocean side for coastal shipping. In spite of the fact that the southern trunkline railroad passes through the area, it does not have a very important role in terms of short and middle distance transportation because of the low frequency of the trains, etc. Furthermore, the branch railway from Semarang, which has a port and is the capital of Central Java Province, to Yogyakarta via Magelang is out of commission because of damage to the girders of its bridge across K. Krasak caused by earth flow from G. Merapi which have not as yet been repaired. Under such circumstances, there is no choice but to rely almost entirely on road transportation. Therefore, improvement of its road network and protection of it from disaster damage coming from G. Merapi has great importance to the socioeconomic activity of the area.

In the survey of those in the area that have experienced disaster damage stemming from G. Merapi considerable mention was made of the desire for more road and bridge construction for both emergency evacuation and access to markets, there is a particular need for roads running crossways across the periphery of the mountain for evacuation purposes.

Table 18 gives figures on the lengths and densities of roads of different classes in the area covered by the plan. Of particular significance in terms of the need for disaster prevention planning is the fact that the highest road density occurs in Type I areas, which are the most hazardous.

3.4 Social Infrastructure

3.4.1 Cultural Assets

Yogyakarta is a city with an old cultural heritage, and many cultural assets in its vicinity. Particularly important in this respect are the monuments of Prambanan and Borobudur, which attract a large number of visitors from both home and abroad as major tourism assets. Table 19 gives figures on the number of visitors to Borobudur in recent years.

Although the number of foreign tourists is declining, the number of domestic tourists is increasing sharply. The increase in domestic tourists was 6.5% over the period 1975-76 and 18.9% over the period 1976-77. Furthermore, almost all of the visitors to Borobudur can also be expected to visit Prambanan which is conveniently located in terms of transportation.

Considering the importance of tourist income from these two groups of monuments to the regional economy, studies have carried out in the last few years regarding ways of promoting tourism development in this area.

3.4.2 Other Social Facilities

Other kinds of social facilities that are very important are educational facilities, medical facilities such as hospitals, clinics, and health offices, sports and recreational facilities, mosques and other religious facilities, and public facilities such as public meeting places and halls.

In the survey of areas that have experienced disaster damage stemming from G. Merapi it was determined that the people concerned want school buildings that can also serve as shelters at times of disaster. Table 20 gives the number of educational facilities (elementary, middle, and high schools, universities and specialized schools) presently existing in the area covered by the plan. As can be seen, there are far fewer schools in the nuée ardente zone, which is the most hazardous, than in the other zones of the area. This is an indication of how inadequate social facilities are in that zone.

Table 21 gives the number of hospitals in the area covered by the plan. Again, it will be noted that there is not a single hospital in the nuée ardente zone. Moreover, there is a low hospital/person ratio (only one hospital for an average of about 19,000 residents) and a low hospital/area ratio (one hospital for an average of about 12 km^2).

Fig. 2 Sectional Daily Traffic Volume (June 12, '78)

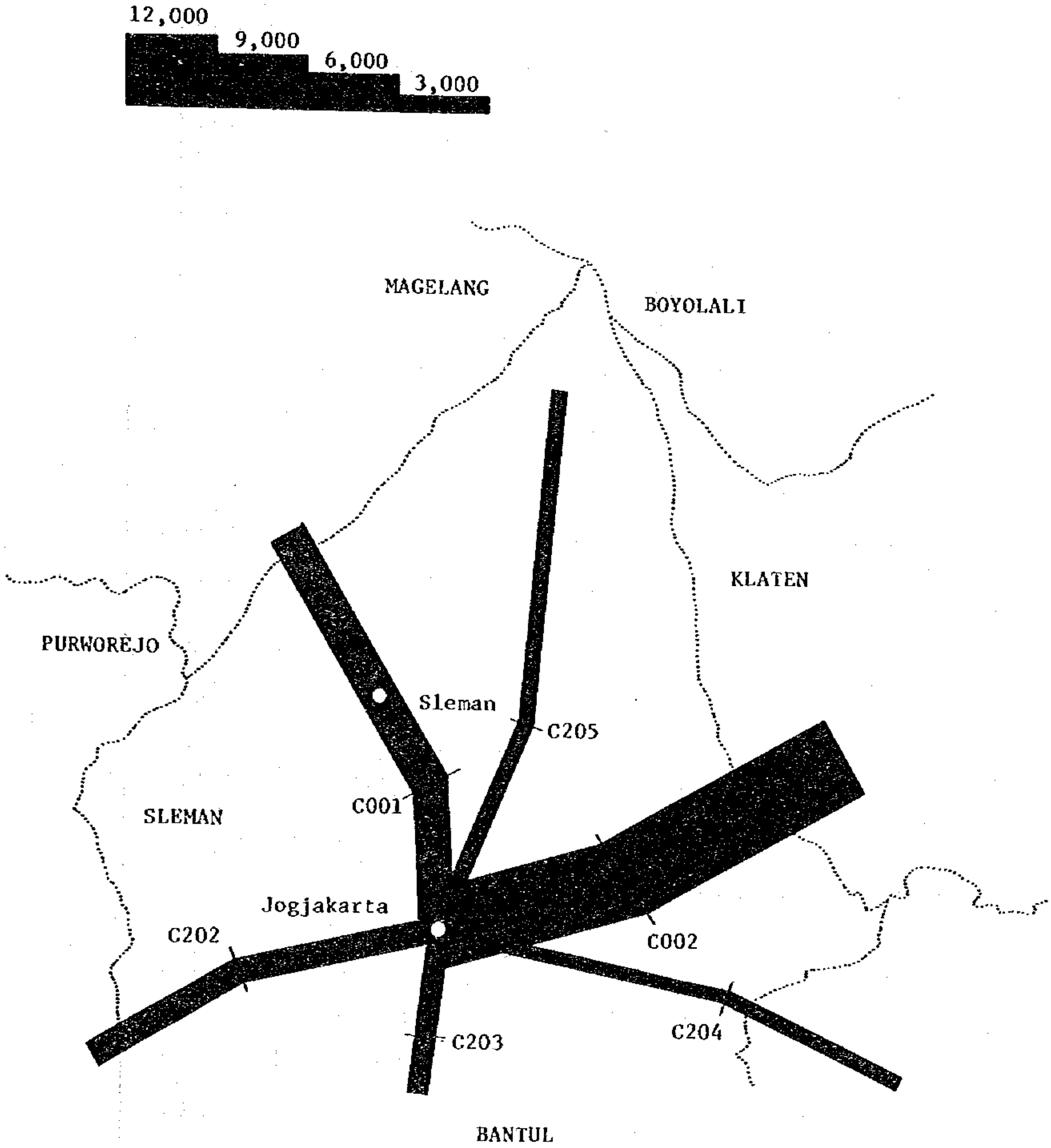


Table 13 Irrigation Area in D.I.Y

Unit: ha(%)

Kabupaten	Irrigation Area: Technical	Semi-technical	Non-Technical	Total
Kab. Bantul	3,500 (18.3)	13,135 (68.7)	2,498 (13.0)	19,133 (100)
Kota, Yogyakarta	-	700 (100)	-	700 (100)
Kab. Sleman	5,000 (13.4)	10,724 (28.8)	21,566 (57.8)	37.290 (100)
Total	8,500 (14.9)	24,559 (43.0)	24,064 (42.1)	57,123 (100)

Source: Public Work of Yogyakarta

Table 14 Mataram Irrigation System

	River System	Area (ha) Uphill offtake	Below Mataram	Design Discharge m^3/sec	Discharge Duty ℓ/s/ha
Mataram System I	K. Konteng	12	1,319	1.70	1.29
	K. Bedog	47	3,796	2.65	0.70
	K. Winongo	-	1,686	1.35	0.80
	K. Code	-	1,337	1.49	1.11
	Overall	59	8,138	5.00	1.11
Mataram System II	K. Code	149	20	0.06	3.00
	K. Belik	-	300	0.52	1.70
	K. Buntung	90	1,595	2.50	1.55
	K. Tambakbayan	31	1,698	1.27	0.75
	K. Kuning	192	644	1.26	1.95
	K. Opak/Gawe	166	2,569	4.17	1.60
	Overall	628	6,826	3.00	0.45
Overall		687	14,964	5.00	0.32

Source: Kali Progo Basin Study

Table 15 Irrigation Systems Between K. Boyong and K. Opak

unit: ha

	Tech. and Semi-Technical: No. of Systems	Area	Non-Technical: No. of Systems	Area
K. Boyong		-	18	229.4
		-	83	530.2
K. Belik				
K. Buntung				
K. Tambakbajan	26	1,375.8	191	1,541.5
K. Kuning	10	712.3	59	810.3
	3	156.0	130	668.5
K. Godjahwong	25	1,031.0	108	1,050.0
K. Tepus	4	298.6	78	1,517.4
K. Wareng	2	79.8	19	294.8
K. Bening	1	21.3	12	236.0
K. Pete	5	159.1	6	142.7
K. Opak/Gowe	2	131.3	136	1,712.0

Table 16 Surveyed Sources of Domestic Water

(Unit: No. of Kelurahans)

Area Type	Location	Rivers	Springs	Wells	Reservoirs	Rain
1	A		2	2		
	B			2		
	C		1	1		
2	A					2
	B	1	1	3		
	C			1		
3			1	2		
Total	19	1	5	11	-	2

A: Upper-stream B: Middle-stream C: Down-stream

Table 17 Daily Traffic Volume (Jun. 12, '78)

(Unit: Vehicle)

Post	Direction	Sedan	Mini-bus	Bus	Truck	Motor-cycle	Bicycle	Cart	Remarks
C 001	To Yogyakarta	2,487	173	300	298	2,568	2,683	6	National Road
	To Sleman	2,468	136	290	350	2,526	2,555	11	
	Total	4,955	309	590	648	5,094	5,238	17	
C 002	To Yogyakarta	3,864	997	268	1,176	4,230	5,888	42	"
	To Klaten	4,219	1,180	409	1,605	4,586	4,746	29	
	Total	8,083	2,177	677	2,781	8,816	10,634	71	
C 202	To Yogyakarta	1,213	114	104	779	1,364	2,105	7	Provin-cial Road
	To Wates	1,424	186	114	540	1,249	2,314	0	
	Total	2,637	300	218	1,319	2,613	4,419	7	
C 203	To Yogyakarta	330	563	49	86	2,699	17,189	107	"
	To Bantul	612	1,253	226	161	3,451	16,166	208	
	Total	942	1,816	275	247	6,150	33,355	315	
C 204	To Yogyakarta	683	146	30	140	535	204	0	"
	To Wonosari	739	188	42	213	566	298	2	
	Total	1,422	334	72	353	1,101	502	2	
C 205	To Yogyakarta	1,591	45	36	85	1,728	1,398	49	"
	To Kaliurang	691	32	24	45	1,331	1,404	12	
	Total	2,282	77	60	130	3,059	2,802	61	

Table 18 Road Density in the Hazard Area of Lahar and Banjir

Unit: m/ha

Class of road	Type-I ($78km^2$)		Type-II ($147km^2$)		Type-III ($71km^2$)		Total ($296km^2$)	
	Length (km)	m/ha	Length (km)	m/ha	Length (km)	m/ha	Length (km)	m/ha
1. Class of road I - II - III	32,600	4.17	9,100	0.62	4,350	0.61	46,050	1.55
2. Class of road III A	0,000	-	1,150	0.07	13,400	1.88	14,550	0.49
3. Others paved road	55,775	7.15	19,125	1.30	44,363	6.24	119,263	4.03
4. Farm road class - 1	804,380	103,12	422,573	28.75	470,591	66.28	1,697,544	57.35
5. Farm road class - 2	161,625	20.72	45,551	3.10	27,810	3.91	234,986	7.94
6. Railway	0,000	-	8,700	0.59	2,250	0.31	10,950	0.36
Total length of roads (Without the length of railway)	1,054,380	135.17	497,499	33.80	560,514	78.95	2,112,393	71.36

Table 19 Number of Visitors to Borobudur

(Unit: Persons)

Year	Domestic	Foreign	Total	Annual Growth (%)
1975	350,285	49,074	399,359	-
1976	373,293	46,025	419,318	5.0
1977	443,880	45,122	489,002	16.6
1978 (Up to June)	187,691	20,069	207,760	-

Table 20 Number of Schools in Project Area

Area Type	No. of Schools	No. of Schools per Kelurahan	No. of Persons per School	No. of Schools per km^2
Nuée Ardente	36	1.4	2,175	0.26
Type I	92	3.4	1,171	1.18
Type II	135	2.8	1,444	0.92
Type III	56	7.0	1,016	0.79
Type IV	561	5.7	1,608	1.36
Total or Average	880	4.2	1.523	1.04

Table 21 Number of Hospitals in Project Area

Area Type	No. of Hospitals	No. of Persons per Hospital	km^2 per Hospital
Nuée Ardente	0	-	-
Type I	4	26,922	19.5
Type II	11	17,725	13.4
Type III	1	56,900	71.0
Type IV	55	16,400	7.5
Total or Average	71	18,871	11.9

4. AGRICULTURE

4.1 Land Use and Farmland Holdings

4.1.1 Land Use

The area covered by the plan has favorable natural conditions, including plentiful rainfall (1,500 - 4,500mm annually), generally gently sloping land (70% with a slope of 0-3° and 88% with a slope of 0-8°), and fertile soil. Almost all of the cultivable land is being used. The main feature of the land use pattern is that 86% of the land is taken up by farmland (62%) and hamlets (24%). Furthermore, approximately 70% of the farmland consists of rice paddy fields, which for the most part yield three crops a year--one of paddy and one or two of some other field crop--although the number of crops depends on the particular irrigation conditions. During the rainy season almost all of the paddy paddy fields are used for paddy production (see Table 22).

4.1.2 Farmland Holdings

According to the agricultural census of 1973, 83% of the farm households in Central Java had farm holdings of less than 1 ha, accounting altogether for 52% of all the farmland, and only 0.4% had more than 5 ha, accounting for 5% of the total. The average was 0.6 ha per farm household.

The socioeconomic survey made in the area covered by the plan showed that farmland holdings are even smaller on the average than for Central Java as a whole (see Table 23): a full 96% of the farm households having less than 1 ha of farmland and nearly 50% having less than 0.2 ha (nearly 60% in Type-I areas).

Table 24 gives breakdowns of the number of farm households for the categories of independent farmer (84.2%) owner-tenant farmer (3.6%), and tenant farmer (10.2%). In Type-I areas, however, the tenancy rate is somewhat higher. Considering the fact that the percentage of agricultural workers and the structure of employment is high, it would appear that in many cases members of farm households are employed by other farm households.

Tenancy fee payment is in cash in about 50% of the cases and in kind in other cases, (see Table 25). In the case of cash payment the amount varies considerably, from about Rp.50,000 to about Rp.300,000 per year, depending on the condition of the land, irrigation conditions, whether or not the persons involved are relatives, and other factors. In the case of payment in kind the tenancy fee is usually half of the crop. In Type-I areas payment in cash is more usual, in Type-II areas payment in kind is more usual, and in Type-III areas the situation is about midway between these two extremes.

4.2 Cropping Pattern

The cropping patterns in the different kabupaten of the area covered by the plan are as listed below on the basis of agricultural statistics and surveys carried out at the kelurahan level.

1) Kab. Magelang (5 kelurahan)

Rice is grown here in paddy fields primarily in the wet season. The range of annual frequency of use thereof is 0.93-1.51 crops and the average, 1.24 crops. The usual second crops are maize, sweet potatos, cassava, and groundnuts, in descending order of frequency. Soybeans are also cultivated, but not much.

2) Kab. Sleman

The range of annual frequency of use of paddy fields here is 1.08-2.57 crops, with a high average of 1.84 crops. The three major second crops in descending order are cassava, groundnuts, and maize; sweet potatos and soybeans are also grown considerably.

3) Kab. Klaten (6 kelurahan)

The range of annual frequency of use of paddy fields here is 1.15-2.02 crops, with an average of 1.35 crops. The major second crops in descending order are maize, groundnuts, and cassava; there is also some cultivation of sweet potatos and soybeans.

Table 26 shows the amount of hectarage devoted to each of the main crops in the different kecamatan, and Table 27 gives examples of cropping patterns based on a survey of selected kelurahan.

4.3 Agricultural Production

4.3.1 Agroeconomic Analysis

1) Stability of Agricultural Production

Besides the level of agricultural production, its stability is also of general importance, particularly in view of the strong influence of natural conditions. The level of production of rice and other crops is relatively high in Central Java, where the area covered by the plan is located, in view of the high intensity of crop management resulting from the small amount of arable land per agricultural worker and a relatively high level of agricultural technology. In 1976, for instance, the wet land paddy yield in D.I. Yogyakarta was nearly 20% higher than the national average. Other factors contributing to this are the richness of the soil and favorable irrigation conditions. Given such a high level of production, the main problem is that of the stability of such argirultural production.

In this study, the yield fluctuation coefficients were calculated for the main crops (irrigation paddy, dry paddy, maize, peanuts, soybeans, cassava, and sweet potatos) grown in the different kecamatan of the kabupaten in the area covered by the plan on the basis of production statistics for the period 1967-1976, (kecamatan being the smallest administrative unit for which such statistics are available).

Except for a very few kecamatan, irrigation paddy production was quite stable, with a fluctuation coefficient of 15% or less in each kecamatan (overall average 11%).

On the other hand, the fluctuation was rather high in the case of dry rice in almost all of the kecamatan at over 20%, and although the yields of soybeans and sweet potatos were comparatively stable (16%), the fluctuation in the case of maize and cassava was greater (20%), the reason in the case of cassava probably being the fact that this crop is not managed as well as, say, rice and is grown on marginal farmland.

2) Land Productivity

In areas such as this in which the ratio of the area of farmland to the amount of labor input is low, it is necessary to raise the land productivity as much as possible since this will also mean higher labor productivity, as explained in the following equation:

$$P/L = P/A \times A/L$$

Where P: Amount of agricultural production

L: Labor

A: Area of farmland

In other words, labor productivity (P/L) is the product of land productivity (P/A) and the amount of farmland per agricultural worker (A/L). When A/L is small, P/L can be increased by increasing P/A.

Normally land productivity is considered in terms of the yield per unit of area when only a single kind of crop is given in the area in question. In actuality, however, such areas are very uncommon; the usual case being one of production of a number of different kinds of crops in the same area, and in such cases the overall land productivity is what matters. That is why crop yield indices have been used for the different kinds of crops in the case of this study. Furthermore, in order to get an idea of the dynamic change in land productivity, calculation was made for the different kabupaten and kecamatan for the years 1971 and 1976 for the purpose of comparison. The results, based on the figures given by the Central Statistics Bureau for the standard yields for different crops in Central Java and D.I. Yogyakarta (index = 100), were plotted as sectors on the four quadrants of a graph, with classification of indices with above and below 100 for each year. This resulted in the following pattern:

Sector	Productivity	1971 Index	1976 Index	No. kecamatan
1	Low	below 100	below 100	7
2	Rising	below 100	above 100	7
3	Declining	above 100	below 100	11
4	High	above 100	above 100	18

In Kabupaten Magelang, comprehensive land productivity was particularly low, all of its kecamatan below 100 in 1976 and even lower than that in 1971.

In case of Kabupaten Klaten and Sleman, however, the indices were over 100 in both 1971 and 1976, and furthermore, there were more kecamatan in them than in Kabupaten Magelang (see Table 27 and Fig. 3 and 2).

3) Degree of Specialization of Agricultural Production

The direction that has been taken in the modernization of agricultural production is to specialize in a profitable crop that is best suited to local conditions. To consider the dynamic change in the degree of specialization, the six secondary crops (maize, cassava, sweet potato, groundnuts, soybean and sugar cane) were considered.

Specialization was particularly high in the case of irrigation rice, forty kecamatan having an index of over 1.0 in both years and one having an index of under 1.0 in 1971 but over 1.0 in 1976. Other crops with a degree of specialization are sweet potatos and groundnut. Maize, on the other hand, can be cited as a crop with a low degree of specialization.

4) Trend of Increase in Yield

With respect to the future of agricultural production in Java, the point of saturation was examined with the concept in mind that where it would be extremely difficult to increase the amount of land under cultivation, the possibility for the advancement of agricultural production must be by further intensification, i.e., increasing the yield per unit of area. Accordingly, in this analysis the possibility of increasing the yield per unit of area has been studied on the basis of the tendency in yield fluctuation over time, using a 3-year moving average. The crops considered in this analysis were the most basic ones--irrigation paddy and dry paddy. The regression equation used was of the first degree type: $\hat{y} = a + bt$ where $\hat{y}$ is estimated yield and t is the year. The present productivity level indicated by a results of the calculations showed that in the case of irrigation paddy 37 kecamatan have a continuing tendency of increase in yield. For them b has a positive value. Only seven of the kecamatan had a negative value for b. For example, the trend line for Kacamatan Manisrenggo in Kabupatan Klaten is analyzed as follows:

where $y = 49.30 + 2.66t$ (t was 1972 = 0) $r^2 = 0.84$

What this means is that the yield is increasing by 2.66 quintal per hectare each year.

The calculation was made only for kecamatan for which a moving a average of seven years or more was obtainable. The results showed that in the area in question there is still the possibility of intensification of cultivation of irrigation paddy, i.e., increasing its yield per unit of farmland (see Table 28 and Fig. 5). The opinion of experts at Gadjah Mada University also was that a 40% increase in yield was feasible for the area in question.

5) Correlation Between Land Productivity and Rate of Land Use

Usually land productivity is measured in terms of the worth of the agricultural production on a unit area of the land. Since, however, the worth of the agricultural production depends on price and price will be lower with higher yields (production), this is not really a very good way of indicating land productivity. Consequently, the crop yield index used in this analysis.

As for the rate of use of the land, it is expressed as the ratio of the total amount of land under cultivation to the total amount of cultivable land, including both paddy fields and dry fields. Only in the case of Kabupaten Sleman and Klaten was a positive correlation obtained between land productivity and the rate of use of the land, and even those correlations were very low: 0.19 and 0.36. Although the reliability of the data used may be questioned, it is safe to say that in the case of crops other than rice there is no necessary direct connection between the degree of use of the land and selection of crops with high land productivity. This is further substantiated by the fact, as we have just noted, the specialization coefficient is not particularly large for crops other than rice. In other words, there is still room for guidance of farmers with respect to more advantageous crop selection.

6) Classifications of Irrigation Areas and Productivity

The productivity of the different classifications of irrigation areas (technical, semi-technical, and non-technical) was found as described below on the basis of comparison in terms of crop yield and rice productivity.

The technical irrigation areas tend to have productivity considerably higher than that of the other irrigation area classifications. In terms of crop yield indices, over 90% of the farmland in such areas is characterized by either a high level of productivity or rising productivity, and the gap between productivity in such areas and that in other areas is widening to about 10%.

Although productivity is rising in semi-technical and non-technical areas, it is at a lower level than in technical areas. In terms of crop yield indices, 63-79% of the farmland in semi-technical and non-technical areas is accounted for by either high productivity areas or areas in which productivity is rising, but in both semi-technical and nontechnical areas, 20% of the farmland is represented by low productivity areas, which is an indication of how great the possibility is for improvement. In 1976 rice productivity in these areas was only 96-37% of that in technical areas, and this gap is expected to widen to 87-82% by 1981 (see Fig. 6 - 9).

Technical areas have higher productivity than other areas. Since much of the periphery of G. Merapi consists of non-technical areas, it is important that the irrigation systems in the area covered by the plan be improved for greater stability and amount of water intake in order that the level of agricultural production rise and greater agricultural production stability be attained.

As things are now, it will not be possible to increase the irrigation water supply on the periphery of G. Merapi very considerably; however, if the courses of the rivers involved are made more stable, it will be possible to use rivers that have hitherto not been possible to utilize, converting temporary weirs to permanent weirs, and upgrading nontechnical and semi-technical areas to technical areas (see Table 29 and 30)

7) The Direction of Promotion of Agricultural Production

Concerning future policy for promotion of agricultural production, the main crop in this area is and will continue to be rice. Since rice is an indispensable food crop for the whole nation, one of the main policies of Repelita-III is that of raising the rate of self-sufficiency in it. In population-dense Java in particular, it is important that the capacity to support more people be increased. Increasing the production of rice and the possibility of introducing more advantageous market crops are also important in terms of increasing agricultural income and in bringing about an economic surplus for capital accumulation. In other words, as T.W. Schultz has said, Indonesia's problem is not a farm problem, but a food problem at this stage of its development. Hence, top priority should be placed on the increasing the amount of production.

Rice production can be increased in two ways: by cultivating it more intensively and by increasing farmland acreage by converting other land to farmland and opening up new land that is not now being used. Both possibilities still seem to exist. It is necessary in particular to increase the number of paddy fields in which it is possible to grow a second crop by improving the production infrastructure, particularly in terms of disaster prevention and irrigation works, and increasing the supply of irrigation water and the stability of such supply. Furthermore, if the supply of irrigation water is improved, it will be possible to convert some of the present dry fields to paddy fields, and it is therefore desirable that a survey be made of the extent to which this will be possible. It will also be necessary to establish and popularize the technical means of improving agriculture on the basis of more rational irrigation, including the introduction of new improved varieties and consideration of what areas can use conventional varieties to the best advantage. A local survey revealed that the farmers in the area are still strongly oriented toward rice production.

The next potential is that of the cropping pattern. For the purpose of preventing depletion of soil fertility through repeated consecutive growth of paddy rice (which would not be a problem in areas where the soil is of heavy clayish composition), the introduction of green manure crops as a second crop is a possibility. Furthermore, if the production infrastructure is further improved, there is the possibility of crop rotation together with cash crops such as maize and groundnut, and soybeans and tobacco. Legumes such as groundnut and soybean are particularly recommendable from the additional standpoint of increasing soil fertility.

At high elevations where the farmland is not suitable for paddy fields, it is possible to gear agricultural production more to the market by cultivating cucumbers and other fruit-like vegetables, and lettuce and other leafy vegetables favored by the temperature variation at such high elevations. As the demand structure for food changes with further economic development, the demand for vegetables should increase considerably. In other words, the demand for vegetables has a high income elasticity. Furthermore, considering the fact that Yogyakarta City has a population of 2.5 million, the project area can become a major supplier of fresh foods for that urban population with agricultural production tailored to that function.

4.3.2 Agricultural Income

1) Input

Table 31 shows the various kinds of inputs presently being used for the cultivation of major crops based on agricultural statistics and information obtained in the socioeconomic survey in the area covered by the plan.

Since detailed data was not available for different varieties of paddy and for the dry and wet seasons separately, only average high yield variety (HYV) inputs were estimated. Furthermore, the labor input for paddy harvesting was not considered in view of the fact that the traditional method of cutting with "aniani" knives is prevalent and the number of participants is always uncertain.

2) Output

Table 32 gives the estimated average yields per hectare of main crops at the kabupaten level based on agricultural survey by kecamatan.

Although the yield per hectare of paddy is fairly high in comparison with the average for the whole country, in the case of maize, cassava, groundnut, and soybean the yields are lower than the national averages.

As for variation within the area covered by the plan, although the paddy yield is lower in Kab. Magelang than in the other kabupaten, there is hardly any difference between the three with respect to the yields of the other crops. Then again, the questionnaire survey in hazard areas showed that the yield of paddy per unit of farmland was 10-50% lower than the average at the Kabupaten level which is an indication of the instability of agricultural production there owing to repeated disaster damage. Unless the disaster prevention works are carried out, the yields in other neighboring areas that are presently up to par with the average can be expected to decline as well.

3) Production Costs for Main Crops

Table 33 gives the production costs for the main crops in the area covered by the plan, using 1979 unit prices on the basis of agricultural survey and price statistics.

4) Production Returns for Main Crops

Table 34 shows the average net income per hectare for the different major crops, also using 1976 unit prices on the basis of agricultural survey and price statistics.

Table 35 shows the net income per income from farmland in each kabupaten as summarize below.