RERORT ON THE WATERSHED MANAGEMENT PLAN IN UPPER MUSI WATERSHED, SOUTH SUMATRA, REPUBLIC OF INDONESIA

MARCH, 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

RERORT ON THE WATERSHED MANAGEMENT PLAN IN UPPER MUSI WATERSHED, SOUTH SUMATRA, REPUBLIC OF INDONESIA

MARCH, 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

It is with great pleasure that I present this report on The Management Plan of the Upper Musi Watershed in South Sumatra to the Government of the Republic of Indonesia.

This report embodies the result of a feasibility study which was carried out in the Upper Musi area, South Sumatra for 20 days from July 1, 1979 and for 30 days from January 13, 1980 by the Japanese survey team commissioned by the Japan International Cooperation Agency following the request of the Government of the Republic of Indonesia to the Government of Japan.

The survey team, headed by Mr. Masayuki Kajiyama had a series of close consultations with the officials concerned of the Government of the Republic of Indonesia and conducted an extensive field survey and data analysis

I sincerely hope that this report will be useful as a basic reference for development of the region.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the Japanese team.

August , 1980

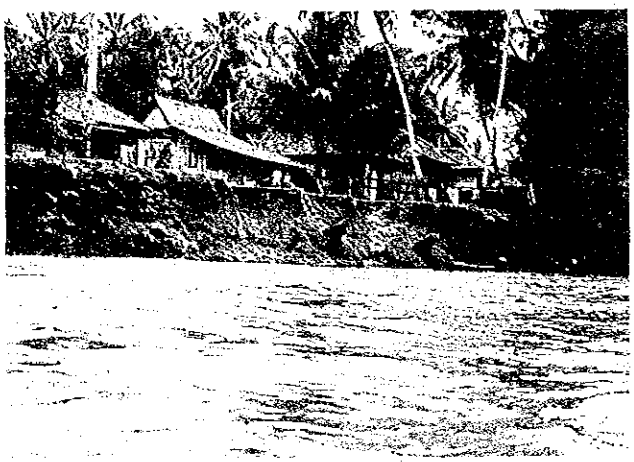
Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

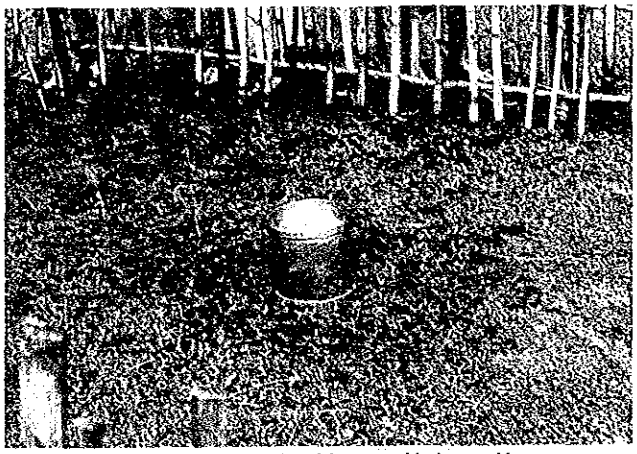
FIELD SURVEY FOR WATERSHED MANAGEMENT PLAN

Bank erosion along the upper stream of Rawas River

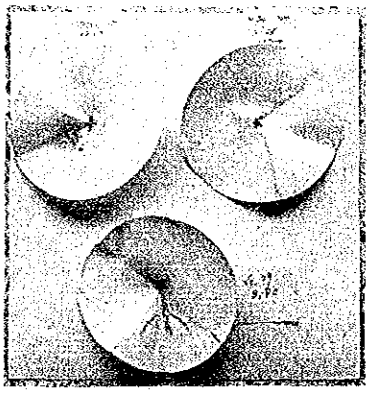
Flood of Rupit River nearby Muara Rupit (December, 1978)



Houses exposed to danger(nearby Tanjungagung)

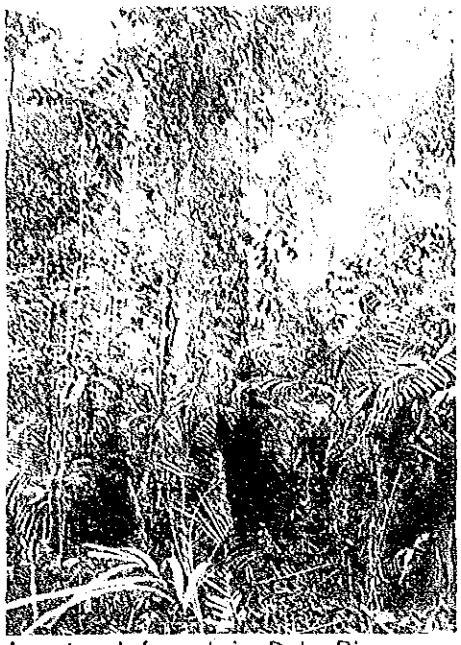


A rain-gauge set up in Muara Kulam, Kec. Rawas Ulu



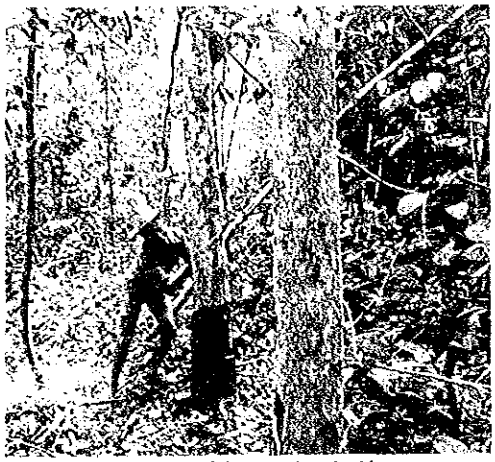
Sediment contents in the sample water (test by filter papers)

PRESENT CONDITION OF LAND USE

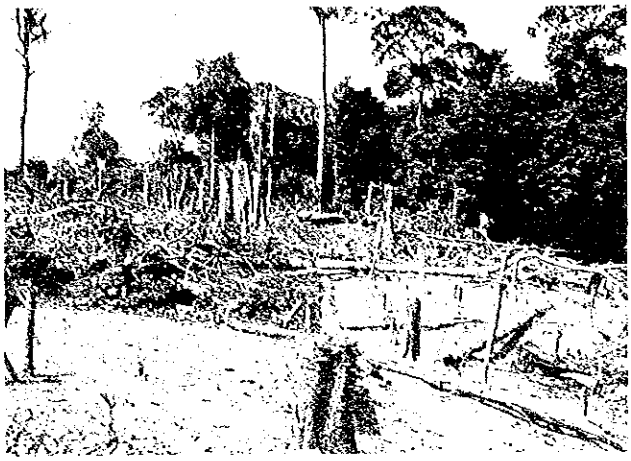


A natural forest in Dulu River Watershed

Shifting cultivated lands spreading toward mountains (Kec. B.K.L. Ulu Trawas)

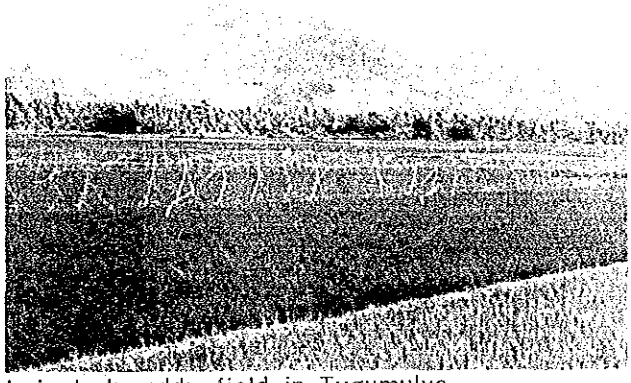


Tapping in a rubber plantation mixed with second growth



A new shifting cultivation

A comparatively good rubber plantation



Irrigated paddy field in Tugumulyo

REPORT ON THE WATERSHED MANAGEMENT PLAN IN UPPER MUSI WATERSHED, SOURTH SUMATRA, REPUBLIC OF INDONESIA

CONTENTS

I. OUTLINE OF THE SURVEY

1. Survey Objectives

This survey is intended to analyse and use the results of mapping by aerial photographs (preparing of topographical maps and of forest survey (forest analysis and topographical analysis) for the Upper Musi Forest Development Survey conducted by the International Cooperation Agency in South Sumatra, Republic of Indonesia, and also to formulate a watershed management plan which takes account of land conservation and afforestation for headwater conservation by carrying out other necessary surveys and analysis of data.

Note: As for the results of the forest survey, refer to the report (JICA: March, 1980).

2. Survey Area

The survey covers an area of about 400,000 ha in the Upper Musi region of South Sumatra, Republic of Indonesia. Fig. 1 is a general location map of the area.

The survey area is located at 2°∿3°S and 102°∿103°E, with the elevation varying from about 50 m to 1,200 m.

Administratively, the survey area is mostly situated in Kabupaten Daerah TK. II Musi Rawas, the western part of Propinsi Sumatra Selatan; the southern part of the survey area includes Kabupaten Daerah TK. II Lahat and a small part of Kabupaten Daerah TK. II Rejang Lebong of Propinsi Bengkulu. The Kecamatan and Perwakilan Kecamatan covered by the survey are as listed below.

a. Propinsi Sumatra Selatan

(1) Kabupaten Daerah TK. II Musi Rawas

Kec. Rawas Ulu, Kec. Muara Rupit, Kec. BKL. Ulu Terawas, Kec. Kota Lubuk Linggau, Kec. Muara Beliti, Kec. Muara Klingi, Perwakilan Kec. Tugumulyo, Perwakilan Kec. Jayaloka

(Total: 8)

(2) Kabupaten Daerah TK. II Lahat

Kec. Tebingi Tinggi, Kec. Kikim (Total: 2)

b. Propinsi Bengkulu

(1) Kabupaten Daerah TK. II Rejang Lebong

Kec. Padany Ulak Tanding (Total: 1)

3. Survey Period and Survey Staff

(1) Survey period

June 14, 1979 ∿ March 31, 1980.

During the period, two field surveys were conducted: Preliminary Survey for the Watershed Management Plan: from July 1 to July 20, 1979; the present survey: from January 13 to February 15, 1980.

(2) Survey staff

The present survey was conducted by the Japan Forest Technical Association entrusted by the Japan International Cooperation Agency. Members of the survey staff are as listed below.

Masayuki KAJIYAMA	Technical Specialist, Head of Survey Department
Tokuji KASHIYAMA	Chief Researcher, Survey Department
Tadao OBARA	Section Chief, Planning Department
Fumitake HASHIZUME	Section Chief, Survey Department
Kiyoshi MOCHIZUKI	Acting Section Chief, Survey Department
Taichi WATANABE	Acting Section Chief, Survey Department

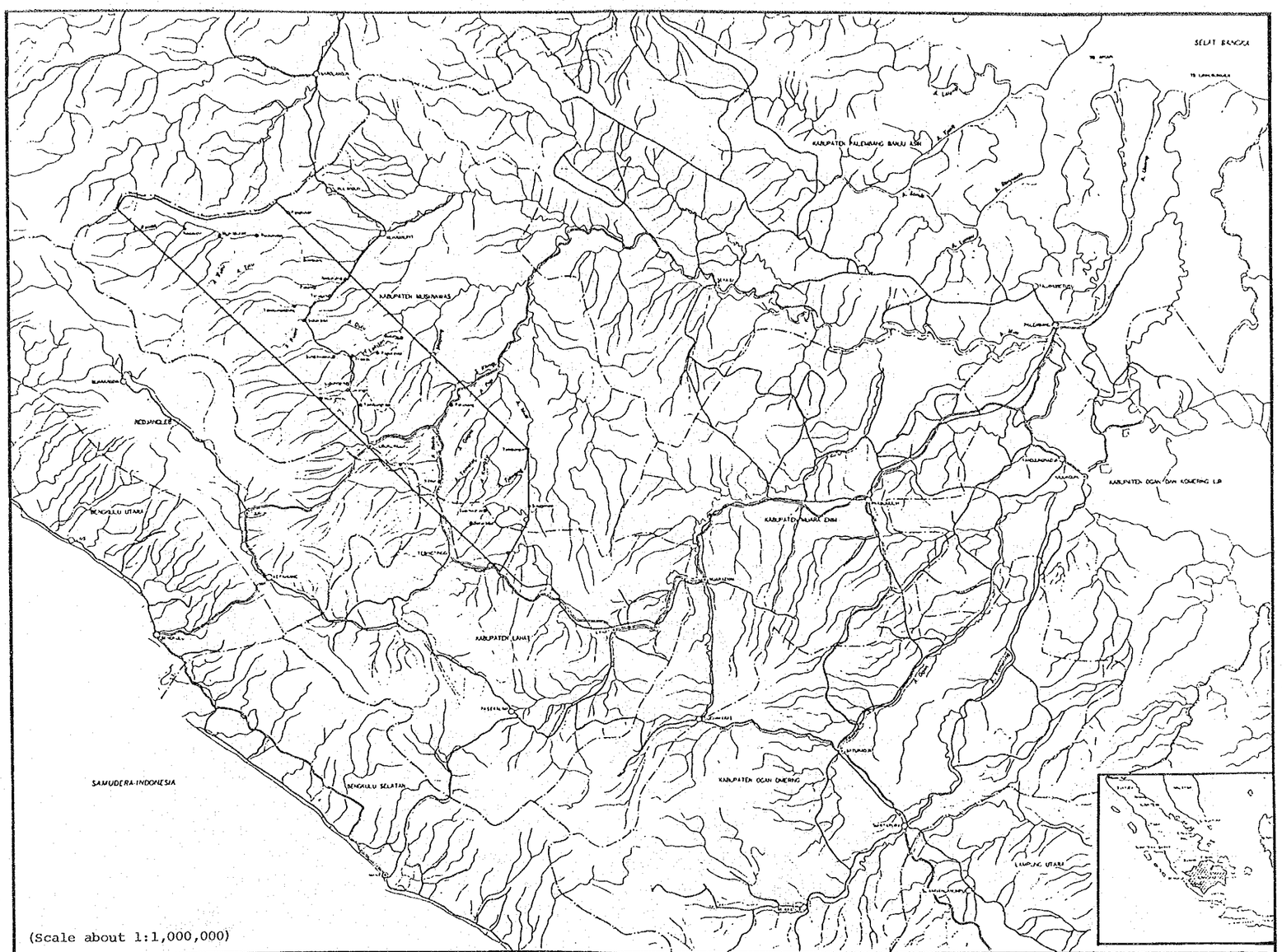


Fig. 1. Location map of the projected survey area

II. SURVEY APPROACH

1. Significance of the Watershed Management Plan

(1) Significance of the Watershed Management Plan

The term "watershed management" may be understood in various ways. Watershed management has clear objectives in such cases as discharge control and sediment discharge control. What is common to both cases is that the ultimate goal of watershed management is effective use of land.

A watershed management plan is often carried out when an undsirable condition exists in the area concerned, e.g., flooding, draught, ineffective use of water and excessive sediment discharge, to correct such a condition so that social and economic development of the area may be ensured.

That is to say, in considering watershed management, the appropriate procedure will be 1) to ascertain the problem in the area concerned and 2) to formulate the countermeasure. There may be different methods in ascertaining the problem and in formulating the necessary countermeasure. This is because the problem in the watershed is by no means caused by a single factor; it is rather due to a complicated combination of many factors. Consequently, the countermeasure may be conceived and selected from different viewpoints.

(2) Significance of the forest in watershed management

Though there are different methods of watershed management as described above under (1), the forest section in the survey area occupies the headwater area, having a large share in the total area. It has been proved in various parts of the world that the headwater conservation function and the sediment run-off preventive function of the forest are playing important roles in the conservation of the watershed. Therefore, making good use of the forest with such conservation functions constitutes an important measure in watershed management.

However, in making good use of the forest, it is important to ascertain the functions of the forest work on the problem of the area concerned, i.e., what role and to what extent the forest can play in its relation to the area. Further, as the forest is an important source of forestry products in addition to its conservation functions, it is necessary to ascertain as to what role in this respect the forest should play in order to contribute to the area.

(3) The mission of the present watershed management plan

In formulating a forest management plan for the area concerned, it is no doubt important to study the prospects of yield based on the forest composition; but they should contribute to the economy of the area and to the well-being of the residents, also making full use of the conservation functions of the forest. In other words, it is necessary to conduct forest management which responds to the problems of the area.

This survey is intended to study forest management in response to various problems of the area from the macroscopical point of view and how effectively the forest may be utilized on the basis of watershed management so that basic guide lines may be recommended for formulating individual forest management plans in the future.

2. Problems of the Watershed and the Survey Approach

(1) Survey approach

Though the problems of the watershed cover a wide range, the survey is, because of its objectives, to be confined to the matters relating to the forest.

Though the problems may be ascertained as a result of various field surveys conducted from various angles, in view of the limited survey period and also the limited capacity of data collection, the survey is to center on the problems described below on the basis of those data collected prior to the survey.

(i) In view of the reported frequency of flooding and sediment run-off, the problems are the river conditions in the watershed and the damage to the area.

(Countermeasure)

The relationship between the river conditions and the distribution of forests in watershed is to be obtained to study the justification of the response based on the disaster preventive function of the forest.

(ii) In view of the reported intrustion of the forest area by burning and shifting cultivation, the problems are the actual situation of burning and shifting cultivation and its effects on the conservation of the watershed.

(Countermeasure)

In order to ascertain appropriate land use and to stop any reckless use of land, the method of determing demarcation in land use including the preservation of the forest area is to be studied.

(iii) In view of the conditions of the undeveloped forest area widely spreads over the watershed, the problem is the approach to forest management in relation to (i) and (ii).

(Countermeasure)

The actual conditions of the forest and forest deployment including above (i) and (ii) are to be studied as well as the possibility and the method of the development of the forest resources.

(2) Survey method

According to the survey approach described above, the method of survey was determined in detail as shown in Table 1.

Table 1. Survey method

Problem	Survey method
River conditions in the watershed	(1) Discharge and sediment content to be measured at model points. (2) Survey of land use and forest conditions in the watershed. (3) Field survey on the damages by interviewing. (4) Analysis of the relationship between discharge, sediment content and land use, particularly forest distribution. (5) Collection and analysis of data on rainfall. (6) Analysis of and comments on the results of the survey.
Actual situation of burning and shifting cultivation and its effects on watershed conservation	(1) Survey of the distribution and the actual situation of burning and shifting cultivation. (2) Analysis of the relationship between discharge, sediment content and the above distribution and situation. (3) Field survey of local conditions (living condition, agricultural production). (4) Survey and analysis on land use by gradient.
Actual situation of unused forests	(1) Survey of the distribution and actual situation of forests. (2) Distribution of forest resources (analysis of statistical data).

Problem	Survey method
	(3) Analysis of the determination of the forest region in land use. (4) Analysis of the relationship between the current condition of the natural forest and natural environment. (5) Evaluation as a production forest.

III. ANALYSIS OF THE RIVER CONDITIONS IN THE WATERSHED

- with special reference to discharge and sediment content -

Many of the rivers in the watershed are reported to have been flooded many times in the past, causing damage, and the actual situation of land use, particularly the distribution of forests, seems to be closely related to the run-off of storm sewage and erosion. The relationship mentioned above is, therefore, to be investigated and the selection of a countermeasure based on the disaster preventive function of the forest is to be studied. Accordingly, it was decided to conduct the survey according to the survey method and items described below.

1. Survey Method

Fifty-five survey points were selected on the rivers in the watershed according to the criterion given below to obtain the discharge by measuring the width of the river, depth and velocity. At the same time, water samples were collected to measure the sediment content. Further, collection and analysis of data on the meteorological conditions, particularly the rainfall, were carried out.

(1) Criterion for selection

On the basis of the results of the previous survey on land use in this area, survey points were located in the lower reaches and selected in the forest area, rubber forests, grassland and farm land to ascertain the relationship between the land use and river conditions. Further, additional four points were set up in areas other than the projected survey area for reference purposes. Fig. 2 shows the positions of survey points. (Fig. 2 and Attached table 1 are based on the same watershed division.)

PLOT LOCATION MAP

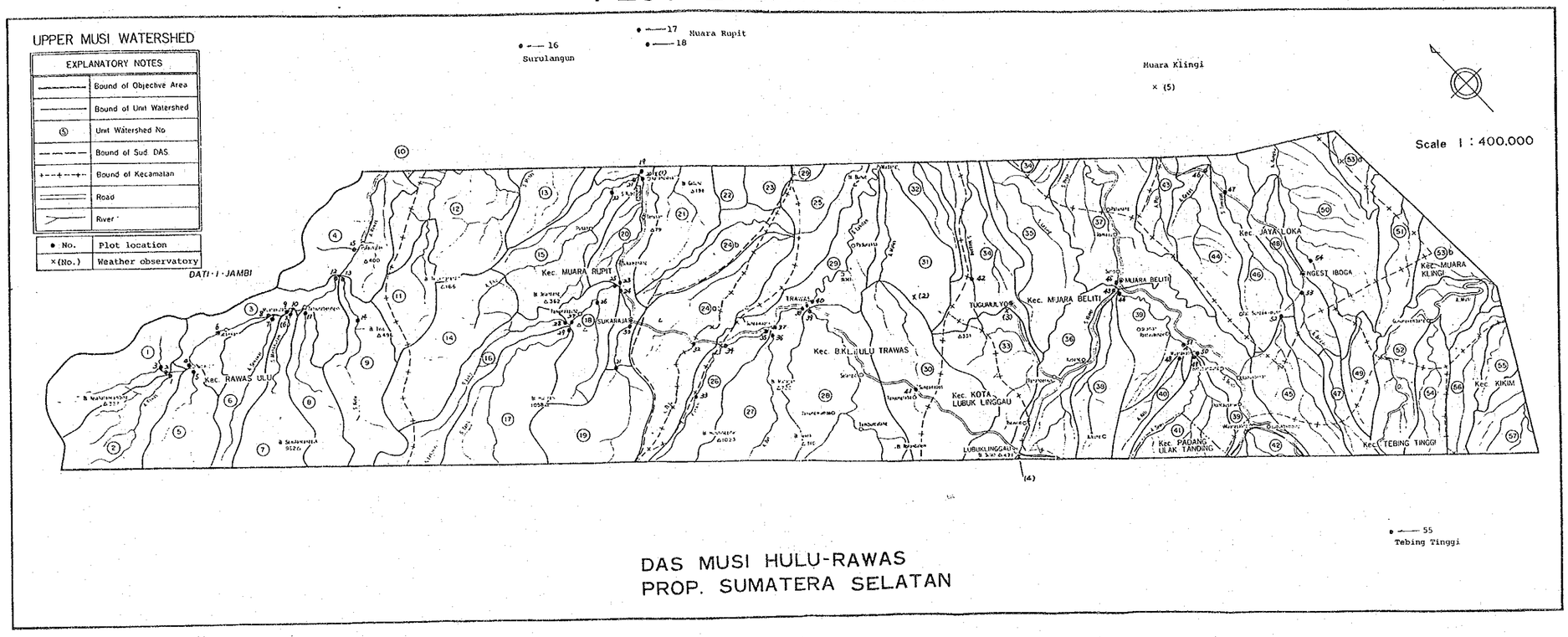


Fig. 2. Plot location map

(2) Survey operation

a. River width ..... to be measured with a range finder.

b. Depth ..... to be measured by means of a tape with a sufficient weight to reach the river bottom.

c. Velocity ..... to be computed by measuring the time required of a float to travel a pre-measured distance.

d. Sediment content ... the river water is to be collected with a jar of 500 ml and a sample of 15 ml is to be placed in a tube. After six hours, the deposition is to be measured and the remaining water filtered. After drying, the sample is to be brought back to Japan to be measured.

2. Characteristics of Rainfall

(1) There are five precipitation stations for the survey as shown by Table 2, of which four are located within the survey area. As shown by Fig. 2, these stations are located relatively to the center of the survey area. There are thirteen station, as shown by Table 3, in Lahat Kabupaten adjacent to the survey area. The monthly data on rainfall were collected from the five stations in the projected survey area for the period 1970-79 and from the thirteen stations in Lahat Kabupaten for the period 1970-79.

In addition, measurement of the rainfall was entrusted with Muara Kulam in the north of the survey area and the daily data on rainfall were thus obtained for the period from July 25, 1979, to January 23, 1980.

(2) As regards the annual rainfall in the survey area, complete data without missing months are available only for Muara Rupit (4 years), B, K, L, Ulu (5 years), Tugumulyo (9 years), Lubuk

Linggau (7 years) and Muara Kelingi (1 year). Further, the annual rainfall shows large fluctuations with the difference between maximum and minimum being 1,096 mm at Murara Rupit, 2,659 mm at B, K, L, Ulu, 2,131 mm at Tugumulyo and 971 mm at Lubuk Linggau.

Further, the monthly rainfall and the number of rainy days at each station fluctuate greatly. The same can be said of the rainfall in Lahat Kabupaten.

Accordingly, it was decided to obtain the average values of the daily rainfall and of the number of rainy days from as many data as possible. The average monthly rainfall was thus obtained for those months for which data were available; the annual total was then obtained as shown by Tables 2 and 3. These tables shown the general rainfall situation in the survey area.

(3) The dry season in Indonesia is said to be normally from May to October and the wet season from November to April. As the table shows, the difference in rainfall between the so-called dry and wet seasons was fairly clear in the survey area, indicating the existence of dry and wet seasons in average terms.

(4) Judging from the distribution of monthly rainfall at each station, rainfall is extremely localized. As the stations in Lahat Kabupaten are between 708 and 47 m in elevation, the relationship between rainfall and elevation was also studied; but no clear relationship emerged.

(5) When the relationship between the monthly rainfall and the number of rainy days is examined against the annual data, we find that there is little relation between them at every station; a month which has a large amount of rainfall does not necessarily have a large number of rainy days. This is probably due to a relatively high frequency of heavy rain.

(6) Data on the daily maximum rainfall of every month for the period 1977-79 were collected for each station in the survey area as shown by Table 4. The table also covers Muara Kulam.

As the table shows, quite many months are missing from the data, making an accurate judgement difficult. It shows, however, that the month in which the largest and the second largest daily rainfall occurs varies from station to station. However, they do not appear in May-June at all stations and relatively few appear in July-October; the period from November to April seems to show a high frequency.

Accordingly, judging from the limited data, it may be concluded that the largest daily rainfall of the year appearing in the survey area is due to showery rainfall which often occurs during the so-called wet season.

(7) To sum up, it may be concluded that localized showers have an influence upon the rainfall at a given point around the survey area. Accordingly, it is difficult to estimate the distribution of rainfall in the survey area from the data obtained over a limited number of years of observation.

(8) In formulating a watershed management plan, it is also important to ascertain the rainfall situation in the headwaters forming the upper reaches of those rivers flowing across the project survey area. However, since no observation had been made in the past, it was impossible to obtain data on rainfall in the mountain region.

Table 2. Monthly rainfall (mm) and the number of rainy days (survey area)

No.	Observation point	Elevation (m)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Observation period
1	MUARA RUPIT (KARANGJAYA, agricultural plan)	175	313 20	262 14	292 18	283 15	102 9	78 8	55 6	113 10	183 12	132 12	280 15	328 19	2,421 158	1972.1 - 1979.12
2	B.K.L. ULU/TERAWAS (SUMBER HARTA, agricultural plan)	70	260 21	143 14	197 19	160 18	75 10	90 6	134 9	158 12	178 10	186 11	207 17	248 22	2,036 169	1974.7 - 1979.12
3	TUGUMULYO	79	309 15	231 13	338 16	283 15	221 10	145 8	200 9	195 9	237 10	239 13	260 14	315 16	2,973 150	1970.1 - 1979.12
4	LUBUK LINGGAU	130	308 15	249 12	373 15	338 14	182 9	137 9	176 10	144 10	204 11	196 10	253 14	309 16	2,869 145	1970.1 - 1979.12
5	MUARA KELINGI (AIR BELITI Plan)	135	428 18	407 17	423 19	427 13	164 7	169 8	132 8	102 7	180 9	280 18	520 17	456 15	3,688 156	1977.1 - 1979.12

Note: Upper figures show rainfall and lower figures rainy days.

Table 3. Monthly rainfall (mm) and rainy days (Lahat Kabupaten)

No.	Observation point	Elevation (m)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Observation period
1	KOTA LAHAT	112	401 19	368 17	427 16	371 15	170 13	128 7	113 7	221 10	238 11	195 12	306 14	361 17	3,299 141	1970.1 - 1977.12
2	PAGAR ALAM	705	321 20	304 17	279 18	387 19	310 15	167 11	147 10	161 11	242 12	245 14	258 16	283 16	3,104 179	1970.1 - 1977.12
3	TJ. TEBAT	374	297 22	306 19	198 17	296 19	161 12	98 9	54 6	68 6	108 9	228 13	148 14	241 15	2,203 161	1972.1 - 1973.12 1976.1 - 1977.12
4	TJ. SAKIT	590	188 14	418 19	408 19	520 17	295 13	171 8	143 11	221 14	144 8	198 10	235 14	346 18	3,287 165	1972.1 - 1977.12
5	MA. PINANG	405	199 18	173 18	140 14	271 22	118 15	81 11	103 11	180 14	217 15	170 14	139 17	160 19	1,951 188	1970.6 - 1977.12
6	TEB. TINGGI	105	305 21	324 18	272 16	338 15	240 10	119 9	144 7	180 9	227 12	229 10	207 13	272 17	2,857 157	1971.8 - 1977.12
7	KOTA AGUNG	374	206 18	197 13	135 12	317 19	121 12	86 10	151 13	157 12	203 11	244 17	163 15	184 13	2,164 165	1971.1 - 1971.12 1974.1 - 1975.12
8	KIKIM	82	352 18	356 14	349 13	336 17	127 8	85 8	90 7	140 10	233 12	163 10	325 15	340 15	2,896 147	1972.4 - 1977.12
9	ULU MUSI	260	173 20	92 17	111 17	220 12	91 12	78 7	97 8	89 8	125 11	155 11	198 14	143 15	1,572 152	1972.6 - 1977.12
10	JARAI	708	159 22	218 20	236 20	261 20	104 16	65 9	150 10	157 11	115 10	118 17	287 19	207 21	2,077 195	1975.2 - 1977.5
11	PENDOPO	357	236 22	156 18	245 17	200 18	146 13	129 12	83 7	318 9	156 8	193 17	160 12	147 18	2,169 171	1976.8 - 1977.12
12	PULAU PINANG	47	- -	- -	- -	- -	- -	- -	- -	- -	- -	440 14	441 14	- -	- -	1976.10 - 1976.11
13	MERAPI	47	590 22	193 15	135 19	113 13	51 9	40 5	46 4	120 7	116 7	188 18	257 15	508 21	2,357 155	1976.8 - 1977.12

Note: Upper figures show rainfall and lower figures rainy days.

Table 4. Monthly maximum daily rainfall (mm)

No.	Observation point	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual rainfall
1	MUARA RUPIT	1977	20	20	40	45	20	15	15	9	14	17	76	38	2,419
		1978	43	37	75	45	10	15	-	11	27	31	37	-	(2,108)
		1979	-	-	41	42	8	-	20	11	16	24	43	17	(1,405)
2	B.K.L. ULU/TERAWAS	1977	8	9	9	7	6	5	5	4	6	8	11	8	783
		1978	12	14	43	19	19	17	8	-	65	57	37	76	(2,439)
		1979	97	76	36	36	16	63	59	61	46	76	48	67	3,442
3	TUGUMULYO	1977	68	40	40	35	65	36	62	20	63	58	85	103	1,925
		1978	75	44	204	50	33	25	50	39	186	77	139	131	4,056
		1979	96	74	74	35	13	101	111	103	61	71	76	78	3,569
4	LUBUK LINGGAU	1977	50	32	90	36	42	58	65	15	12	90	40	43	2,575
		1978	27	15	18	12	20	21	16	-	-	-	-	87	(1,178)
		1979	84	90	-	62	74	62	72	36	86	90	57	45	(3,196)
5	MUARA KELINGI	1977	27	46	40	-	-	-	30	20	18	-	-	-	(1,587)
		1978	40	40	74	134	39	34	20	24	24	43	37	93	3,363
		1979	126	70	84	105	53	44	36	32	85	50	133	58	(4,529)
6	MUARA KULAM	1979							(10)	21	29	31	28	32	
		1980	(55)												

Note: Of the Monthly maximum daily rainfall at Muara Mulam, figures in brackets are the maximum figures excluding the period in which no observation was made.
Under the Annual rainfall, figures in brackets exclude those months when no observation was made.

3. Results of the Survey and Comments

(1) River discharge

(i) Results of the measurement of river discharge

The results of the measurement of the river discharge are as shown in Table 5.

(ii) Relationship between the measured discharge and the area of the watered

The relationship between the discharge measured in the field survey and the area of the upstream watershed was studied by preparing a correlation diagram (Fig. 3) with the following results:

a. When the discharge is Y and the area of the watershed area X, the distribution shows a high correlation coefficient of 0.8762 along the regression formula below.

$$Y = 0.00136X + 4.09441$$

(However, extremely abnormal samples, No. 7, 10 and 40 were excluded from the computation. The area of the watershed was measured on the 1/100,000 topographical map, including the area outside the projected survey area.)
In general, the amount of discharge is in proportion to the area of the watershed.

b. There were some abnormal samples away from the general trend (deviating from the regression line), i.e., 6 samples showed small discharge in relation to the area of the watershed; 7 samples showed large discharge in relation to the watershed area. (See Table 6.)

(iii) Comments

a. Though the discharge normally increase as the area of the watershed increases, the results of the survey show some abnormal samples which may be analysed as below.

Table 5. Results of the measurement of river discharge

No.	River	Watershed number	Area of watershed x (ha)	Ratio of natural forest %	River width w (m)	River depth d (m)	Velocity v (m/sec)	Discharge y (m^3/sec)
1	Rawas	(2)	17,966	71	40.5	0.53	2.2	46.2
2	Keruh	(1)	6,830	84	17.0	1.35	0.3	7.8
3	×							
4	Rawas	(1)(2)	25,071	78	36.0	2.00	0.5	33.8
5	Kulus	(5)	34,400	51	41.0	2.00	1.3	103.3
6	Rawas	(1)(2)(5),<3>	61,996	71	33.0	1.50	1.8	86.6
7	Senawar	(6)	67,966	51	21.0	1.10	0.6	14.1
8	×							
9	×							
10	Mengkulam	(7)	79,526	66	51.0	0.40	0.6	11.2
11	Kuwis	(8)	7,370	76	22.5	0.75	0.6	9.9
12	Rawas	(1)∿(3),(5)∿(8)	92,786	63	60.0	2.70	1.0	168.5
13	Kutu	(9)	38,970	96	41.0	0.90	1.3	49.1
14	×							
15	Seri	<4>	1,230	77	11.0	0.60	0.2	1.0
16	×							
17	×							
18	×							
19	Rupit	(14)∿(19),<20>	88,085	66	55.0	2.00	0.8	88.0
20	"	(16)∿(19),<20>	71,315	64	85.0	1.20	1.5	153.0
21	Tiku	(14),(15)	3,560	67	24.0	1.50	0.4	14.4
22	"	(14),(15)	13,210	67	18.0	1.90	0.6	20.5
23	Rupit	(16)∿(19),<20>	66,675	64	52.0	2.50	0.7	91.0
24	"	(19),<20>	20,070	53	33.0	1.90	0.8	50.2
25	Leko	(16)∿(18)	46,605	72	45.0	1.00	1.6	72.0
26	Lacang	<18>	3,950	40	12.5	2.10	0.2	5.3
27	Leko	(16)(17)	41,015	83	60.0	1.10	1.1	72.6
28	"	(16)	13,540	80	27.0	1.00	1.1	29.7
29	B. Pu	(17)	27,475	84	58.0	1.10	1.2	76.6
30	Rupit	(19),<20>	19,000	53	34.0	1.40	1.2	57.1
31	"	(19),<20>	18,330	98	28.0	1.50	0.7	29.4
32	Dulu	<24a>	3,615	72	12.0	0.75	0.5	4.6
33	×							
34	Plikai	<26>	9,565	89	30.0	0.75	1.0	22.5
35	"	(26)	11,350	71	15.0	1.70	0.7	17.9
36	Bal	<27>	20,790	60	28.0	0.60	0.6	10.1
37	"	(26),<27>	32,140	65	28.0	1.00	1.0	28.0
38	"	(26),(27)	34,110	65	32.0	1.00	0.6	19.2
39	Lakitan	(28)	59,465	6	44.0	1.10	1.1	53.2
40	Bal	(26),(27),(28)	93,575	37	60.0	0.95	0.9	51.3
41	Halus	<30>	8,585	3	22.0	0.50	0.8	8.8
42	Megang	<34>	7,695	3	15.0	1.50	0.6	12.6
43	×							
44	Beliti	(39)∿(42)	94,325	8	52.0	3.10	0.6	100.8
45	×							
46	Gegas	(44)	8,215	1	12.5	0.70	0.3	2.6
47	Temlat	<46>	6,530	5	19.0	1.20	0.4	9.1
48	Kati	(40)	16,310	19	34.0	0.80	0.5	13.6
49	Semi	(41)	10,575	8	16.0	2.10	0.2	6.7
50	Beliti	(42)<39>	59,110	4	52.0	2.00	1.1	114.4
51	"	(40)∿(42),<39>	85,995	8	57.0	2.10	0.8	95.8
52	Temelat	(45)	7,890	13	11.0	1.40	0.7	10.8
53	Bingin	(47),<48>	4,930	10	11.5	0.80	0.6	5.5
54	Kungku	(49),<50>	4,745	11	11.0	0.90	0.5	5.0
55	Musi	-	-	-	(170.0)	(3.00)	(1.0)	(510.0)
Total			1,767,012					2,393.8
Average			38,413					52.2

Note: Watershed numbers in brackets denote the entire watershed areas under the land use survey, whereas those in < > denote parts of them. × denotes the lack of data. The area of the watershed covers as far as headwaters outside the projected survey area (measured on the 1:100,000 topographical map). The ratio of natural forest are obtained from the land use survey. $Y = w \cdot d \cdot v$

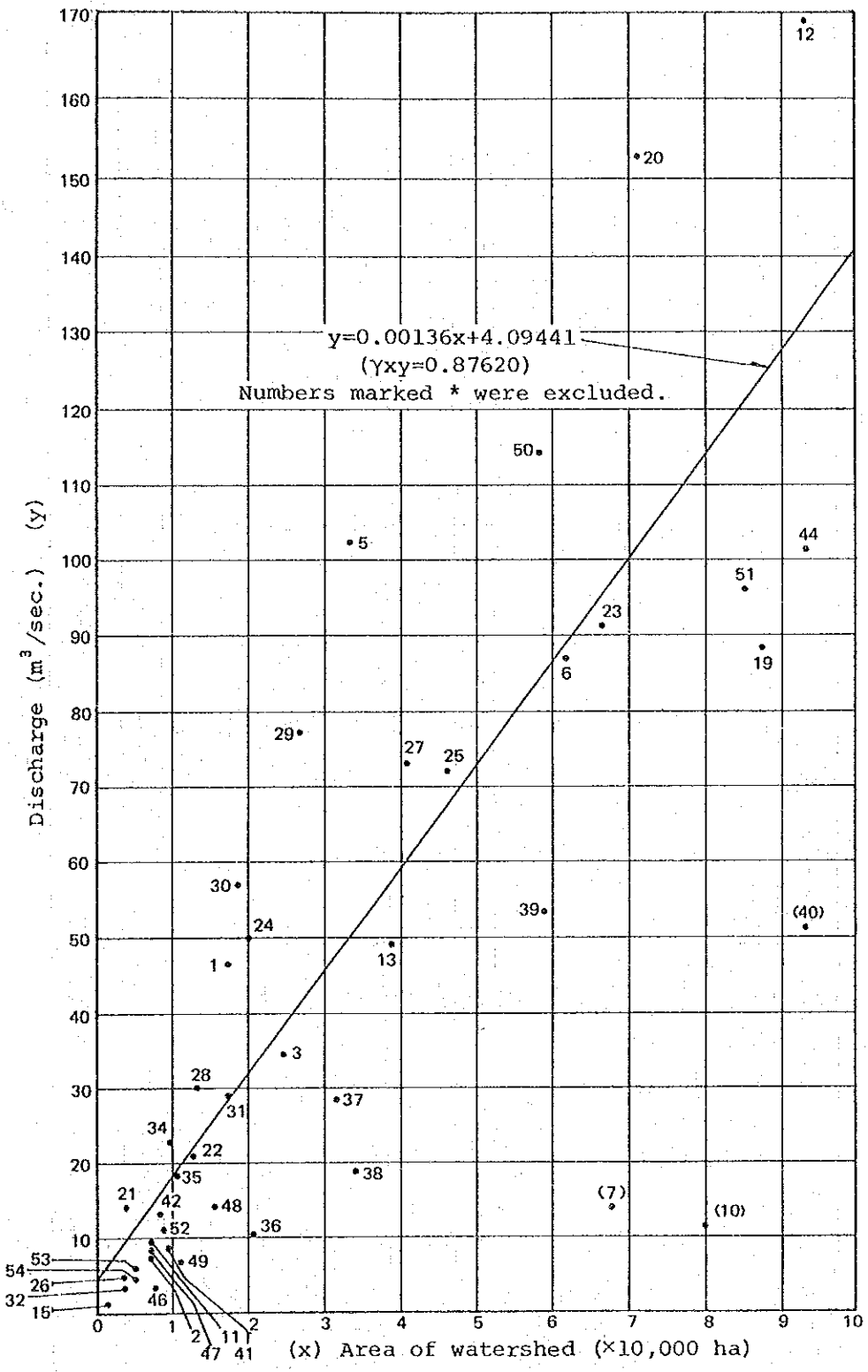


Fig. 3. Relationship between discharge and the area of the watershed

Table 6. Land use of watersheds with abnormal discharge

Division	Sample number / Land use	Natural forest	Second growth	Rubber plantation	Grass-land	Bare land	Arable land	Burnt field	Cluster
Watershed with abnormally small discharge	7	51	6	38			1	5	
	10	66	2	26			2	4	
	36	60	2	34			2	2	
	38	65	1	28		1	3	2	
	39	6	1	78			12	2	
	40	37	1	52		1	7	2	
	Average								
Watershed with abnormally small dischrage	1	71	1	25	1			2	
	5	51	5	39			2	4	
	20	64	1	31			3	1	
	24	53	1	40			5		1
	29	84	1	14			1	1	
	30	53	1	40			5		1
	50	4	1	86	1		4	3	1
	Average								
Average of the whole area		35	2	46	6	-	7	3	1

- o Large discharge in relation to the area of watershed is seen in a sample with a relatively small area of watershed. This is probably because a small area is greatly affected by localized rainfall.

- o Small discharge is seen in a sample with a large watershed area. This is probably because the discharge per unit area becomes to be small due to localized rainfall in a large watershed area.

- o The general trend (expressed by the regression line) is seen in a sample with fairly large watershed areas and a relatively high forest ratio. Average discharge is shown in large watershed areas with forests.

b. During the period of the survey of rivers (January 23 - 30, 1980), rainfall at survey points was recorded on only two days. The fine weather corresponded to the dry season and, according to the local residents, the discharge was even smaller than during the dry season. If so, all watershed areas should show the same tendency; but the discharge was extremely small at some points, pausing a question.

According to the field survey by interview, the water level would normally rise 30 min. after rainfall, returning to the mean level after two hours (e.g., Kutu and Kuwis Rivers). The water level might also rise by 2-3 m (Kulus River of Napalicin, Beliti River of Muara Beliti and Gegas River of Sekakalya). Judging from these facts, the discharge was greatly affected by the pattern of rainfall prior to the measurement. It seems that the discharge in this area is subjected more to localized showers which have the characteristics of rainfall (already methioned) than to the area of the watershed.

c. As mentioned, the discharge observed during the survey similar to that during the dry season even in the rainy

season. If the normal condition of the rainy season prevailed, the relationship between the discharge and the forest distribution would have emerged more clearly.

d. Though the present situation of watershed development is extensive, it will be more intensified and the land use will change to the social and economic development accompaniment. The effect of discharge control by the forest will only then appear clearly and the forest ratio of the watershed area will be the decisive factor in controlling the discharge.

(2) Sediment content

(i) Method of analysis

a. 500cc-samples of the river water were collected and filtered with a filter paper.

b. The filter paper with the half-dried sediment was placed in a vinyl bag and brought back to Japan. The sediment was first dried at a laboratory for three hours at 45°C. After one hour, the sample was weighed on the Mether's direct reading analytical balance.

c. In the meantime, 30 unused filter papers were soaked in distilled water and then dried at 45°C. After two hours, the average weight was computed.

d. The average weight of the unused filter paper was deducted from the weight of the sample to obtain the sediment content.

e. In order to compare samples, the sample of the smallest weight (Sample No. 30) was used as the base 0 to obtain the ratios of increase in weight of other samples.

f. In addition to the measurement by instrument, 47 samples were compared visually to ascertain the degree of pollution from the amount of sediment on the filter paper and were classified into four classes.

g. In some cases, the upper reaches of the river where the sample was taken extend further inland from the projected survey area. Accordingly, the area of the upstream watershed for each sample was measured on the 1:100,000 topographical map. As the previous survey on land use covered only the projected survey area, these conditions of land use are not clear in a strict sense, but estimated by the applications of the results of the pervious survey on land use. (On the whole, the ratio of natural forest will be considerably high, while other ratios in land use will fall.)

(ii) Results of the analysis of river water samples

The results of the above analysis may be summarized as Table 7.

a. The total weight of the sample varied from 1.13935g of No. 30, the smallest, to 1.20325g of No. 32, the largest, with the average being 1.17353g.

b. The weight of the unused filter paper varied from 1.12828g to 1.21325g with the average being 1.18364g and the standard deviation 0.01949.

c. The average sediment content was 0.01011g per 500cc.

d. The average ratio of increase over the sample of the smallest weight (No. 30) was 3.00%

e. The results of the visual comparison of sediment content were checked as shown below by the ratio of increase above mentioned corresponding to each category of classification. We found that visual observation was correct in general.

Category	1	..... 2.55%
"	2	..... 2.93%
"	3	..... 3.44%
"	4	..... 3.94%

Table 7. Analytical table of water samples (1/2)

Sample number	Number of related unit watershed	Total weight of sample A (g)	Average weight of filter paper B (g)	Sediment content C (g)	Ratio of increase P over the smallest sample A (%)	Visual classification of sediment content				Land use ratio in upstream watershed								Discharge (m^3/sec)	Area of watershed (ha)
						Low	Medium		High										
						1	2	3	4	Hr	Mb	Pk	Al	Tk	Pt	Sc	Kp		
1	(2)	1.18935	1.18364	0.00571	4.39	o				71	1	25	1			2		46.2	17,966
2	(1)	1.16676		-0.01688	2.41	o				84	1	13				2		7.8	6,830
3	-	-		-	-													-	-
4	(1),(2)	1.18677		0.00313	4.16			o		78	1	18	1			2		33.8	25,071
5	(5)	1.18105		-0.00259	3.66	o				51	5	39			2	4		103.3	34,400
6	(1),(2),(5),<3>	1.20191		0.01827	5.49			o		71	2	24			1	2		86.6	61,966
7	(6)	1.18485		0.00121	3.99				o	51	6	38			1	5		14.1	67,966
8	-	-		-	-													-	-
9	-	-		-	-													-	-
10	(7)	1.19736		0.01372	5.09			o		66	2	26			2	4		11.2	79.526
11	(8)	1.14891		-0.03473	0.84	o				76		21				2		9.9	7,370
12	(1)∿(3),(5)∿(8)	1.19500		0.01136	4.88				o	63	3	30			1	3		168.5	92,786
13	(9)	1.17912		-0.00452	3.49			o		96		4						49.1	38.970
14	-	-		-	-													-	-
15	<4>	1.16268		-0.02096	2.05	o				77	13	3	1			6		1.0	1,230
16	-	-		-	-													-	-
17	(×)	1.17924		-0.00440	3.50				o									-	168,576
18	(×)	1.15900		-0.02464	1.72			o										-	151,980
19	(14)∿(19),<20>	1.16512		-0.01852	2.26			o		66	1	30			2	1		88.0	88,085
20	(16)∿(19),<20>	1.15089		-0.03275	1.01			o		64	1	31			3	1		153.0	71,315
21	(14),(15)	1.17400		-0.00964	3.04		o			67	1	29			1	2		14.4	3,560
22	(14),<15>	1.17725		-0.00639	3.33			o		67	1	29			1	2		20.5	13,210
23	(16)∿(19),<20>	1.19008		0.00644	4.45			o		64	1	31			3	1		91.0	66,675
24	(19), <20>	1.17450		-0.00914	3.09	o				53	1	40			5		1	50.2	20,070
25	(16)∿(18)	1.16825		-0.01539	2.54		o			72	1	25			1	1		72.0	46,605
26	<18>	1.17900		-0.00464	3.48		o			40	1	55		1	2	1		5.3	3,950
27	(16),(17)	1.15712		-0.02652	1.56		o			83		15			1	1		72.6	41,015
28	(16)	1.17293		-0.01071	2.95	o				80		19				2		29.7	13,540
29	(17)	1.19015		0.00651	4.46		o			84	1	14			1	1		76.6	27,475
30	(19),<20>	1.13935		-0.04429	0	o				53	1	40			5		1	57.1	19,000

Table 7. Analytical table of water samples (2/2)

Sample number	Number of related unit watershed	Total weight of sample A (g)	Average weight of filter paper B (g)	Sediment content C (g)	Ratio of increase P over the smallest sample A (%)	Visual calssification of sediment content				Land use ratio in upstream watershed								Discharge (m^3/sec)	Area of watershed (ha)
						Low	Medium		High	Hr	Hb	Pk	Al	Tk	Pt	Sc	Kp		
						1	2	3	4										
31	(19),<20>	1.16264		-0.02100	2.04	o				98		2						29.4	18,330
32	<24a>	1.20325		0.01961	5.61	o				72	3	17	1		2	5		4.6	3,615
33	-	-		-														-	-
34	<26>	1.17255	1.18364	-0.01109	2.91	o				89	1	4		3	3			22.5	9,565
35	(26)	1.19105		0.00741	4.54	o				71	1	21			5			17.9	11,350
36	<27>	1.19125		0.00761	4.56	o				60	2	34			2	2		10.1	20,790
37	(26),<27>	1.18110		-0.00254	3.66	o				65	1	28		1	3	2		28.0	32,140
38	(26),(27)	1.16930		-0.01434	2.63	o				65	1	28		1	3	2		19.2	34,110
39	(28)	1.14976		-0.03388	0.91	o				6	1	78			12	2		53.2	59,465
40	(26),(27),(28)	1.18354		-0.00010	3.88	o				37	1	52		1	7	2		51.3	93,575
41	<30>	1.16932		-0.01432	2.63	o				3		76	1		16	3	1	8.8	8,585
42	<34>	1.17676		-0.00688	3.28				o	3	2	10	11		58		16	12.6	7,695
43	-	-		-	-													-	-
44	(39),(40),(41),(42)	1.18395		0.00031	3.91	o				8	1	82	1		3	4	1	100.8	94,325
45	-	-		-	-													-	-
46	(44)	1.15800		-0.02564	1.64	o				1	2	56	34		2	3	1	2.6	8,215
47	<46>-(46)	1.19581		0.01217	4.96		o			5	5	56	23		9	1	1	9.1	6,530
48	(40)	1.14728		-0.03636	0.70	o				19		70	2		2	5	1	13.6	16,310
49	(41)	1.18230		-0.00134	3.77	o				8	3	82	1		2	5		6.7	10,575
50	(42),<39>	1.17042		-0.01322	2.73	o				4	1	86	1		4	3	1	114.4	59,110
51	(40),(41),(42),<39>	1.15127		-0.03237	1.05	o				8	1	82	1		3	4	1	95.8	85,995
52	(45)	1.15650		-0.02714	1.51		o			13	1	78			2	6		10.8	7,890
53	(47),<48>	1.16082		-0.02282	1.88		o			10	2	60	16		8	3	1	5.5	4,930
54	(49),<50>	1.14300		-0.04064	0.32	o				11	2	43	33		8	2	1	5.0	4,745
55	(×)	1.18557		0.00193	4.06				o									510.0	-
Total		55.15608		-0.47500	141.02													2393.8	1,767,012
Average		1.17353		-0.01011	3.00													53.2	38,413

Note: ( ) are entire areas under the Land Use Survey, < > are parts of them and that marked by × too large to be measured.

Table 8. Visual comparison of sediment content and the ratio of natural forest

Sediment content classification	Low (1)		Medium				High (4)	
			(2)		(3)			
Item	Sample number	Ratio of natural forest	Sample number	Ratio of natural forest	Sample number	Ratio of natural forest	Sample number	Ratio of natural forest
Ratio of natural forest for each sample (%)	1	71	21	67	4	78	7	51
	2	84	25	72	6	71	12	63
	5	51	26	40	10	66	42	3
	11	76	27	83	13	96		
	15	77	29	84	19	66		
	24	53	47	5	20	64		
	28	80	52	13	22	67		
	30	53	53	10	23	64		
	31	98						
	32	72						
	34	89						
	35	71						
	36	60						
	37	65						
	38	65						
	39	6						
	40	37						
	41	3						
	44	8						
	46	1						
	48	19						
	49	8						
	50	4						
	51	8						
	54	11						
Total	1,170		374		572		117	
Average	46.8		46.8		71.5		39.0	

(iii) Relationship between the sediment content of the sample and the conditions of land use in the upstream watershed area

The results of the analysis of water samples showed that the total weight of the sample measured mechanically was in general smaller than the weight of the unused filter paper and that the standard deviation of the weight of the filter paper was larger than the sediment content.

Accordingly, in order to ascertain the relationship between the sediment content in river water and the conditions of land use in the upstream watershed area, the classification of sediment content made visually was used as the standard. As regards the conditions of land use, attention was paid only to the ratio of natural forest to ascertain if the natural forest was effective in checking sediment run-off.

Thus, as Table 8 shows, as far as Categories 1 and 4 are concerned, we find that if the sediment content is high, the ratio of natural forest is low; if the former is low, the latter is relatively high. However, if we take the medium category of visual classification into consideration, considerable doubts arise as to the accuracy of the tendency.

(iv) Comments.

a. As the rivers in the area are invariably earthlike in color, considerably high sediment content was expected; but the survey found low sediment content.

b. This is probably because the soil in the watershed area is on the whole clay of high grain density it floats in the river water presenting a colloid form, appearing to be earthlike in color due to the angle of light.

c. In the case of Sample 12, though sedimentation was observed at the bottom of the tube, the sediment content is 0.01136g according to the analytical table. Since the sample is

500cc of river water, the content ratio is mere 0.0023%. Sample 12 was taken from the main river of Rawas and Samples 1 and 4 taken from the upper reaches showed only 0.0011% and 0.0006% respectively.

The fact that the sediment content increases towards the lower reaches is probably because 1) the ratio of farm land increases while that of forests decreases in terms of land use; 2) it contains the erosion loss along the river; and 3) it contains the sediment from branches.

Many large deposits and ruptures are observed in river bends on the Rawas and Musi Rivers downstream from Muara Rupit, which are likely to cause considerable damage every year, though the sediment content is low with a low grain density. Accordingly, with the progress of development, larger expectations will be placed on the forest with its large soil cover as in the case of river discharge.

IV. ANALYSIS OF LAND USE

- Relationship between Land Use and Inclination -

1. Distribution of Land Use

As reagrds the current land use in this area, the results of the survey on land use show the ratios of land use as given below for the total area of 405,401 ha. (See the Report on the Forest Survey, March, 1980, JICA.)

(1) Average land use in the project survey area

Natural forest	35%	144,000 ha
Second growth	2%	7,000 ha
Rubber forest	46%	186,000 ha
Grassland	6%	24,000 ha
Bare land	- (0.05%)	200 ha
Farm land	7%	29,000 ha
Shifting cultivation	3%	11,000 ha
Urban site	1%	4,000 ha

Rubber forests and their second growth account for as musch as 46% of the total, followed by natural forest at 35%, farm land at 7%, grassland (Alang Alang) at 6% and shifting cultivation land at 3%. Accordingly, the handling of rubber forests will pose an important problem in the watershed management of the area concerned.

There is virtually no planted forest (for lumber) in this area. Further, though "swamps or river side area" and not fixed on the calculation of the area, they are changed by season and are included in the computation under the above division. (They are included mainly under natural forest, rubber forest and farm land.)

The current condition of the natural forest in the projected survey area is as shown below.

Total growing stock of natural forest on 144,000 ha	:	about 25,400,000 m^3
Mean growing stock per ha	:	176 m^3/ha

(2) Conditions of two major watersheds

a. A. Rawas

Located in the north of the projected survey area, this watershed occupies 36% of the area and may be classified in terms of land use as below.

Natural forest	:	about 66%
Rubber forest	:	28%
Shifting cultivation	:	3%
Second growth	:	2%
Farm land	:	1%

As shown above, it has a high ratio of natural forest, indicating that it is far behind the southern part of the survey area in development.

It accounts for 68% of the total natural forest area and 71% in volume ratio, thus showing the per ha volume of 185 m^3/ha, which is considerably higher than the average.

In the light of the above, this watershed will require attention in future forestry management (aspects of production and protection).

b. A. Musi

Situated in the south of the projected survey area, this watershed occupies 64% of the area showing the following land use:

Rubber forest	:	56%
Natural forest	:	18%
Farm land	:	11%
Grassland	:	9%

Shifting cultivation	:	3%
Second growth	:	2%
Urban site	:	1%

Compared with the north, it shows closer involvement with people with higher ratios of rubber forest and farm land; even urban site appears at 1%. Further, grassland accounts for as much as 9% and the area for shifting cultivation is also large. Accordingly, apart from the handling of rubber forests, the issue in this watershed will be how to formulate afforestation planning while maintaining a balance between forestry and agriculture.

(3) Conditions of six medium watersheds

a. A. Rawas, A. Rupit, S. Liam

These three watersheds belong to the A. Rawas major watershed and invariably show a high ratio of natural forest (66%, 71% and 66%), followed by rubber forest (27%, 24% and 28%). The ratio of shifting cultivation land is 2-3%. This distribution of land use is due to the topographical and geographical conditions that these two watersheds are mostly mountanous land with the S. Liam consisting of flat land (swamp) away from any trunk road.

b. A. Lakitan

This watershed occupies about 29% of the middle part of the projected survey area, displaying the land use midway between north and south in character: rubber forest (45%), natural forest (29%) and farm land (17%). The southern part of this watershed forms a large area of arable land which may be called the grain basket of Lubuk Linggau.

With the national highway running through the area at the center, this watershed seems to be suitable for formulating an ideal watershed management plan maintaining a balance between

agriculture and forestry. (The north is bent on forestry, while the weight in the south tends to be on agriculture.) Though the volume ratio of natural forests accounts for 21% of the totoal, the per ha volume is considerably low at 161 m^3/ha.

c. A. Klingi

Though Lubuk Linggau, the Kebapten town, is located at the northern end of the area, rubber forests account for as much as 77% of the total; land use is not intensive for the watershed which runs along the trunk road and the railway line.

This seems to be due to the fact that the land is undulating with numerous small branch rivers and that rubber forests are hindering land use.

d. A. Musi

In this watershed, which belongs to the main river of Musi, rubber forests account for 60% of the total, followed by grassland with 19%. Natural forests are scattered away from the trunk road and rivers (mainly on flat land or in swamp forests), accounting for 11%.

Though the natural forests account for only 5% of the total in volume ratio with low productivity at 134 m^3/ha, this watershed will be the center of afforestation in the future.

2. Distribution of Slope

According to the previous report, the distribution of slope in this area is as below.

(1) Conditions in major watersheds

Table 9.

Classification \ Watershed	A. Rawas	A. Musi	Whole area
0° - 1°	2.6 %	16.8 %	11.6 %
2° - 5°	18.3	65.3	48.4
6° - 10°	22.0	9.1	13.8
11° - 15°	19.4	2.5	8.6
16° - 20°	24.0	3.2	10.7
21° - 30°	11.9	2.5	5.9
30° -	1.8	0.6	1.0
Total	100	100	100

As the table shows, the slope of 16° - 20° accounts for 24% of the A. Rawas in the north, followed by 6° - 10° at 22%, thus indicating on the whole a medium degree of inclination, though the slope is rather steep at 21° - 30° in some parts and partially over 31°.

In contrast, in the A. Musi of the south, the slope of 2° - 5° accounts for 65.3% or 2/3 of the total. With the inclusion of flat land of 0° - 1° the ratio increases to more than 80%, showing that the area is gently inclined land.

As the average inclination of 25 ha per mesh was used for the survey, the area tended to be expressed as being gentle in inclination on the whole. However, flat land and gentle slopes dominate this area as a whole with steep inclination of over 20% accounting for less than 20%.

(2) Conditions in medium watersheds

Table 10.

Watershed / Classification	A. Rawas	A. Rupit	S. Liam	A. Lakitan	A. Klingi.	A. Musi
0° - 1°	1.3 %	1.9 %	15.0 %	25.0 %	10.1 %	9.8 %
2° - 5°	7.3	22.0	55.5	45.3	82.7	81.5
6° - 10°	19.8	24.2	17.3	10.2	7.2	8.7
11° - 15°	23.5	18.0	6.7	5.5	0.0	0.0
16° - 20°	30.8	21.3	5.2	7.1	0.0	0.0
21° - 30°	15.2	10.9	0.3	5.5	0.0	0.0
30° -	2.1	11.7	0.0	1.2	0.0	0.0
Total	100	100	100	100	100	100

Note: Medium watersheds are arranged in the order of north to south starting on the left.

Table 10 shows clearly that though the area is dominated by gentle slopes, the ratio of gentle inclination increases towards the south; but the inclination tends to be steeper towards the north.

The distribution of slope shows that A. Rawas and A. Rupit are either mountanous or hilly (large undulation) areas, while A. Klingi and A. Musi are completely flat (including small undulation). S. Liam and A. Lakitan are mostly flat with pockets of slopes (mountains and hills).

3. Method of Analysis

The 25 ha-mesh was placed on the entire projected survey area. Samples were then selected by means of mechanically extracting one out of four (1/4 of the projected survey area), totalling 3,949 points.

Land use, topographical category, inclination category, valley density and geological category (prepared from the 1:250,000 geological map, Direktorat Geologi, 1977) of each sample were ascertained from each category map to prepare a series of data sheets. A cross table was then prepared from these data in order to ascertain the relationship between the factor and the category by computer.

Figures in the cross table, given as Attached table were converted to a percentage for each cateogry.

4. Relationship between Land Use and Slope

The following comments may be made from the cross table and Table 11 giving the area ratio of each land use category to the area of each inclination category produced from the cross table:

(1) Natural forests are mainly distributed between 2° and 30° Extremely flat areas have already been cleared for other categories of land use. Further, extremely steep areas are small in area and have relatively few forests.

However, the ratio of natural forests to the area of each inclination category (to be called the distribution ratio by inclination for convenience) shows that the 11° - 15° class accounts for 68%; natural forests account for more than 80% of those areas of over 16° in inclination.

(2) Secondary stand

The 2° - 5° class accounts for 48.3% of the total second growth. In the distribution ratio by inclination, however, 1.5 - 2.0% of those areas up to 20° is second growth. Second growth is extremely rare in those areas of over 21° in inclination.

(3) Rubber forest

Those areas of 2° - 5° account for as much as 65% of the total rubber forests, 15% in 6° - 10° and about 11% in 0° - 1°. Rubber forests disappear rapidly in steep areas of over 11° - 15°.

Classified by the ratio of distribution by inclination, high ratios are shown also in the order of 2° - 5°, 6° - 10° and 0° - 1° (63%, 51% and 44% respectively). The ratio begins to decrease at 11° - 15° to 27% and to 16% at 16° - 20°. Further, it decreases drastically to 8% at 21° - 30° and to 5% at over 31°.

Accordingly, rubber cultivation is most extensive in those areas of less than 10° in inclination. Though rubber cultivation is carried out in parts of hills and mountains of 11° - 20°, they occupy an extremely small area in relative terms and are very rare in those areas of over 21°.

(4) Grassland

Those areas of 2° - 5° account for as much as 79.1% of the total grassland with 14.5% distributed in flat areas of 0° - 1°.

As regards the ratio of distribution by inclination, grassland accounts for 7.9% of the area of 0° - 1°, 10.3% of 2° - 5° and 2.7% of 6° - 10° and hardly any grassland in the area of over 11°.

(5) Farm land

Of the farm land, those areas of 0° - 1° account for about 40% of the total and the gentle slope of 2° - 5° accounting for about 54% as expected; but farm land is extremely rare in those areas of over 11°. Though 1.4% of the farm land is found in hilly areas of 21° - 30°, this is probably due to the fact that some burnt fields and coffee and papaya plantations became fixed to some extent and that some of the farm land was included in the surrounding steep area due to the degree of accuracy in measuring the inclination.

Table 11. Relationship between land use and inclination

Land use	Ratio of land use by category in the projected area (Ai)	Categories by inclination	Area ratio by inclination (a)	Area ratio by land use category (b)	Ratio of land use by inclination (c)
	%				
Natural forest	35.8	0 - 1°	11.5%	5.9%	18.3%
		2 - 5	48.4	20.5	15.0
		6 - 10	14.0	15.8	40.5
		11 - 15	8.4	16.0	68.0
		16 - 20	10.9	24.5	80.6
		21 - 30	5.9	14.6	88.4
		31 -	1.0	2.6	93.1
Second growth	1.5	0 - 1	11.5	12.1	1.6
		2 - 5	48.4	48.3	1.5
		6 - 10	14.0	13.8	1.5
		11 - 15	8.4	10.3	1.9
		16 - 20	10.9	13.6	1.9
		21 - 30	5.9	1.7	0.4
		31 -	1.0	0	0
Rubber forest	47.2	0 - 1	11.5	10.8	44.4
		2 - 5	48.4	64.6	62.8
		6 - 10	14.0	15.0	50.5
		11 - 15	8.4	4.9	27.4
		16 - 20	10.9	3.7	16.1
		21 - 30	5.9	1.0	8.0
		30 -	1.0	0.1	4.7
Grassland	6.3	0 - 1	11.5	14.5	7.9
		2 - 5	48.4	79.1	10.3
		6 - 10	14.0	6.0	2.7
		11 - 15	8.4	0	0
		16 - 20	10.9	0.4	0.3
		21 -30	5.9	0	0
		31 -	1.0	0	0

Land use	Ratio of land use by category in the projected area (Ai)	Cateogires by inclination	Area ratio by inclination (a)	Area ratio by land use category (b)	Ratio of land use by inclination (c)
	%				
Farm land	7.2	0 - 1°	11.5%	39.6%	24.8%
		2 - 5	48.4	53.7	8.0
		6 - 10	14.0	4.6	2.4
		11 - 15	8.4	0.4	0.4
		16 - 20	10.9	0.4	0.3
		21 - 30	5.9	1.4	1.7
		31 -	1.0	0	0
Shifting cultivated land	1.5	0 - 1	11.5	6.7	0.9
		2 - 5	48.4	46.7	1.4
		6 - 10	14.0	23.3	2.5
		11 - 15	8.4	10.0	1.8
		16 - 20	10.9	12.7	1.6
		21 - 30	5.9	1.7	0.4
		31 -	1.0	0	0
Urban site	0.5	0 - 1	11.5	38.9	1.7
		2 - 5	48.4	55.6	0.6
		6 - 10	14.0	5.6	0.2
		11 - 15	8.4	0	0
		16 - 20	10.9	0	0
		21 - 30	5.9	0	0
		31 -	1.0	0	0

(Note 1)

$$C = \frac{(\frac{Ai}{100} \times S) \times \frac{b}{100}}{(\frac{a}{100} \times S)} \times 100$$

$$= \frac{b}{a} \times Ai$$

S = projected survey area

(Note 2) The category of bare land was excluded from computation as the ratio was less than 0.1% of the total projected survey area.

(Note 3) Total ratios by inclination

0° - 1°	99.6%	16° - 20°	100.8%
2 - 5	99.6	21 - 30	98.9
6 - 10	100.3	31 -	97.8
11 - 15	99.5		

They do not amount to 100% as they are estimates.

(6) Shifting cultivated lands

Gentle slopes of 2° - 5° account for about 47% of the total shifting cultivated lands, 23% in 6° - 10°, 10% in 11° - 15° and 12% in 16° - 20°, i.e., about 40% in hilly areas.

The ratio of distribution by inclination shows that 2.5% of the land of 6° - 10° consists in shifting cultivated lands; in terms of ratio there are more shifting cultivated lands in hilly areas than in flat areas. They are rare on steep slopes of over 21°.

The shifting cultivated lands mentioned here refer to those new ones as of 1978; many of those older ones seem to have turned into farm land and rubber forests.

(7) Urban site

As it is to be expected, about 95% of the urban site is found in the areas of less than 5°; they are seldom seen in the areas of over 6°.

5. Comments

(1) Forests are distributed among all classes of inclination. However, in terms of land use, each category is concentrated in a particular inclination class as shown below.

Rubber forests	: 0° - 10°	90.4% (indicating that 90% of rubber forests are located in the inclination class of 0° - 10°)
Farm land	: 0° - 5°	93.3%
Urban site	: 0° - 5°	94.5%
Grassland	: 0° - 5°	93.6%

The above figures show that land use in categories other than forest are limited by inclination, whereas forests are not.

(2) This shows that the people was indifferent to the forest from the viewpoint of economic land use. Though it will be interesting to know the history of the current land use. The present land use was made by people beginning from an area where they can easily clear off the forest. A future exploitation will be done in gentle slopes as a favourable condition as in the past.

(3) The present tendency in land use in relation to inclination categories seems to show the most desirable form of land use for the residents. Accordingly, it will be appropriate to follow the tendency in planning land use in the future.

Based on this approach, though it may sound extremely bold, land use may be planned as below.

a. The forest zone is to be where the inclination is over 11°.

b. Those rubber forests, currently located in places of over 11° in inclination, are to be retained for the time being and their future is to be determined by taking account of the intention of the residents, stand age, forest type, etc.

c. The farm land, currently located in places of over 11°, is to be retained for the time being and its future is to be determined by taking account of the intention of the residents and crop conditions.

d. Others are to be managed as forests. However, the method of management is to be determined separately by taking account of land conditions, forest type, etc.

e. Those forests, currently located in places of less than 11°, are to be diverted, as a rule, to other categories of land use and are not to be covered by forest management. However, those necessary for conservation purposes such as flood control are to be designated and managed separately.

f. Those forests belonging to settlements and arable land are to be retained as much as possible for such purposes as environment conservation and collection of fruits. However, they are to be maintained and managed together with those in other categories of land use and are not to be managed as production forests.

g. As regards those categories of land use other than forest, they are to be determined separately by taking account of the tendency in food production, rubber production, grassland development, etc., and it suffices to put forward basic suggestions in respect to the conditions after felling.

V. ROLE OF THE FOREST

In Chapter IV, attempts have been made to elucidate on the basic approach to land use. Moreover, there is a need to study it from a different point of view.

The question concerns what role forests in this watershed should play in this country. For a fulfilment of this role, it also concerns how many forests should be retained and under what program the forests should be dealt with. In other words, it is necessary that the forest region as seen from the inclination should be studied from the viewpoint of forest resources in order to clarify its propriety.

1. Review of the Present Forest Distribution

As indicated in Table 12, the island of Sumatra accounts about 27% of the total area of Indonesia's national land. Its forests have a share of about 23% in the total area of forests throughout the nation.

The Province of South Sumatra accounts for 6% of the national land and about 4% of the national forests. It also accounts for about 23% of the land of the island of Sumatra and about 18% of its forests.

Musi Rawas County including the survey area is 0.7% of the national land of Indonesia and about 0.7% of its forests. It also accounts for 12% of the land of the Province of South Sumatra and about 16% of its forests.

The share of forests in the total area of the national land is 60%. The share of forests in the area of the island of Sumatra is 52%. In this island, the Province of South Sumatra shares 42%, suggesting that the development of forests in this island has made progress. However, the share of Musi Rawas County is 54%, indicating

Table 12. Role of forests in South Sumatra Province and Musi Rawas County

Area	Area of national land (km^2)	Area of forests (km^2)	Ratio of forests to all forests (%)	Ratio of forests to national land (%)	Area of production forests (km^2)	Area of protection forests (km^2)	Timber output			Estimated stock (in ten thousand km^2)
							1972 (1000 m^3)	1975 (1000 m^3)	1977 (1000 m^3)	
Whole national land of Indonesia	2,027,000[a]	1,222,000[a]	100	60	{420,000[a] 487,806[b]	430,000(36,000)[c]	17,717(13,891)[a]	16,296(13,921)[a]	24,500(16,543)[a]	870,000[a]
Island of Sumatra	541,000[a]	284,000[a]	23.2	52	221,570[b]	59,760(13,476)[b]	- (2,625)[a]	- (2,893)[a]	- (3,140)[a]	
Ratio to national land	26.7	23.2			45.4(52.8)[b][a]	13.9	- (18.9)	-- (20.8)	- (19.0)	
Province of South Sumatra	122,579[b]	51,830[b]	4.2	42	40,007[b]	11,162(661)[b]	372(169)[e]	563(335)[e]		
Ratio to national land	6.0	4.2			8.2(9.5)[b][a]	2.6	2.1(1.2)	3.5(2.4)		
Ratio to Sumatra	22.7	18.3			(18.1)[a]	18.7	- (6.4)	- (11.6)		
Musi Rawas County	15,200[d]	8,230[d]	0.7	54(36)[f]	5,981[d]	2,249[d]	53[e](-)	- (-)		(2,541)[f]
Ratio to national land	0.7	0.7			1.2(1.4)[b][a]	0.5	0.3(-)	- (-)		(0.3)
Ratio to Sumatra	2.8	2.9			(2.7)[a]	3.8	- (-)	- (-)		
Ratio to South Sumatra Province	12.4	15.9			(14.9)[a]	20.1	14.2(-)	- (-)		

References:
a. "REPELITA III" (The Third Five-Year Development Plan)
b. "Report to the Government of Indonesia on Forest in Indonesia" (F.A.O), Rome, 1971)
c. "World Forest Resources"(Royal College of Forestry, Stockholm, 1974)
d. "Kabupaten Daerak TK. II Musi Rawas," Laporan (1979).
e. "Tegakan Hutan Indonesia" (Buku II Sumatra Bagian Selatan, Direcktorat Bina Program, 1977.)
f. Portions of the Surveys by JICA on Forest Resources in Upper Musi Watershed (1978, 1979) which concern the survey area.

The figure in brackets under the colum of "Area of Protection Forests" represents the area of natural forests and forests for the conservation of wild life and vegetables. The figure in brackets under the column of "Timber Output" represents Timber exports. The figure in brackets under the column of "Area of Production Forests" represent cases where the figure (a) for the entire land of Indonesia is used.

that natural forests remain in this country than in other parts of the Province of South Sumatra.

As regards the area of production forests, about half (45-53%) of all production forests in Indonesia, or 420,000 km^2, exist in the island of Sumatra. The Province of South Sumatra accounts for about 8-10% of all production forests in the nation and about 18% of the island. Musi Rawas County shares about 1% of all production forests in the nation and about 15% of the Province of South Sumatra.

In contrast, relatively small numbers of protection forests are available in the island of Sumatra, accounting for only about 14% of all protection forests in the nation. The Province of South Sumatra accounts for only about 26% of all protection forests in the nation. Musi Rawas County shares 0.5% of all protection forests in the nation and about 20% of all protection forests in South Sumatra Province.

2. Review of Timber Production and Exports

(1) Timber Output and Exports at Present

As indicated in Table 12, the total output of timber throughout the nation stood at 17,717,000 m^3 in 1972. Of this total, about 2% was produced in the Province of South Sumatra and 0.3% in Musi Rawas County.

Incidentally, this county accounts for 14.2% of the output of the Province of South Sumatra.

A check of timber exports in 1972, 1975 and 1977 as a whole indicates that about 19-21% of the total national timber exports was diverted from the island of Sumatra. The province of South Sumatra produced timber to the tune of 1.2-2.4% of the national total and shares about 10% of the output of the island of Sumatra.

(2) Future Increases in Timber Production and Wood Processing Capacity of This Area

According to the National Program on Forestry, Indonesia, 1973, not so big increases are envisioned in the total exportation of timber in the coming several years, but there are signs that the exports of processed timber would certainly register greater rises than those of logs, as shown in Table 13.

Table 13. Tendency of timber exports in indonesia

Units: 1,000 m^3 for volume, 1,000 t for others, US$1 mil. for value

		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Volume	Logs	3,672	7,304	10,631	13,400	15,500	16,900	17,600	18,300	19,000	19,700	20,300
	Processed wood	29	46	80	120	250	500	750	1,000	1,250	1,500	1,750
	Total	3,701	7,350	10,761	13,520	15,750	17,400	18,350	19,300	20,250	21,200	22,050
Value	Logs	27.7	99.0	165.9	217.3	279.0	321.1	352.0	384.3	418.0	453.1	487.2
	Processed wood	0.9	1.5	2.4	3.6	7.5	16.0	27.0	40.0	55.0	72.0	91.0
	Total	28.6	100.5	168.3	220.9	286.5	337.1	379.0	424.3	473.0	525.1	578.2
Other wooden products (not by volume)		54.90	199.50	73.40	97.80	134.60	147.29	159.98	172.67	185.36	198.05	210.74
Value		1.5	3.9	2.9	7.6	5.71	6.17	6.63	7.09	7.55	8.01	8.47
Total value		30.1	104.4	171.2	228.5	292.2	343.2	385.6	431.4	480.6	533.1	586.7

Reference: Directorat Jenderal Kehutanan

Notes: Unconfirmed figures for 1972; target figures for 1973 and subsequent years

In the Third Five-Year Development Plan (REPELITA III), the following projection is made:

"The forestry program projects an annual increase in total timber exports of 4.6%. Policies to reduce the export of logs will be continued and it is projected that during the Plan period export of logs will decline by 2.6% a year while that of sawn and proceesed wood (plywood and others) will increase annually by respectively 25.5% and 117.1%."

In other words, there are signs that sharp rises in timber exports would be checked and the exports of logs would be toned down so as to concentrate efforts on the promotion of the domestic wood processing industry.

On the other hand, the sawmill industry of the Province of South Sumatra accounts for about 8% of all sawmills in the nation, 4% by logs (m^3/year) and 4.3% by lumber (m^3/year).

Table 14. Number of sawmills (1972)

Province	Number of sawmills	By logs (m^3/year)	By lumber (m^3/year)
1. Banda Aceh	39*	129,500	37,064
"	78**	28,264	7,066
2. North Sumatra	217*	364,000	145,000
3. Riau	44*	234,000	141,994
4. West Sumatra	2*	2,400	1,440
"	112**	28,805	14,402
5. Jambi	22*	35,256	18,504
6. South Sumatra	72*	133,590	62,034
7. Lampung	41*	98,000	40,000
8. Bengkulu	1*	1,500	600
9. Jakarta	9*	182,000	61,000
10. West Jawa	28*	86,000	45,000
11. Central Jawa	58*	232,000	93,000
12. Yogyakarta	-	-	-
13. East Jawa	77*	86,000	35,000
14. West Kalimantan	43*	636,000	280,000
15. Central Kalimantan	24*	547,437	218,978
16. South Kalimantan	26*	13,500	6,800
17. East Kalimantan	57*	462,160	240,140
18. South Sulawesi	39*	7,352	3,670
19. Southeast Sulawesi	10*	3,600	2,750
20. North Sulawesi	2*	9,600	4,800
"	19**	1,560	780
21. Maluku	-	-	-
22. Bali	-	-	-
23. West Nusa Tenggara	-	-	-
24. Irian Jaya	-	-	-
25. Indonesia	901*	3,325,359	1,437,774
	209**	586,629	22,250

\- Values unconfirmed
* Mechanical sawmill
** Manual sawmill

Table 15. Potential productivity of production forests in 20 years

Unit: 1,000 ha for area, 1,000 m^3 for volume

	Man-made/natural forests								Natural forests, mixed hard wood forests								Total	
	Teak		Coniferous trees		Mixed hard wood forests		Total		Exports		Imports		Others		Total		Area	Volume
	Area	Volume	Area	Volume	Area	Volume	Area	Volume	(m /ha)	(1,000m)	(m /ha)	(1,000m)	(m /ha)	(1,000m)	Area	Volume		
1. Sumatra	-	-	150	15,000	24	2,400	174	17,400	35	258,510	44	324,984	8	59,008	7,386	642,582	7,560	659,982
2. Jawa	761	76,100	145	14,500	85	8,500	991	99,100	-	-	-	-	-	-	-	-	991	99,100
3. Kalimantan	-	-	-	-	-	-	-	-	40	611,640	28	428,146	15	198,783	15,291	1,238,571	15,291	1,238,571
4. Sulawesi	7	525	-	-	4	300	11	825	39	38,961	29	28,971	6	5,994	999	73,926	1,010	74,751
5. Maluku	-	-	-	-	-	-	-	-	90	140,940	5	7,830	10	15,660	1,566	164,430	1,566	164,430
6. Irian	-	-	-	-	-	-	-	-	25	91,600	9	32,976	78	285,792	3,664	403,430	3,664	403,430
7. Bali·Nusa Tenggara	6	300	3	225	18	1,170	27	1,695	27	378	97	1,358	14	196	14	1,932	41	3,627
Indonesia	774	76,925	298	29,725	131	12,370	1,203	119,020	39	1,142,029	28	824,265	20	565,433	28,920	2,524,871	30,123	2,643,891

Notes

1. Sources: 1) Survey Reports, up to 1st Phase, 1971, Forestry Planning Bureau
   2) Development of Forests, up to June 1971, Directorate of Forestry
   3) Statistics of Directorate of Forestry, 1969
   4) Basic Figures, West Jawa Forestry Inspection Department, 1969

2. The aforementioned area represents 70% of the commonly known area.

3. Here, the production forests represent:
   1) Jawa Island: All production forests
   2) Outside Jawa: Right to develop forests = 50% of the area under the final agreement, survey agreement and under a permit for the right of development and under application

Table 16. Indonesian wood industry's capacity based on potential productivity of timber

Unit: 1,000 m^3

Area	Log exports	Sawmills	Veneer, plywood	Tips, Hard board	Total production capacity
1. West Jawa	-	307.8	-	93.3	401.1
2. Central Jawa	20	275.0	-	65.4	360.4
3. East Jawa	10	510.6	-	30.0	550.6
Entire Jawa	30.0	1,093.4	-	188.7	1,312.1
4. East Kalimantan	5,718.8	4,575.0	1,715.6	4,087.3	12,009
5. South Kalimantan	316.9	193.2	95.0	131.0	605.1
6. Central Kalimantan	2,024.4	2,555.8	480.7	1,554.1	5,060.9
7. West Kalimantan	1,131.2	1,328.2	268.6	847.9	2,727.9
Entire Kalimantan	9,191.3	8,652.1	2,559.9	6,614.6	20,403.3
8. Banda Aceh	565.9	678.8	169.8	418.2	1,414.5
9. North Sumatra	265.0	334.6	62.9	197.9	662.5
10. West Sumatra	270.2	351.3	54.0	207.1	675.5
11. Bengkulu	-	-	-	-	-
12. Jambi	1,077.1	1,373.5	242.3	825.6	2,692.9
13. Riau	1,230.3	1,553.4	292.1	918.1	3,075.8
14. South Sumatra	516.6	632.5	142.3	395.6	1,291.4
15. Lampung	108.4	136.0	27.1	83.4	271.5
Entire Sumatra	4,033.5	5,060.1	990.5	3,016.9	10,084.1
16. North Sulawesi	98.0	124.9	22.1	73.3	245.0
17. Central Sulawesi	207.3	264.3	45.8	154.9	518.2
18. Southeast Sulawesi	26.0	33.1	5.8	19.9	64.9
19. South Sulawesi	156.3	199.2	35.2	119.9	390.7
Entire Sulawesi	487.6	621.5	109.7	368.0	1,218.8
20. Maluku	1,171.6	1,552.3	322.2	901.2	3,046.1
21. Nusa Tenggara	33.3	43.9	6.1	22.7	83.3
22. Irian Jaya	2,790.5	3,348.6	837.1	2,976.2	6,976.2
Entire East Indonesia	3,995.4	4,944.8	1,165.4	3,900.1	10,105.6
Entire Indonesia	17,737.8	20,371.9	4,825.5	14,088.3	43,123.4

* No data available

Notes: - Tips in Jawa are based on coniferous trees.
- Tips outside Jawa are based on the following. 50% of skidded and waste wood at logging area + 30% of waste wood at sawmills + 30% of waste plywood.
- Tips outside Jawa are not included in the output.
- The figures do not include those of miscellaneous tree species.

Sources: Directorate of Forestry, Bureau of Forest Development and Industry.

The potential productivity of production forests in Indonesia over a period of 20 years from 1973 or so is estimated as indicated in Table 15. On the basis of this potential productivity, Indonesia's wood industry is computed as shown in Table 16. According to these tables, the potential productivity of Indonesia over a period of 20 years stands at 2,643,891,000 m^3, of which the island of Sumatra accounts for about 25%, or 659,982,000 m^3. It is also estimated that the island of Sumatra accounts for about 23.4% of the total productivity of Indonesia and that the Province of South Sumatra shares 12.8% of the capacity of the wood industry in the island of Sumatra and about 3% of the Indonesian wood industry's capacity.

(3) Future Timber Demand

The Third Five-Year Development Plan envisions the development of the following housing environment, and it is believed that there will be a rise in the domestic demand of timber in the future.

Expansion of low-cost dwellings: 150,000 houses
Expansion of the program for the improvement of rural communities: 150,000 ha, 3,500,000 persons

3. Relationship between Growing Stock and Natural Environment

It is possible to come to grips with the relationship between the growing stock of natural forests and the natural environment with the data of the multiple regression analysis done in the latest topographical analysis or the data of the plot survey conducted in the prior survey of 1978.

(1) Analysis by Index Score Table for the Site Class of Natural Forests using Mesh Data

From several classification charts prepared in a topographical analysis, one out of every four plots, or a total of 1,415 meshes, were mechanically sampled to survey the topography, inclination, valley density and geological type of each mesh.

With these meshes used as samples, a multiple regression analysis was conducted with a computer to prepare a table of sole indices for the position of natural forests. (Table 17)

Table 17. Score table of indices for site class of natural forests using mesh data from analysis of topography

Factor No.	Factor	Category No.	Category	Score
1	Topography	1	Mountain ridge	10.38
		2	Mountain side	5.60
		3	Mountain dale	-22.06
		4	Large-wave	-10.52
		5	Small-wave	-16.28
		6	Low, flat plateu	-18.27
		7	Flood plain	0
2	Inclination	1	0° - 1°	-10.18
		2	2° - 5°	- 7.73
		3	6° - 10°	3.05
		4	11° - 15°	6.18
		5	16° - 20°	- 4.92
		6	21° - 30°	-20.36
		7	31° -	0
3	Valley density	1	0 piece	- 1.55
		2	1 "	- 2.46
		3	2 "	7.69
		4	3 "	- 3.75
		5	4 more than	0
4	Geological type	1	Qhv.	185.70
		2	QTpv	184.20
		3	Tppp	152.26
		4	Tmpl	177.00
		5	Tmts	201.23
		6	Tomlp	143.20
		7	Tmv	197.33
		8	Tov	206.47
		9	Ta	344.60
		10	Kgr	178.89
		11	Jrs	179.89
		12	pTsb	231.63

(Number of samples: 1,415; Heavy correlation coefficient 0.32123)

This table indicates the following correlations between the various natural factors and the scores. (Note: It may be interpreted that the higher the score, the higher the growing stock of forests.)

(i) Topography

The scores of mountain ridges are highest, follwoed by those of mountain sides. In contrast, the scores of mountain dales (valleys), flat plateus and small-wave hills are significantly low.

In other words, these data suggest that stands of trees with a great growing stock exist on the mountain sides and ridges but that the growth is inferior in the flat plateus and small-wave hills. The scores of the mountain feet and hillocks come in between.

(ii) Inclination

The scores of natural forests in areas with moderate slopes of 11-15° and 6-10° are high, whereas those of flat areas with slopes of 21-30° and less than 5° and 21-30° are low. With the aforementioned topography taken into consideration at the same time, it might be said that the growth on sharp slopes is inferior even in the mountainous area.

(iii) Valley density

It might be pointed out that the scores of moderate areas with two valleys or so are high but that the growth of natural forests in small-wave hills (hillocks) is relatively inferior.

(iv) Geological type

The scores of areas with Ta (andesite), PTSb (saba), TOV (old andesite), Tmts (upper Telisa formation) are high, and they are distributed in mountain areas from the north to the central area. Even in the mountain areas, the scores of areas with Tomlp (Lahat formation), distributed along the upper reaches of the Rawas and Minak rivers, and with

TPPP (middle Palembang formation), distributed in the southern most part of this area, are low. Elsewhere, there is not much difference.

(2) Analysis by Score Table made of Data on Survey Plot

Using the findings of a plot survey conducted in conjunction with a forest survey of this area in 1978, a similar computation was made to prepare a score sheet. (Table 18)

Table 18. Score table of indices for site class of natural forests made of data on survey plot in 1978

Factor No.	Factor	Category No.	Category	Score
1	Forest type	1	Mountain forest (M)	76.210
		2	Hill forest (H)	40.022
		3	Flat land forest (F)	-31.447
		4	Swamp forest (S)	-24.268
2	Tree height	1	21 - 25m	0
		2	26 - 30m	- 7.828
		3	31 - 35m	23.207
		4	36 - 40m	-46.223
3	Crown diameter	1	- 15m	0
		2	16 - 20m	45.004
		3	21 - 25m	-23.143
4	Crown density	1	31 - 50%	0
		2	51 - 70%	81.096
		3	71 - 90%	154.840
5	Number of trees for formation	1	21 - 40 pcs/ha	0
		2	41 - 60 pcs/ha	29.702
		3	61 - 80 pcs/ha	-34.137
6	Inclination and direction	1	N	0
		2	E	- 1.710
		3	S	-10.525
		4	W	- 7.837
		5	All directions	39.225

(Number of Samples: 91; high correlation coefficient: 0.850)

The differences in the growing stock of natural forests as viewed from the forest pattern and position are described below.

(i) Forest type

In particular, the scores of mountain forests are high. The scores go down in the order of hill forests, swamp forests and flat land forests. These correlations are markedly similar to those of the aforementioned "topography," and it might be said that the swampy areas which are constantly placed in excessive humidity and the flat lands in which there is an extreme difference in the water content of the soil between the dry and the rainy seasons is unsuitable for the growth of productive forests.

(iii) Inclination

The scores of natural forests along the ridgeline, and on the top or the upper slopes including the ridgelines and the tops are extremely high, whereas those of natural forests on the south and west slopes are low.

(3) Comments

From the foregoing, it might be summarized that stands of trees with a favorable growing stock are formed along mountain ridges with moderate slopes and on flat mountain sides but that the growing stock is low for natural forests in flat and swampy lands. The difference in growing stock is upwards of 300 m^3/ha for favorable mountain forests, as against the average value of 176 m^3/ha for this area, and the growing stock does not exceed 100 m^3/ha for some flat land forests and swampy forests.

However, the forests in flat and swampy areas are easier to develop than mountain forests in the remote areas, and it must be taken into consideration that favorable forests with a good growing stock have already been felled, with the consequence

that forests in the flat and swampy areas cannot be brushed aside merely as stands of trees with a low growing stock.

4. Conclusion

(1) Appraisal with Statistical Data

Judging from the wood producing capacity based on the potential productivity of the Province of South Sumatra and also from the actual timber output (in 1972 and 1975), the following points may be pointed out.

(i) The island of Sumatra takes charge of about 20% (actual output) to 25% (capacity) of Indonesia's total timber output.

(ii) The Province of South Sumatra takes charge of about 2% (actual output) to 3% (capacity) of Indonesia's total timber output.

(iii) Musi Rawas County takes charge of about 15% of the timber output of the Province of South Sumatra, judging from the area of production forests in the county and its timber output. This is equivalent to 0.45% of the total output of Indonesia.

On the basis of the aforementioned statistical data, the area of production forests which should be formed in this area may be computed on a trial basis as follows.

7,386,000 ha (natural forests and production forests in Sumatra according to Table 16) × 0.03 (ratio to the Province of South Sumatra) × 0.15 (ratio of Musi Rawas County to the Province of South Sumatra) = 33,237 ha

$$33,237 \text{ ha} \times \frac{144,229 \text{ (A)}}{823,000 \text{ (B)}} = 5,800 \text{ ha}$$

A: Area of forests in the survey area

B: Area of forests in Musi Rawas County (production forests + protection forests)

A/B = 0.175

5,800 ha ÷ 20 (years) = 290 ha

If the rotation age is hypothesized at 35 years, the area of production forests required for the time being will be:

290 × 35 = 10,150 (ha)

If production was done by other areas according to their potential productivity and 290 ha a year was felled in the subject area (144,229 ha of forests), it would be possible to realize an annual wood producing capacity of 43,123,900 m^3 (the actual output in 1979 is estimated at 25,000,000 m^3, of which actual log exports account for 18,500,000 m^3) for the whole area of Indonesia.

Therefore, no special reasons are warrantable from an analysis of the aforementioned data for the establishment of wide areas of production forests in the subject area.

(2) Appraisal Based on Local Interviews

Statiscally, a trial computation may be made as indicated in the preceding tables, but local timber dealers report that about 1,200,000 m^3 of timber is traded a year in the vicinity of Palembang.

When this volume is checked against the output of the Province of South Sumatra, the annual output of Musi Rawas County should stand at:

1,200,000 m^3 × 15% = 180,000 m^3

as this county accounts for about 15% of all production forests in the Province of South Sumatra. Of the 1,200,000 m^3, 600,000 m^3 is positive, but the remaining 600,000 m^3 (a speculated figure) is not positive. If it is assumed that the sound volume is 75% of the aforementioned output, the sound output will be:

1,200,000 m^3 × 75% × 15% = 135,000 m^3/year.

If it is assumed that of the average growing stock of forests which stand at 176 m^3/ha, 30% is economically useful, the area of felling (exploitation) a year will be: 135,000 m^3 ÷ (176 × 0.3) = 2,557 ha. If the cutting cycle is set at 35 years, the area of forests required will be:

2,557 ha × 35 ≒ 89,500 ha.

If it is to be obtained from the forests of the projected area of Musi and Rawas County (natural forests covering 144,000 ha and second growths 7,000 ha), it will account for 60% of the total. If the required total of 89,500 ha is spread evenly through the country, each area concerned will have to provide just 15,700 ha.

(3) Conclusion Based on Correlations between Growing Stock of Forests and Natural Environment

To establish the production forests in suitable areas on the lines of the above-mentioned study, or to raise the productivity of forestry, there is a need to come to grips with correlations between the growing stock of natural forests and the conditions of stand site at present.

The accurate grasp is necessary not only in terms of forestry but also for harmonization with agriculture.

As described in 3-(3), it is desirable that a basic program for land use and forest deployment be worked out with due consideration given to correlations between the growing stock of forests and the natural environment (topography and inclination, in particular).

VI. BASIC APPROACH TO LAND USE PLANNING

On the basis of the foregoing analysis of the status quo of this area, a basic policy has been formulated for the preparation of a land use planning for this area.

1. Necessity of the Demarcation of Forest Region

In order to sustain the yield of timber without interruption in response to the demand of local people and other people of the nation and also the global demand, it is necessary to make the demarcation of natural forests, first, and then to conduct forest management in a systematic manner.

The demarcation of natural forests, or the boundary of the forest region in itself also served as a basic line, or a necessary and important line, for the formulation of a land use planning for areas outside the forest region as well.

For this reason, the demarcation of a forest region must be carried out on the basis of a comprehensive land use planning which will contribute to the coexistence and prosperity of agriculture and forestry and the development of the region.

2. Demarcation of Forest Region

The forest region will be set up in the area of existing natural forests for the time being, in which legitimate forest management will be conducted. Therefore, the boundary of the forest region coincides with the outer circumference of the natural forest as a rule.

Consequently, in case felling has been done in this area designated as a production forest or in case there exist areas burnt of unstocked land, such as grass lands, burnt fields or second growths, the demarcation of the forest region must be altered on lines of the existing natural forests.

For this, it is desirable that in future the demarcation of the forest region be defined preliminarily on the basis of an idea for a land use planning and the forest development be carried out step by step.

For the future demarcation of the forest region, a line with a slope of 10° is decided after having taken note of the findings of an analysis of the various data which have been mentioned before -- that is to say, the following factors have been taken into consideration.

(1) It is desirable that slopes with an angle of upwards of 11° be remained as natural forests as much as possible from the standpoint of land conservation, such as the checking of a rapid flow out of rainwater and soil.

(2) In slopes with angles of upwards of 11° -- particularly, 11-15°, the growing stock of natural forests is great. Conversely, intensive agriculture (such as rubber plantation and upland cultivation) is difficult to carry out on the slopes, and its productivity is low.

(3) When the development of the local economy is taken into account, it is desirable that the areas in which intensive agriculture may be carried out be positively turned into farmlands, without retaining natural forests. This will encourage the settlement of inhabitants and prevent an expansion of burning and shifting cultivated lands and shifting cultivation.

Therefore, we expect to set the upper boundary of the agricultural region at a 10° slope line in view of the fact that most of the existing rubber forests (about 90%) are located in areas with slopes of less than 10°.

3. Inside Forest Region

The forest region represents an area which should be managed as forests to conserve the land, and part of the area is offered for forestry production. The forests as referred to here include those which should be managed by Directorat Jenderal Kehutanan, such as protection forests, production forests and reserved forests, and those special-purpose forests which are managed by provincial governments, such as a flood control forests for the prevention of flood damage.

Here, the forest region is classified into the following categories, depending on the method of treating forests.

(1) Protection forests

(2) Temporary protected forests against felling

(3) Production forests

(4) Reserved forests

The concept about this classification and its directory will be mentioned later in regard to programs for forest deployment.

4. Outside Forest Region

Outside forest region is a living space directly connected with local residents, including agricultural, commercial and industrial areas and communities. It should be made a policy to maintain or develop main communities, commercial and industrial areas as much as possible, and no drastic reforms should be carried out unless a substitute program is established.

The same thing also holds true in the case of settled agricultural areas. In this report, a proposition will be made mainly as to how the flat lands and moderate slopes which are used natural forests at present should be used after these forests are felled.

It necessarily follows that the areas of less than 10° in inclination where natural forests have been felled should be regarded as farm land for the time being (including the communities which maintain these areas). The areas for use in agriculture are classified into three types -- irrigated paddy fields, export crop lands and mountainous farm lands, depending on the inclination. According to this classification, the following concepts emerge.

(1) Irrigated paddy fields

In the vicinity of Tugumulgo, irrigated rice plantation has been carried out on a large scale by local residents -- particularly, by migrants from Jawa Island, and this area is developing into a major granary.

In Indonesia, it is an urgent task to increase rice production. It is also an important task to work out measures for migrants from the overpopulated island of Jawa. Judging not only from this particular area but from the whole of Indonesia as well, it is necessary to establish an irrigated rice plantation belt in the appropriate places of this area as in the vicinity of Tugumulgo. More than anything else, there is a need to assure staple food and job opportunities for local residents, stabilize the infrastructure for their lives and raise their living standards with the diversion of rice to other parts of Indonesia.

To carry out highly productive rice plantation in an irrigation project, it is indispensable to make available lowlands vast in area and abundant in water. For this reason, low plateus with slopes of 0-1° and alluvial plains -- both with inflows of river water, have been selected this time for farm areas for irrigated rice plantation.

(2) Export crop lands

This area is actively engaged in the production of rubber, "cingkeh," coffee and coconuts. In most cases, they are produced by petty farmers.

Although rubber plantations account for 46% of the total acreage of this area, they have virtually turned into second growth and their management is extensive, with the consequence that the productivity is insignificant. Therefore, these fields are not suitable for irrigated rice plantation, but it is conceivable that moderate slopes, where farms may be managed on a large scale, could well be set aside for the increased production of export crops.

With the conversion of natural forests into farms for export crops, the economic strength of this region may be augmented and the job opportunities increased. It is desirable, however, that these endeavors should not be made in the form of estate agriculture by a limited number of capitalists but that the endeavors should be made by a cooperative which is joined by inhabitants in the vicinity. The large-scale farms which were to be operated by local residents would stimulate the entrepreneurs who are engaged in the management of extensive rubber plantation and would be tied in with an improvement of the poor rubber plantations.

It has been proposed that such a farm be established on a small-wave land with slopes of 2-5°. The reason is because this area has a suitable slope for a large-scale farm and because this area assures a farm wide in area.

(3) Mountainous farm lands

The decrease in the number of natural forests due to shifting is at issue in Indonesia. For this area, too, it is an important issue to prevent both shifting and clandestine felling. For this purpose, it is necessary that inhabitants should migrate to, and settle in, lowlands.

The establishment of farm areas for irrigated rice plantation and those for export crops as elucidated earlier is one of the measures which are in line with this purpose. This step alone, however, would not encourage inhabitants to migrate to lowlands, as they are making a living on rubber collection and also on such by products as rattan, durian and jelutung resin.

Therefore, one way of preventing shifting from the natural forests would be to secure living space around the forests for residents in the mountains and to enable them to engage in the production of forest byproducts as local specialities, and vegetables and also in upland plantation for their daily lives so as to work for the maintenance of manpower in forestry.

It has been proposed that this mountain farm area (which might also be called an agro-forest area) be established in an area with slopes of 6-10°.

VII. BASIC APPROACH TO FOREST DEPLOYMENT PLAN

In the chapter in which the basic policy for a land use planning has been dealt with, attempts have been made to describe a basic concept about areas both inside and outside the forest region broadly from the viewpoint of land use. Here, attempts will be made to elucidate on a basic concept for a forest arrangement program of this area.

1. Necessity of Forest Deployment Plan

In broad terms, the forests play many roles as they function, for example, for the conservation of the national land, production (economy), preservation of scenic spots and protection of wildlife. To give full play to such functions of the forests, forests should be appropriately arranged, depending on the function, and their management and control should be made in a systematic manner.

In Indonesia, three types of forests -- protection forests, production forests and reserved forests -- and those for the preservation of nature and wildlife are established. It could not necessarily be argued, however, that they are compatible with the actual functions and it seems that they are not well arranged. Consequently, there is a need, more than anything else, to carry out a variety of environmental surveys and analyze relations with the forests before a forest arrangement program is worked out, but the fact remains that such data are available in extremely small quantities.

Given this situation, it was made a rule to incorporate realistic concepts in the existing method used for the classification of forest regions and amend the method. This time, four types of forests -- protection forests, temporary protected forests against felling, production forests and reserved forests -- have been arranged, and it has been decided not to subdivide them until a functional analysis of the forests is completed in the future.

2. Approach to the Establishment of Land Sections

(1) Protection forests

The protection forests, as referred to here, are those which will serve as various functions as mentioned below. They also function as various other protection forests.

a. Cultivation of water sources -- reserved forests for the cultivation of water sources

b. Rapid outflows of rainwater
c. Rapid outflows of mud and sand
} -- Reserved forests for the prevention of mud and sand outflows (*conservation of* the national land and flood prevention)

d. Protection of wildlife -------- Reserved forests for wildlife and forests for scientific reference

e. Preservation of scenery ------- Reserved forests for scenery

In the island of Sumatra, the natural forests at heights of more than 450 meters above sea have already been designated as protection forests, and no felling is authorized in these natural forests. On the other hand, the subject area is situated at the eastern foot of the Barisan mountains, and there are many undulations which range in height from tens of meters to more than 1,000 meters above sea. They westernmost part of the subject area is occupied by highlands ranging from 2,383-meter-hight Mt. Seblat and the Barisan mountains, 1,500 to 2,000 meters in height, which include Mt. Hulukulus, Mt. Condong and Mt. Pasu.

The "height of more than 450 meters" as prescribed at present is sufficient when only the reserved forests are taken into consideration, but when forestry production is taken into account, it might be considered that mountainous highlands, such as those in this area, are too low in height. In other words, it is desirable that the lower borderline of the protection forests be set at the height which is parallel to the main ridgeline of

the Barisan mountains and the heads of the main stream and tributaries of the Musi River, and that production forests, which may protect branch ridgelines, sharp slopes and main rivers, be in low areas.

On the basis of this concept, it has been decided that forest regions similar in treatment to protection forests be designated along the main ridgeline in forests of less than 1,000 meters in height and along the main rivers and also in sharp slopes, as the lower borderline of the height of the protection forests is set at 1,000m.

(2) Temporary protected forest against felling

In areas at heights of less than 1,000m above sea, temporary protected forests will be arranged along the main ridgeline and the main river and also in sharp slopes to give full play to their functions as forests. It is projected that the temporary protected forests will be treated in the same manner as the protection forests for the time being, but the restrictions on felling may be alleviated in the future, depending on changes in the relations between the supply and demand of lumber. When the arrangement of forests proves unnecessary or substitute facilities are set up as the result of a functional analysis of each forest, such forest may be turned into a production forest.

(i) Along main ridgeline -- Shelter belt

At least on the main ridgeline which constitutes a unit watershed in the mountains of the subject area, a shelter belt should be arranged. The arrangement of this shelter belt will produce the following effects.

a. Windbreak effects

In this area, wet northwesteries blow in the rainy season (October through April) and dry south winds in the dry season (May through September). As the subject area belongs to the equatorial windless zone, it is conceivable that strong winds

blow on few occasions, but the drying of the forest bed along the ridges and also on the leeward may be prevented, and vegetation may be protected.

b. Collection of seeds of superior natural trees

The results of a forest survey indicates that many natural forests are accumulated in the moderate slopes of ridges in the subject area. After felling in the periphery, these forests are likely to become mother trees due to regeneration by natural seeding or forests for the collection of seeds for artificial forests.

c. Protection of boundary

The unit watershed (forest compartment), which forms the basis for a program for the management of forests in the future, must be protected.

d. Protection of wildlife and conservation of scenic spots

Although the height of reserved forests has been raised to 1,000m, there is a need to leave some habitats for wildlife in the lowlands. This step is also required for the preservation of scenic spots in the mountains.

With the above factors taken into account, a shelter belt, at least 100m in width, will be arranged on the windward of the main ridge of a mountain. This width is required to enable natural forests in this area to take shape and raise the windbreak effects. It has also been assumed that this width will assure some degree of profitability in felling (selective felling) and regeneration, when they are turned into production forests.

(ii) Along main river -- Bank erosion prevention forests and flood control forests

At least along the main river which will form the core for a unit watershed, there is a need to arrange a shelter belt

for the prevention of an erosion of the river banks, flood control and the protection of fish and wildlife along the waters.

As the erosion of rivers and in particular their erosion in terms of attack is conspicuous in this area, it is desirable that there be a shelter belt of 100m in width on both sides of the river. The value of 100m is a minimum distance at which natural forests may deter the impact of a flood.

Incidentally, the places which are constantly flooded during the rainy season or remain wet play a role in the flood control of the lower reaches as they serve as natural retarding basins.

Therefore, forests in such an area should be kept intact as flood control forests up to a maximum flood level. In another aspect, it is also important to arrange flood control forests due to the fact that it would be extremely difficult to re-generate such swampy forests after felling is done.

(iii) Sharp slopes (with slopes of more than 21°)
-- Erosion control forests

In this area, the slopes are relatively sharp when the average slope is more than 21° according to the mesh method, so that it has been decided that no felling be done in this area for the time being as a preventive measure against a land-slip and a sediment runoff.

Up to now, the techniques of felling, carrying-out and reforestation suitable for the mountains of this area have not yet been established. Therefore, if a series of techniques for which the conservation of the mountains is taken into account is established, more restrictions may be put on the slopes and the erosion control forests may be narrowed down to a minimum necessary degree.

(3) Production forests and reserved forests

Natural forests with slopes of less than 20°, excluding the aforementioned protection forests and temporary protected forests will be made production and reserved forests. Natural forests with slopes of less than 10° will be turned into farmlands after cutting is done, and natural forests with slopes of 11° to 20° will be reforested and maintained as production forests even after cutting is done.

For convenience's sake this time, the forests have been classified into two types -- production forests and reserved forests for production, depending on the growth stock by forest type in a forest growth stock survey of this area.

(i) Production forests

The stand for production forests has been set at 150 m^3/ha (clear length volume of upper-story trees with a diameter of more than 40 cm at the chest height). Now that the average growth stock is 176 m^3/ha for the natural forests in this area, it follows that the production forests in this area have half, or more than half, of the growth stock of the natural forests in this area. It is conceivable, therefore, that it is possible to produce lumber on a profitable basis in a somewhat large area.

(ii) Reserved forests for production

As for stands with less than 150 m^3 per hectare, the production of lumber could not be put on a payable basis unless the cutting area is considerably wider than that of the production forests. Therefore, it will be feasible to embark upon production, when the supply and demand of lumber becomes acute after production forests have been cut down. In the meantime, it might be expected that there would be a more or less rise in the growth stock of forests.

Or, if they are reserved forests for production, the topographical conditions of which are better than those of production forests in the back country and if there are full prospects for a profitability, there will presumably be no reason why a production project cannot be carried out for a production forest first.

3. Management of Forest for Each Land Class

Basically, each area category should be treated in the following manner.

(1) Protection forests -- Cutting should be prohibited.

(2) Temporary protected forests -- Cutting should be prohibited (in the future, the advisability of selective cutting will be studied). It is inevitable to cut down the minimum number of obstructing trees required for lumber transportation from production forests and also to fell the minimum number of trees required for residential areas in the river basins, such as farmlands.

(3) Production forests -- Selective cutting (in the future, the advisability of clear cutting in small area will be taken into account). The present method with which the rotation age is set at 35 years with the cutting of useful trees with a diameter of more than 50 cm at the chest height will be adopted, but clear cutting in small area will be discontinued when a method of regeneration under clear cutting is established.

(4) Reserved forests for production -- Selective cutting (in the future, the advisability of clear cutting in small area will be studied).

Incidentally, the treatment of grasslands, shifted fields and second growth under the present circumstances is based on the following concept.

i) More than 1,000m above sea -- Afforestation will be urgently done to arrange protection forests.

ii) Within a width of 100m on the main ridge line, within a width of 100m on both banks of the main river and with a slope of more than 21° -- Afforestation will be made to arrange temporary protected forests (quasi-protection forests).

iii) With slopes of 11-20° other than those in (1) and (2) -- Afforestation will be made to arrange production forests. For slopes of less than 10° other than those in (1) through (3), the treatment will be made as mountainous farm lands export crop lands and irrigated paddy fields as described in the basic policy on a land use planning. (This includes the Green Movement, which is known as Penghidiauan in the Indonesian language.) No new attempts will be made for afforestation in the rubber forests, settled farm areas and communities in the protection forests and the temporary protected forests (particularly, main ridgeline shelter belts, erosion prevention forests and flood control forests), but appropriate control will be exercised as these areas are considered conservation areas.

4. Land Use Plan and Forest Deployment Plan -- Summary of Chapters VI and VII

In an attempt to summarize in a comprehensive manner the basic approach of the aforementioned land use and forest deployment plan, Table 19 and Fig. 4 are prepared as a table for the basic watershed management plan and its flow chart.

Table 19. Table of the watershed management plan

Region	Classification	Areas arranged under present circumstances	Areas arranged after cutting of natural forests	Management	Remarks
Forest region		Existing region of natural forests (outer circumference)	Line with a slope of 11°	Defining of boundary on the field and protection and control of boundary	Shifting cultivated lands, grasslands and second growths partly included
Inside forest region	Protection forest	Over 1,000 m above sea level		Cutting prohibited	Immediate afforestation will be made in barrens or poor stand
	Temporary protected forest	Within a width of 100 m on the main ridgeline. Slopes at more than 21°. A width of 100 m on both banks of the main river. Frequently flooded areas will be set up at the flood level as retarding ponds in the temporary protected forest.		Cutting will be prohibited for the time being, and selective cutting will be partially done in the future.	Ditto
	Production forests	Natural forests of more than 150 m^3/ha except protection forests and temporary protected forests	Slopes at 11° ∿ 20°	Selective cutting will be done for the time being as at present, and clear cutting in small area will be done in the future.	Tree species for man-made forest will be planted for production forests.
	Reserved forest for production	Natural, forests except protection forests, temporary protected forests and production forests.			
Outside forest region	Mountainous farmland	The existing farmlands, rubber plantations and communities will be maintained as they are or redeveloped. As for the grasslands, shifting cultivated fields and second growths, refer to the descriptions in the columns on the righthand side.	Slopes at 6° ∿ 10°	Extensive agriculture for rubber, coffee, vegetables, etc. (including collection of forest by-products)	
	Farmland for export crops		Slopes at 2° ∿ 5°	Promotion of large-farm cultivation of export crops (rubber, oil palm, coconut, etc.)	
	Irrigated paddy field		Slopes at 0° ∿ 1°	Expansion and redevelopment of large-scale irrigated paddy field	

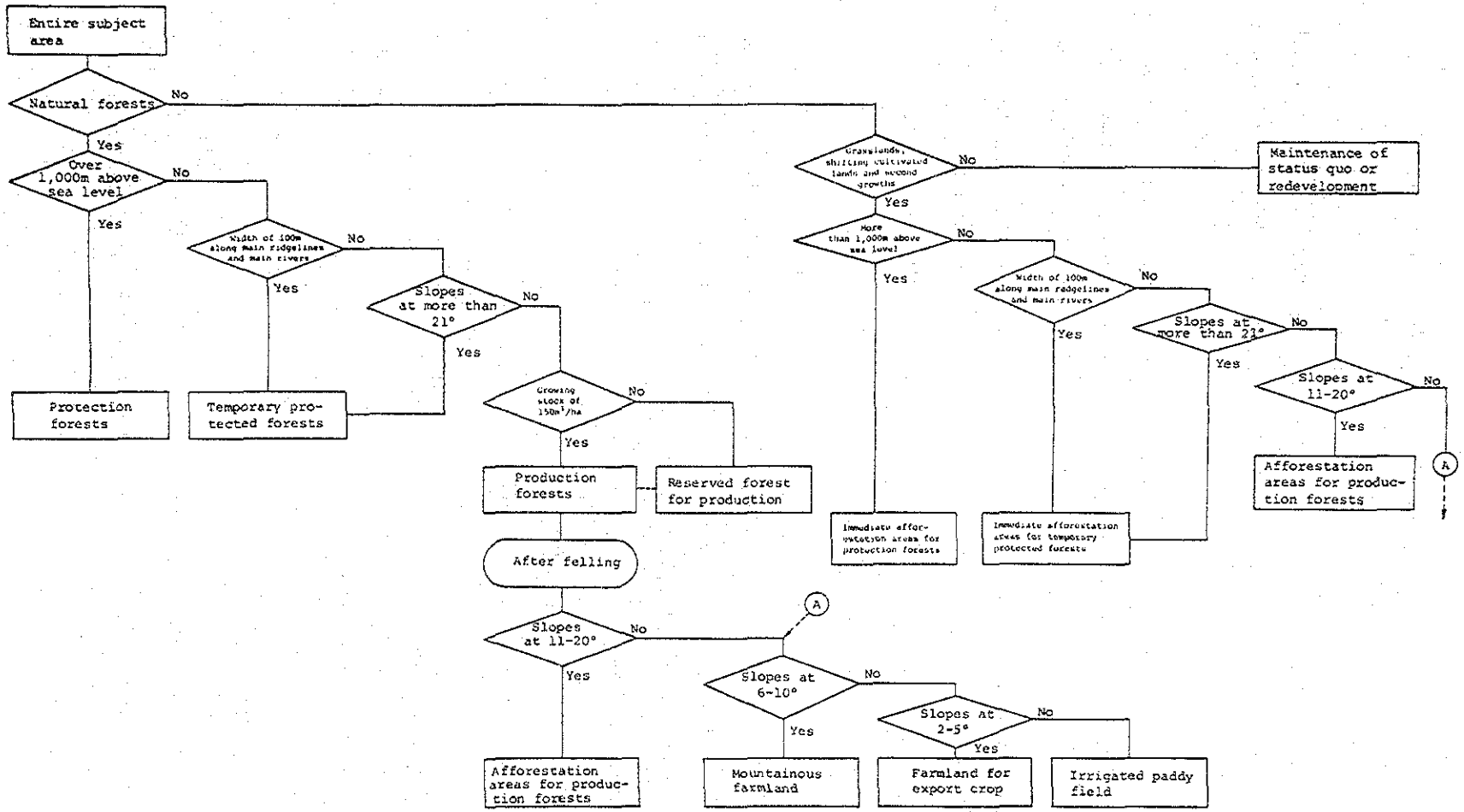


Fig. 4. Flow chart of basic watershed management plan