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SOIL AND LAND POTENTIAL
IN
THE SERIAN DEVELOPMENT AREA

(1st. Division)

by
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(*Soil Surveyor*)

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DEVELOPMENT AREA.

(a report on the semi-detailed Soil Survey of the Serian Development Area, 1st. Division, Sarawak).

by

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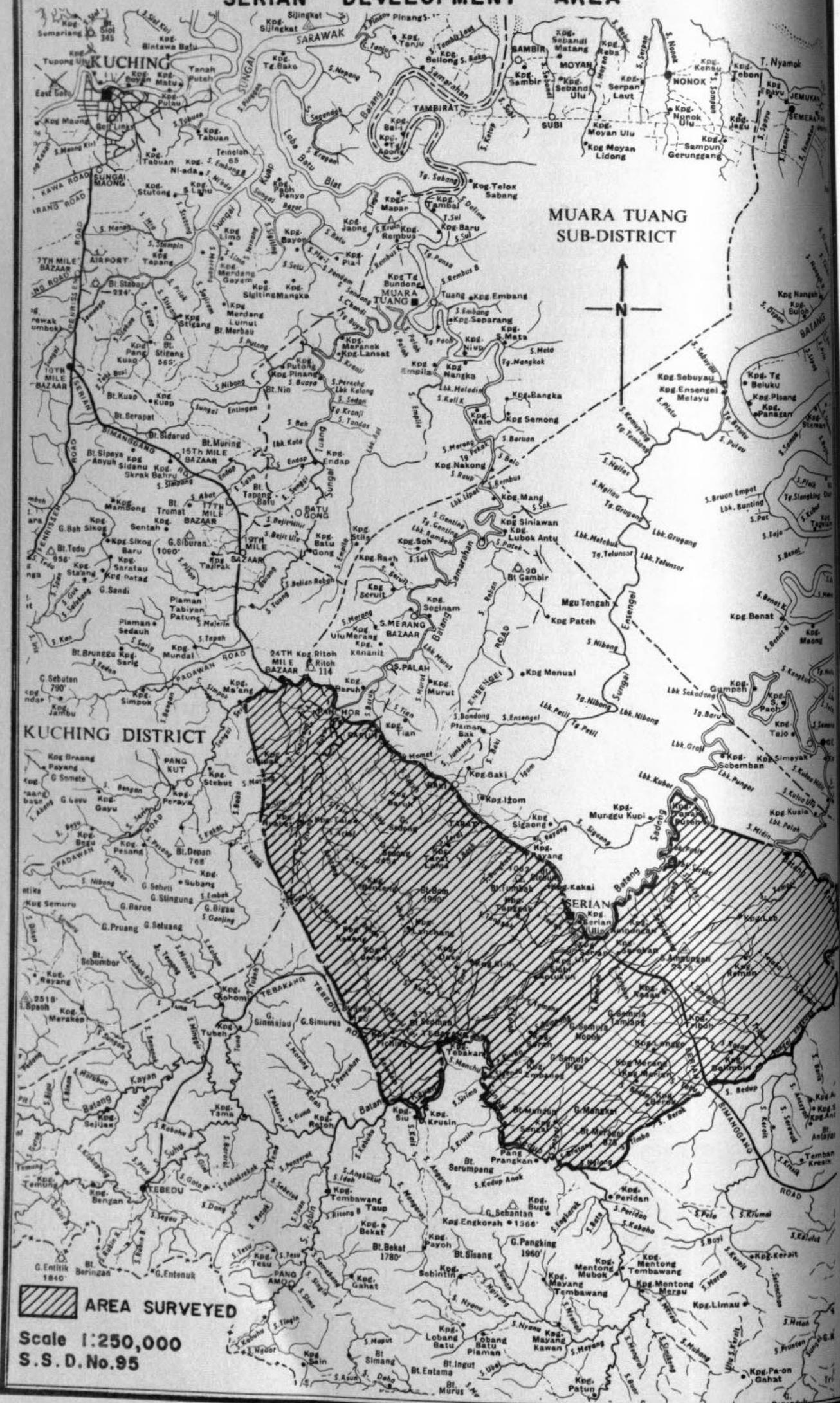
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LOCATION MAP of SERIAN DEVELOPMENT AREA



AREA SURVEYED

Scale 1:250,000
S.S.D.No.95

OUTLINE OF THE REPORT.

The report has been compiled in accordance with recommendations given in the U.S.D.A. Soil Survey Manual (ref. 1) which have been adopted in Sarawak as the basis for soil surveys.

Because of the nature of the survey concerned (semi-detailed) the reporting is of a much more detailed character than that of reconnaissance surveys.

In more developed countries a report on a semi-detailed soil survey should, apart from reporting on soils, contain information on the level of farming in the area, production costs of crops on the various soil types, market facilities, etc., so that correlations between crop yields, cost-price and soil type can be made and suggestions put forward for the better use of the resources available.

Such information in these countries is readily obtainable from a variety of sources and with the use of such material the interpretation of the soil map in the form of, for example, soil suitability maps or crop potentiality maps are greatly enhanced.

The soil surveyor in developing countries has the difficult task of interpreting his soil surveys in terms of practical recommendations without having available such useful information.

Apart from the economic considerations which play a role in the practical applications of a soil survey there is also the human angle to account for because there can be no agricultural development without the farmer.

Although constantly bearing in mind that 'A Soil Survey (or report), which is not basically sound on the scientific side, has little chance of serving the practical users' (quoted from Kellogg ref. 2) the terms and concepts in many instances have been simplified to be able to convey the meaning and background of our studies to the general report user.

This is the reason that in most chapters some form of introduction to the subject has been added, and that much explanatory text occurs in this report.

The report has been divided into 4 sections:

- Section 1 - General introduction
- Section 2 - General description
- Section 3 - Soils
- Section 4 - Practical application of the investigations reported upon.
This last chapter forms in itself the conclusive part of the report.

Appendices include:

- Appendix A - Tables on land category distribution.
- Appendix B - giving analytical data on the soils occurring in the area together with detailed description of typical profiles of soils.

Readers who are mainly interested in the conclusions of the survey need only read section 4 which provides all the required information. Likewise readers interested only in soils can obtain all the necessary information from sections 2 and 3.

SECTION 1.GENERAL INTRODUCTION.a. Historical.

In the second part of 1960 a reconnaissance survey was carried out in the areas along the Serian/Simanggang road as far as 40th mile beyond Serian. The aim of this survey was to indicate areas with potential for agricultural development. The results of this survey were published in Soil Survey Report No. 33 titled 'Report on the Reconnaissance soil survey of the Serian/Simanggang road area (1st Part)'. The areas surrounding the Simuja and Ampungan mountains (between 0-7 mile beyond Serian) were recommended for future development partly because the soil pattern indicated that conditions favourable for agricultural development could best be found in this area and partly because the greatest concentration of population could be found there.

During 1961 the reconnaissance survey along the Simanggang road was followed up with further reconnaissance surveying in the region delimited by a line joining 7th mile Kuching-Serian Road, Serian, the Sadong and Kayan rivers as far as the Indonesian border, along the Indonesian border to the Sarawak Kiri river, along this river to its junction with the Kuching-Bau road and back to 7th mile.

In 1961 and 1962 other parts of the First Division, were surveyed which include the areas along the Kedup river and those between Stumbing and Stunggor in the Bau area.

The results of these surveys were published in the following reports:

- a. Report No. 44 - Progress Report for 1961 of a Reconnaissance Soil Survey 1st Division. (Proposals for Development of the Serian Area.) (ref. 4)
- b. Report No. 27 - Report on a Reconnaissance Soil Survey of the Tebakang-Mongkos Road Area - 1st Division (ref. 5)
- c. Report No. 31 - Report on a Reconnaissance Soil Survey of the Stimbang-Stunggor-Tundong Area - 1st Division (ref. 6).

In the report no. 44 it was indicated that within the area between 25th mile Kuching-Serian road to Serian, along Sadong river to Tebakang, line from Tebakang-Pichin to Nyabeth and back to 25th mile the largest areas of good soils (for Sarawak conditions) could be found. A proposal was therefore made for the development of this area in conjunction with those previously recommended (Simuja-Ampungan Area). The combined areas were then called the Serian Area due to the central position of that town.

The Divisional Development Committee in its meetings in the 2nd part of 1962 decided to put the development of the Serian area on their list of priorities and it was placed second after the Nonok Peninsula. The area was then renamed the Serian Development Area.

For technical reasons it was more practicable to tackle the survey of the Serian area prior to that planned for the Nonok Peninsula.

b. Itinerary.

The soil surveyor was assisted in the field by the following junior staff members:

Rosli bin Sahari
 Michael Chua
 Edward Mansel
 Abdul Rahman
 Chua Geok Chan
 Talib bin Mohammed (part of the period).

The field parties moved into the area in February 1963 but owing to adverse weather conditions the parties had to be withdrawn after a fortnights work. The survey started again at the end of March and was completed by the end of May. It is only due to the excellent way in which the remaining fieldstaff carried out their duties that this large area could be surveyed in such a relatively short time and within the scheduled period allocated to this work.

Certain parts of the area were revisited in early 1964 to check on certain soil boundaries.

During the field period village boundaries in the western part of the area (sheet 1) were mapped schematically following indications obtained from the local population. In total an area of 160 sq. miles was surveyed in a total of 242 man/days spent in the field (counting only staff engaged in surveying).

Methods of surveying.

The fieldwork was carried out on a scale of 1:12,500. Enlarged air photographs originally at scale 1:25,000 (R.A.F. 1947/51) served as base map. The enlarging was carried out by the Lands and Surveys Department whose assistance is gratefully acknowledged.

The air photographs were systematically analysed and interpreted. Using field data acquired during the reconnaissance survey and from the topography and geological information obtained from the 1:125,000 scale geological reconnaissance maps (ref. 7 and 8) preliminary boundaries of probable mapping units could be drawn. The fieldwork consisted of checking the soiltypes in these tentatively delimited areas (mainly landscape units). This involved the cutting of rentises at close intervals in representative places. Fortunately the existence of many footpaths greatly reduced the laborious cutting of rentises in forest.

It was found that the preliminary boundaries of map units needed little alteration, although in places additional ones were necessary while others appeared to be of too little importance to justify final plotting. After the whole area had been checked, soil samples were taken from representative places. An attempt was made to sample 10 pits for each major soil classification unit in order to acquire a statistically sound average in the analytical data. Because of the limited time available this however was impossible for all units.

After the completion of the fieldwork the air photographs were re-examined now using the detailed field information from cut-lines and paths. The final soil boundaries were thereafter transferred from the photographs on to 1:25,000 contoured topo-maps which arrived in the final stage of surveying using the Hilger and Watt's stereosketch.

The Soil and Advisory Land Use Maps.

The accuracy of the map unit boundaries could be greatly increased by using the contours of the topo-map. Only in those areas lying below the 50 feet contour may boundaries be slightly inaccurate. (This is specifically the case in the Triboh, Blimbin, Bedup areas where the accuracy is more of a Reconnaissance nature.) Acreages of soil mapping units in such areas should be used with caution especially in areas where long, narrow valleys exist. There has been a tendency to exaggerate these areas of alluvial soils due to the methods employed for reducing field-maps. Acreages of map areas are also influenced by the type of landscape i.e. in very dissected areas the measured map areas give smaller acreages than actually exist on the ground.

The soil map has been issued in two separate sheets.

- sheet 1: showing the western portion of the surveyed area.
- sheet 2: showing the eastern part.

The Sadong/Kayan river has served as a useful dividing line between the two sheet areas.

The Advisory Land Use Map is based on environmental aspects such as present agriculture, crops which at present are most likely to be grown, topography, flooding and characteristics of soils.

The boundaries of village areas shown on the 1:50,000 topo map were surveyed by the Lands and Surveys Department in so far as they occur in the area covered by sheet 2 of the soil map. The village boundaries in areas covered by sheet 1 of the soil map were schematically drawn following indications received from the local population and they are therefore likely to be less accurate.

SECTION 2.GENERAL DESCRIPTION.a. General Geography

The surveyed area is centred around Serian, its main marketing places, situated at 40th mile Kuching-Simanggang Road.

The area does not form a well defined physiographic unit and a description of boundaries is complicated. The reader is therefore referred to the location map.

The area is at present well served by roads, the Kuching-Serian road forming part of the northern boundary, beyond Serian the road intersects the eastern part of the area. The Tebakang-Serian road forms the present outlet for the people living in the centre of the area; this road is at present not built to all weather standards and in the wet season is difficult to use.

In addition to these two main roads, the Sadong river forms an important link with Serian, for the people living in the southern and the eastern parts, while it serves as an alternative to the Tebakang road for the people living on the west bank of this river.

A new secondary road has been planned starting from the Simanggang road at the new village of Blimbin to Gedong on the Sadong river. This road will open up the Lebor, Triboh and Blimbin areas.

A few small bicycle tracks built mainly by the local population run from Tai-1 through Paya Megok to the Kuching-Serian road, the last part of this road has been constructed by the Government to serve the former Wet Rice experiment station at Paya Megok. Another path is being constructed from Lanchang to the Tebakang road but this is only half completed.

The area is also well served by numerous footpaths which during the dry season are a pleasure to use but which resemble muddy cattle tracks in the wet season.

In the dry season there is hardly any kampong which cannot be reached from a main or secondary road, the exception being perhaps the Meringgu area. In the wet season it is often difficult to travel, especially when carrying market products. In this season it is not only the bad state of the paths which prevents travelling but the frequent flooding of payas (small valleys) which can last as much as one week and cut off a whole area from the nearest marketing place. The Serian-Tebedu road, for example, is frequently flooded along the stretch Kuhas-Pichin at 5 places to a depth of 4 feet. In the western area the Nyabeth, Chupak, and Megok paths are often impassable as floods up to 9 feet deep can occur over considerable distances.

The most important bazaars serving the area are: 25th mile bazaar and a few shophouses at 27th mile for the northern part of the area, 32nd mile bazaar, and Tarat bazaar for the people living along the Serian-Kuching road. Serian, which serves most of the southeastern and eastern portion of the area and Tebakang which caters for southern and south western parts.

Since the construction of the Serian-Tebedu road the Tebakang bazaar has lost part of its trade to Tebedu bazaar and Serian.

At present the major production centres of agricultural produce lie along the Kuching-Serian road, i.e. the mixed zone land. Belian is extracted from Bukit Simuja mainly by Kpg. Rasau people in collaboration with a Chinese business firm in Serian. When the wild fruits are in season the Bukit Ampungan and Simuja areas, and to a lesser extent the Kakeng area, become important suppliers to the Serian and Kuching markets.

b. Climate.

Meteorological data over the area are scanty and comprise mainly rainfall records for two stations; namely Tarat and Tebakang.

Some data on temperature, sunshine hours and humidity are available from Tarat Experiment Station but the period over which records have been kept is too short to allow calculation of reliable average figures.

For these reasons it is only possible to discuss the climate in very general terms.

Tables 1 and 2 give useful indications on the distribution of the rainfall and the total yearly rainfall which can be expected.

It appears that in Tarat and Tebakang the annual rainfall is in the region of 130-140 inches. The months of January and February receive, in general, most rain while the period May - September is comparatively dry. The rainfall in the wet months depends largely on the intensity of the N.W. monsoon which arrives in Sarawak in December-January. Frequently the monsoon rains are too late or too early. In the absence of rainfall figures over long periods it is impossible to assess whether this phenomena is cyclic or not. Wet padi cultivation, which is heavily dependent on the monsoon rains, is adversely affected by the unreliable periods of drought and heavy rainfall.

Although the total rainfall per year or per month over the whole area may not significantly vary, there is evidence that the intensity of rainfall varies locally. During three subsequent years spent in the area it has been noticed that local rainstorms are very common, especially in the months of April - November. These rainstorms bring sometimes excessive amounts of rain in localised areas, after which it may be dry for two or three weeks. It is unfortunate that no complete rainfall statistics of intensity of rain are available over the whole area; because it is thought that crops such as pepper may be affected by such periods of drought followed by heavy rain.

TABLE 1.
MONTHLY RAINFALL AT TARAT.
in inches.

Latitude: 1° 12'N
Longitude: 110° 32'E

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1950	10.73	18.66	19.87	16.54	7.43	8.83	6.50	5.72	11.52	11.80	22.30	16.52	156.42
1951	20.79	8.73	8.43	16.36	12.26	7.03	6.22	4.38	19.71	13.29	12.75	9.79	139.74
1952	19.78	14.09	9.01	18.03	13.53	6.62	7.36	7.53	8.30	8.37	16.07	10.89	139.58
1953	27.39	12.07	10.25	9.66	9.20	5.11	9.15	3.34	7.96	5.62	11.91	8.20	119.86
1954	16.57	17.56	9.91	9.66	5.32	6.10	6.38	8.63	8.46	17.38	14.06	11.65	131.68
1955	27.44	16.28	9.23	10.86	9.11	4.24	3.56	9.34	13.45	3.71	18.99	11.71	137.92
1956	21.58	14.45	14.20	8.85	8.22	6.88	8.82	9.48	10.36	14.84	15.82	14.36	147.86
1957	21.06	16.57	7.59	6.54	10.91	2.98	11.89	8.11	13.21	15.65	8.86	16.50	139.87
8 Years' Mean	20.67	14.80	11.06	12.08	9.50	5.97	7.49	7.07	11.62	11.33	15.09	12.45	139.13

Derived from: "Rainfall Statistics of the British Borneo Territories (Sarawak - Brunei - North Borneo) period 1896 - 1957. Compiled by the Department of Civil Aviation and Meteorological Services, British Borneo Territories. September 1961."

TABLE 2.
MONTHLY RAINFALL AT TEBAKANG
in inches

Latitude: 1° 18'N
Longitude: 110° 30'E

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1950	4.66	11.89	20.71	16.62	9.57	12.35	4.74	6.17	11.69	13.31	14.55	9.51	135.77
1951	13.93	11.41	10.95	13.23	8.73	8.01	5.82	6.08	16.11	12.95	11.99	9.70	128.91
1952	14.66	12.42	8.29	14.05	11.95	6.62	13.75	5.19	8.61	11.12	12.99	9.25	128.90
1953	23.79	13.86	12.56	9.02	10.25	6.88	10.71	2.40	8.51	11.70	12.99	13.64	136.31
1954	15.05	9.94	12.64	12.73	4.35	5.22	8.53	9.31	5.64	17.84	15.74	10.97	127.96
1955	20.61	17.44	7.31	11.51	6.07	3.95	8.13	14.66	20.62	9.80	9.05	10.61	139.76
Year's Mean	15.45	12.83	12.08	12.86	8.49	7.17	8.61	7.30	11.86	12.79	12.55	10.61	132.60

Derived from: "Rainfall Statistics of the British Borneo Territories (Sarawak - Brunei - North Borneo) period 1896 - 1957. Compiled by the Department of Civil Aviation and Meteorological Services, British Borneo Territories. September 1961."

9.

TABLE 3

TARAT METEOROLOGICAL DATA FOR 1963 (excluding rainfall)

Month	Air Temperature of			Sunshine in hours			Humidity %		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
	INSTRUMENT OUT OF ORDER			INSTRUMENT OUT OF ORDER			INSTRUMENT OUT OF ORDER		
January	72.2	78.2	69.0	1	4	0	87.6	95.0	71.1
February	78.8	87.0	74.0	2	8	0	86.7	94.8	65.6
March	81.1	91.1	75.0	6	11	1	82.3	95.2	53.1
April	80.4	90.8	74.8	5	10	0	84.3	94.6	55.8
May	81.4	90.0	76.8	8	11	1	79.0	94.4	47.5
June	81.0	92.4	73.2	7	11	0	77.0	93.8	46.8
July	81.0	91.7	74.3	6	10	0	77.7	93.3	48.4
August	81.9	92.7	74.8	6	10	0	77.4	94.1	41.0
September	79.5	91.2	73.9	4	9	0	81.9	92.1	52.6
October	79.8	90.7	73.8	5	9	1	84.0	94.1	55.4
November	79.3	89.7	73.0	6	10	1	84.9	95.7	54.3
December									

Derived from: Annual report, Tarat Agriculture Station for the year 1962.

The strongly dissected topography and the height of a number of mountains also influence rainfall in that storms frequently discharge most of their rain in the more mountainous areas.

It would be advisable to study the local rainfall in more detail in order that any effect it may have on crop production may become clearer.

The whole area can be regarded as being continuously wet for the whole year. There is no single month in which the rainfall is expected to be below 2.5 inch a year which according to Mohr's rainfall classification for pedological purposes indicates that through-out the year a continuous leaching process characterises soil formation in the area.

Subsoils in the area will be in a moist stage throughout the year, a fact which is mainly responsible for the absence of any structure in most of the soils. Topsoils may dry out in the period April to September depending on soil drainage.

Table 3 has been added to indicate the range of air temperature, sunshine hours and humidity which may characterise the climate in the area. The figures are from only one recording year.

c. Physiography.

The largest part of the area is formed by the basic igneous massifs: namely the Sedong mountain rising approximately 2,400 feet out of the surrounding flat land and the Simuja-Ampungan massif, the highest point also being approximately 2,400 feet high. The flanks of these mountains are steep above an altitude of approximately 150 feet (25° to more than 35°). Below this level lies shale-sandstone country which surrounds the greater part of these mountains. The shale-sandstone country is deeply dissected with slopes ranging from 15° to more than 25° . The tops of the hills are all of approximately the same height suggesting the base level of an old erosion surface. Further evidence of this base level can be found in the occurrence of basalt gravels on watersheds in the Sungei Karoi and Sungei Jenan valleys, near Kakong and Bentang respectively, which occur at the same altitude as the tops of the hills, namely between 120 and 150 feet.

The level of 100-150 feet appears to be significant in that the boundary between soils derived from basalts and soils derived from shales and sandstones can generally be found at this altitude. Colluvial soils from the basalt mountains may in places cover the sedimentary rocks occurring at this altitude and the slopes in such areas are more gentle below the 150 feet contour. In relation to these features it is significant that Wilford (ref. 7) observes that the sea-level in the pre-pleistocene period has been 120-150 feet higher than it is now. Further field observations have shown that the weathering of sedimentary rocks between a height of 50-150 feet is much deeper than in those found below the 50 feet level. Deep white layers commonly occur in soils found between these altitudes

perhaps indicating a more lateritic type of weathering during the erosion surface stage. Subsequent erosion and dissection has removed most of the old deeply weathered material and shallower soils formed on freshly exposed shale and sandstone material can now be found between the 50 feet contour and sea-level. These altitudes are only approximate and they vary; nearer to present sea-level all mentioned altitudes are somewhat lower indicating that the original level of the peneplain was sloping towards the sea. At a height between 20 and 50 feet above sea-level old river terraces near Serian along the Sadong river are evidence of another late pleistocene erosion base level. It is possible that these terraces are beach terraces built up when the sea level was higher than it is now.

Numerous small terraces in the eastern part of the area in minor valleys suggest that deposition of quartzitic material at this time has been widespread. In the western and northern part of the area this material may have been totally removed except for a small part found near Bukit Mas. In recent times the vertical erosion of the larger rivers seems to have slowed down considerably and deposition of fresh alluvial material is taking place at a level between 50 feet in the upper river stretches and almost at sea-level lower down the rivers. Lowland acid peats have gradually filled up basins existing between major river courses, whereas clay alluvium has been deposited along the river banks, specifically so in the eastern part of the area. Remnants of old peat deposits found at depths of 4 to 5 feet in the Megok payas suggest that coastal swamps existed there in former times.

In a subsequent phase of deposition these basins have been filled in by approximately 5 feet of young alluvium. A remarkable feature of the basic igneous massifs is their generally shallow soil cover. The climatic conditions now prevailing in Sarawak would suggest very deep weathering of such rocks, as in other tropical countries with an identical climate. The soil-eroding agents must be or have been very active on these massifs during the Quaternary.

It is also remarkable to find that very little alluvial material from these mountains can be found in the area itself. Some minor occurrences can be found in valleys around the mountains such as S. Kuhas, Bentang, Kakai and Tarat.

Recent colluvial material has mostly accumulated at the lower slopes of the mountains but the soil cover is generally very thin. It is suggested that most of the eroded material being mainly clayey in nature has been carried much further away and has possibly contributed much to the building up of the coastal plain of the Nonok peninsula. Mineralogical investigation may throw more light on this aspect.

Other conspicuous landscape features are the steep limestone mountains protruding from the surrounding country in the west. They form the boundary between sedimentary rocks of Cretaceous and Upper Triassic age. The nature of the hard almost pure limestone, which prevented deep horizontal weathering and subsequent lowering, has been mainly responsible for their present form.

d. Geology

Most of the information in this section has been extracted from Geological Memoirs no. 1 and 3, respectively on the 'Geology and Mineral Resources of the Strap and Sadong Valleys', by N.S. Haile (ref. 8) and on the 'Geology and mineral resources of the Kuching, Lundu Area and Bau mining District', by G.E. Wilford. (Ref. 7).

Additional information was obtained by discussion with the geologists G.E. Wilford and A.C. Pimm.

The geology of the area is very varied and complex. Almost all rock types occurring in Sarawak are represented in the area.

(i) The Volcanic rock types

The largest part of the area is formed by altered basic volcanic rocks, probably of pre-Upper Triassic Age. They form the two massifs of the Sedong and Simujan-Ampungan mountains and a number of parallel ridges along the Kuhas and Karoi valleys, such as Bkt. Suka, Kedadum and Bukit Sedihan. Smaller outcrops occur in the south of the area near the Kedup river. The Igneous rock types are varied and include lavas, tuffs (near Bukit Suka), agglomerates and volcanic breccias. Most of the lavas are augite andesites and basalts; most have been intensively altered and replaced being chloritised, prehnitised, silicified, zeolitised, serpentinitised and calcitized. (ref. 8 page 69.)

The chemical composition of these rocks is varied which results in many small differences in the mineralogical composition of the soils weathered from them.

The tuffs are probably highly siliceous because the soils derived from them do not differ greatly from those developed from e.g. siliceous shales. The percentage of sesquioxides in the former is in the range 16-20% (samples S1911-1914), while on the sedimentary rock types this percentage varies from 5-25%. In soils from basic rock types it can be as much as 40%.

(ii) The Sedimentary rocks.

Most of the sedimentary rocks found in the area are of Upper-Triassic age and belong to the so-called Sadong Formation. They comprise sandy shales, siltstones, polymict sandstone and conglomerate while in certain areas tuffaceous shales occur. In the surveyed area sandy shales are probably the dominant sedimentary rock. In the northern part of the area between Tarat and 25th mile and also in the Ampungan area arkose appears to be the dominant rock type and gives rise to distinctive soil types. The shales are in places highly carbonaceous and micaceous, while the sandstones and conglomerates are composed of fragments of quartz, chert or hornstone, feld-spar (usually albite, microcline and other alkali varieties) and rare fragments of volcanic rock.

Most shales and sandstones are highly siliceous because the percentage of total sesquioxides in the soils are all below 25%. In the Lebor and Triboh/Blimbin areas schist occurs as dykes in the Triassic Sediments.

A small part of the area, mainly in the west and north-west, consists of sedimentary rocks of Cretaceous age, mainly limestone in places interbedded with sandstone (G. Kedadam).

Rocks of Tertiary age have not been recorded in the area.

(iii) Pleistocene deposits can be found at the foot of some of the limestone hills (e.g. Bukit Mas) and near Serian. It is thought that these deposits were originally more widespread before erosion caused their dissection and removal (see also page 10 in section on Physiography).

Other Quaternary deposits comprise recent alluvium which can be found in almost all small valleys and alongside the larger rivers. Recent alluvium is most extensive in the Tai-i, Chupak and Megok areas in the North where it is underlain by limestone of Cretaceous age. The alluvium in the whole area is mineralogically and chemically varied because of the mixed nature of the parent rocks.

Geological boundaries were found to be significant for soil surveying in the area because they commonly coincide with boundaries between major soil groups. In detailed work, especially on the sedimentary rock types, they are of less value due to the lithological complexity of the weathered rock material. The various soil types have differences due as much to local drainage and topography, as to parent material.

Mineral resources found in the area to the present time are of low commercial value except for the small amount of guano which the local population extracts yearly from some caves in the limestone hills.

e. Drainage.

The largest portion of the surveyed area forms part of the Sadong river catchment area; only the northern part of the area (approximately north of a line from 32nd mile to Kampong Kakeng) forms part of the Samarahan river basin.

Streams of secondary importance in the Sadong basin are the Kedup river draining the most southern part of Bukit Simuja, the Bedup and the Engkuan draining the south eastern part of the Simuja-Ampungan massive while the Karoi, Kuhas and Tanggak streams drain the south and west of the Sedong massif. Secondary streams in the Samarahan basin are the Sira, Bentang and Risong draining the northern and north western parts of the Sedong massive. At the confluence of these three streams the river is called the Bukar.

Flooding occurs in the wet season near the confluence of most secondary streams with the major rivers. While the capacity of most streams during the dry season is adequate most courses are too small in times of high rainfall to cope with the tremendous amount of surplus rainwater in a reasonably short time. Such periods of high rainfall occur particularly in the wet season and extend in general over wide areas, while the storms during the dry period are more of a local phenomenon. In the wet season therefore all streams in one river basin reach floodlevel at about the same time and smaller tributaries are unable to discharge their rainwater into the fully charged major streams.

It would be impracticable to store rainwater in reservoirs in the valleys so that the waterlevel in the main rivers may be kept at a lower level during such rainy periods. The great number of small streams involved would cause such a scheme to be too expensive in relation to the comparatively small acreage of land which could be saved from flooding downstreams.

Other alternatives of flood prevention include the clearing of rivers of debris. This has recently been done for part of the Kedup river. Such measures however are only of temporary value and mainly of local importance because any measure to stop flooding in the upper parts of the rivers, aiming at a more rapid discharge of the water would have an adverse affect on the flood situation lower down river.

It is suggested that one of the major causes of the floodings is the removal of primary forest in most of the area. Rainwater discharged to the streams as surface run-off water must have increased tremendously after the removal of this forest. This may be one of the reasons why the present river courses are too small to cope with this amount of water and that floods are said to be becoming more severe.

Irrigation, although feasible in a number of valleys, is seriously hampered by the fact that the possibilities for storing water are very limited and the impossibility of keeping floodwater within bounds. Only in areas which at present are not liable to flooding offer prospects for land improvement by irrigation and drainage. (e.g. Paya Bentang, Paya Jenang and perhaps alongside the Kuhas river.)

The streams derived from the basic igneous massifs carry water the whole year round probably because the soils and rocks may be sufficiently pervious for storing water. The streams in the shale country are in general dry during the dry season, mainly because the soils and rocks are so impermeable that most of the rainwater is lost by surface run-off. Sources for piped water supplies are therefore only to be found in the Sedong, Ampungan and Simuja mountains. The local population centred around these mountains enjoy the presence of small springs which are tapped by bamboo pipes and brought down to the kampong (panchur system). In a number of places and also outside the survey area (e.g. Prangkan) streams have been tapped by an ingeniously constructed three way bamboo pipe system.

A number of underground streams occur in the limestone hills which could be used for domestic purposes were they not generally found in inaccessible areas too remote from the kampongs. Areas that might be usefully investigated however are the limestone mountains in the vicinity of Kpgs. Nyabet, Chupak and Bentang.

f. Population.

The Dayak population in the area is approximately 8,000. (ref. 9).

A factor of interest is that the number of persons forming a bilek family in these Land Dayak areas is generally greater than in the Iban areas. An average of 6 to 8 people per bilek would be a more reasonable figure than the figure of 4 often used for Iban longhouses. In 'Iban Agriculture' (ref. 10) Freeman uses a factor of 6 bilek families per sq. mile as an average figure to sustain reasonable soil fertility for pioneer areas, whereas a population of 8 families per sq. miles would in general induce soil deterioration because of overfarming.

Perhaps this figure should be less in part of the area under review because of the larger bilek families. In certain kampongs the difference is off-set by the presence of superior soils, especially wet padi soils, so that the amount of land per bilek family which is necessary for obtaining their daily food is less than one would expect. It would therefore be advisable to study these aspects kampong per kampong rather than taking an average figure for the whole area. The tables in Appendix A would perhaps be useful for such purposes.

The native population in the area is mainly Land Dayak. In the eastern part (Lebor-Ramun area) people belong to the Melikins. The Land Dayaks in the north western part of the area belong to the Bukar tribe whereas the remainder of the area, by far the greater part, is populated by Land Dayaks of the Kayan tribe. The difference in language between the Bukar and Kayan people is mainly a matter of dialect.

Most people in the area seem to have spread from a number of mother kampongs such as Lanchan, Ri-i, Taub (outside the area on the Robin river) and Gahat (near Taub). There are still certain relationships in common in local adat forms between the mother kampongs and their derivative kampongs. Large kampongs such as Pichin have become secondary mother kampongs from which new kampongs have sprouted. Recent separations of kampongs have given rise to protracted battles over soil rights such as between Tebakang, Pichin and Krusin. It appears that the boundaries of the old mother kampong areas were fixed whereas the separation of the new kampongs from secondary mother kampongs within the original area of the old mother kampong meant in fact a cutting up of this area.

The majority of the Land Dayaks are still pagan, although a number of kampongs have been converted either to Anglicans (e.g. Tai-i, part of Lanchan and Bentang) or to Roman Catholics (among others, parts of Kakai, Sorah-Koran, and Krusin). The Seventh Day Adventist Mission has been active mainly along the Kuching road and in Lanchang. In most pagan Dayak villages there are some converted families or young people who have received their education at Mission schools. They live as Christians among other pagan relatives in the same bilek.

It is of interest that in the Christian kampongs the economic situation appears to be much better than in the pagan kampongs. In the cases where a part of a kampong has been converted only, followed by separation of the two, the opposite is often true because these people have had to make a completely new start.

The influence of Christianity on land use has proved beneficial in that it means the end of the observation of 'pantangs' (prohabitive regulations) related to land-use and crops; in the new converted kampongs rubber and pepper gardens are prolific. The response to the advice given by the Extension Branch of this Department has been most rewarding in such kampongs.

The Chinese although forming a minor part of the total population are at present the most important in business and commercial spheres. They are concentrated in the mixed zone land along the Serian-Kuching road and in places along the Serian-Tebakang road. In a number of villages the local shopkeeper is also a Chinese. Chinese owned land is generally well developed the most use having been made of its potential. The achievements of both Christian Dayak kampongs and Chinese settlers prove that the potential of the land if fully realized is adequate for raising the standard of living of the rural population in the area.

g. Present Land Use and Agriculture.

Most of the natural forest cover has been removed in the area except for that found on limestone hills and a few scattered areas on the Sedong, Ampungan and Simuja mountains. These areas are all either too steep or the soils too bouldery and shallow to allow any form of agriculture. The largest single blocks of primary vegetation found on land suitable for agriculture are Sungei Kamang and Munggu Babi, forest reserves (Panchur-Tai-i area).

Most of the area is used for shifting cultivation or bush-fallow cultivation. Only a small part (the mixed zone strip along the Serian-Kuching road area) is intensively developed for agriculture. During the last few years some patches of land in the Dayak owned areas have been more intensively developed, mainly through the activities of the Extension Branch of the Department of Agriculture and the Rubber Planting Scheme.

In the following section shifting cultivation is first discussed followed by an account of other agricultural activities, mainly that concerned with cash crops.

(1) Rice Cultivation.

The staple diet of the Land Dayaks consists of rice grown by both hill and swamp cultivation. Yearly part of the natural vegetation, mainly secondary, owned by the individual bileks is cut down, left to dry and burned, afterwhich the land is planted with hill rice using the planting stick.

On the best land or that situated nearest to the kampong, maize and cucumbers with other vegetables are interplanted with the rice: tapioca and sugarcane are also included maturing after the rice has been harvested. The land is therefore used for 1½ or at the most two years after which it is left fallow. It soon becomes covered with weeds, lallang and other secondary growth. Regardless of soil type the secondary vegetation is generally poor indicating that the soils have been used for shifting cultivation for a considerable time. The presence of lallang, weeds and ferns over large areas is reason that most of this land is not used any more for hill rice growing. It is still an open question whether it is actual soil fertility or the problem of the eradication of weeds which necessitates the population to abandon such areas. Soil analyses reveal that there is little actual difference in available food supply between soils under good secondary forest and those infested with weeds. Most probably it is mainly the ash from the burned vegetation which acts as the main source of plant food for one rice crop. A further factor may be the deterioration of the structure and the low biological activity in soils covered with weeds. (ref. 11).

The main factors limiting yields of hill padi are: available nutrient supply (perhaps directly related to the burning), management, rainfall, pests and diseases.

The low lying areas are largely in use for wet padi cultivation which has been introduced comparatively recently. Limitations in the use of low lands for wet padi growing are:

- a. the availability of water
- b. the risk of flooding
- c. the soil type. Deep peats (more than 3 feet deep) are not generally suitable.

The rotation of wet padi land is in general much shorter than that of hill padi land. There are several reasons for this, the principal one being the greater fertility of wet land. It is probable that the alternate reduction and oxidation of iron in the padi soils caused by seasonal water table fluctuation could make available Iron or Aluminium bound phosphate while (oxidation) of NO_3 giving ammonia appears to be a great contributing factor to the fertility of wet padi land. The rotation period differs from 1 to 3 or 4 years in most areas. Only the most fertile soils are used every year.

Several areas of wet padi are destroyed each year by flooding, but the population continues to take the risk of using these areas since they know that good yields can be obtained if the floods are not too great.

The cultivation of wet padi fields entails the cutting down of grasses and padi stubble of the previous year and leaving the cut material to dry until it is ready to burn off. The padi is sown in much the same way as is done with hill padi. 'Bibit' planting (rice seedlings from nursery) is rarely practised. In recent studies with West African soils, endorsed in Japan, (ref. 12, 13) it has been shown that the addition of freshly cut vegetative matter to the padi soils appears to be more beneficial to the padi plant than the burning of the litter.

Aqueous solutions of vegetative matter seem to have a great impact on the reduction potential of the iron compounds and may make available more plant nutrients otherwise fixed as insoluble compounds. (Phosphate fixed as aluminium and iron compounds).

Other factors affecting rice yields in the padi fields are: bad management, incorrect soil preparation, lack of water control (proper irrigation and subsequent drying off of padi fields), pests and diseases. It appears that these combined factors at present play a more important role in yields than the soil fertility factor.

It can be concluded that most of the surveyed land if suitable for shifting cultivation by Dayak standards, is or has been used for such purposes. Yields are generally low, due largely to factors such as rainfall, diseases and pests and available plant nutrients which are generally in short supply.

(ii) Rubber.

Rubber is by far the most important perennial cashcrop in the area. There is very little old rubber compared with other areas in Sarawak (e.g. Iban areas). A considerable acreage of old rubber was cut down in the first half of this century owing to the influence of some Dayak priests who blamed the planting of rubber on padi soils for the decrease experienced in rice yields. The absence of old rubber is most evident in the areas occupied by the Kayan tribe of the Bukar-Sadong Land Dayaks, and this is the main factor for the often appalling economic conditions in these kampongs (ref. 14). Since the initiation of the Rubber Planting Scheme a considerable acreage of land has been planted with clonal stumps or seedlings, the first areas now being ready for tapping. Kampongs who some years ago resisted the planting of rubber (e.g. Koran) now appear to have given in and there now remain few Kampongs in this area which have not taken part in Rubber Planting Scheme planting.

Apart from the old rubber and R.P.S. rubber approximately 2,000 acres have been planted with seedling rubber but most of it is young. Rubber grows on most hill soils found in this area, and it seems to be more a matter of management and fertilizers whether rubber grows well or not. Even the best soils carry bad stands of rubber if the management has been poor.

Until now the people have used mostly inferior soil types for planting rubber, soil which was of little further use for hill rice, i.e. land infested with weeds and degenerated soils. This is linked directly with the distance from kampong sites since soils near the village are mainly those that have been used for hill rice for a number of generations.

The land far away from the village is commonly of a better quality for rubber but the people are generally reluctant to use them for rubber because they are now considered to be the best hill rice areas.

In conclusion it can be said that since rubber has become the major perennial cash crop the economic situation of most kampongs will show considerable improvement as the trees become ready for tapping, provided the present world market prices for the crop are maintained.

(iii) Pepper

Pepper is mainly cultivated by the Chinese farmers along the Serian-Kuching road and the Serian-Tebakang road. In most kampongs the majority of bileks grow a small amount of pepper, generally not more than 50 to 100 vines per farmer. In a few kampongs such as Tarat and Baru the majority of families possess more than 100 vines. The quality of the pepper among the Dayaks is very poor, due mainly to the lack of fertilizers and proper management. There is certainly a growing interest for pepper cultivation among the Dayak farmers, especially among those living in close contact with the Chinese growers.

In many instances lack of capital to buy fertilizer is the reason why pepper cultivation among the Dayaks in the area has consisted of a trial often followed by failure. In the Dayak areas however soils can be found superior to those normally farmed by the Chinese for pepper cultivation. If this potential could be better explored and the Dayaks be given the means to make these soils more productive, pepper cultivation in the area could undoubtedly become of great economic importance.

(iv) Minor crops.

Minor crops grown in the area are described below. Coconut is mainly distributed through the Coconut Planting Scheme for small plots situated around kampongs.

Coffee, primarily grown for home consumption is grown in the Lanchang area. The trees look healthy and are planted on alluvial soil of good quality. In this area there is some scope for the development of this crop.

Cacao as far as known is only planted at Tarat Experiment Station.

Citrus fruits are cultivated by some Chinese and Dayak farmers. The amount harvested is small and mainly for home consumption. This crop could become of more importance if the potential of certain alluvial soils were fully realized.

Most kampongs have wild fruits such as rambutan, langsat and durian. They occur extensively in areas where soils derived from basic igneous rock types can be found. The alluvium derived from such rock types appears to form an excellent medium for the growing of such crops.

(v) Vegetables.

Vegetable gardening is only of commercial importance in the mixed zone area along the Kuching road. The Chinese farmers make liberal use of nightsoil and other organic refuse, so much so that the original soil fertility has little to do with crop response. In the Land Dayak kampongs it is only those visited by extension teams of the Department of Agriculture that have actively undertaken vegetable gardening, largely for home consumption.

Most of the land is therefore put to some use and apart from those areas where unfavourable topography and soil conditions prevent any form of agriculture, no unused land is available.

The bulk of the available land is extensively used for shifting cultivation. If the soil potential could be fully exploited by introducing new crops, by planting the crops on the right soil, by the adoption of better management, and by capital investment to help the local farmers to get on their way, then sufficient land could be made available for a much larger population than the land carries at present.

SECTION 3SOILSa. NOTE

Soils are classified into series, each of which has a defined range of characteristics. The series are themselves classified into larger groupings, such as the 'soil groups', on the grounds of common features (particularly those connected with their form of development). At the level of the soil group one can easily compare soils which are widely separated in location. Soil is very varied in its properties and such a grouping is an essential preliminary if one wishes to make general statements of wide application.

The series is the basic division of any soil classification system and, if the field work is sufficiently detailed and the mapping scale sufficiently large, can be used on the soil map as the basic mapping unit. At a reconnaissance and semi-detailed level of survey, this is rarely possible. Few series boundaries are established and those which are can be portrayed on the map in only exceptional cases as each series usually occupies only a very small area before grading into another. On a semi-detailed soil map, such as that appended to this report, it is thus necessary to group a number of series together in one mapping unit. Topographic features are often used but sometimes proximity is the only common feature of these series and they may occupy very different positions in the classification system. Each mapping unit, which is called an association or complex, has to be defined as it occurs.

The mapping unit is merely a convenient cartographic symbol which locates on the map a community of more or less varied soils which are discussed in the text accompanying that map. Classification units refer to the genetic classification system into which the soils of the whole country are divided.

b. CLASSIFICATION UNITSThe soil series

The basic unit used for classification and mapping on this survey has been the soil series. A soil series is a collection of soil individuals essentially uniform in differentiating characteristics and in arrangement of horizons; or, if genetic horizons are thin or absent, a collection of soil individuals that within depth limits, are uniform in all soil properties diagnostic for a series (def. 7th approximation U.S.A. Soil Classification. (ref. 15)). In this definition chemical and morphological differences in so far they are of genetic origin and sufficiently well expressed in the soil profile are used for differentiating between soil series.

Relatively small chemical differences, such as the kind and quantity of plant nutrients in the exchange complex, appear to be of less importance because, with fertilizing, these differences can quickly be eliminated.

In Sarawak, soils have generally a very low base-status and small chemical differences appear to be of importance, especially as proper fertilization is in general impractical or economically impossible. The natural base-status of the soil is therefore often of primary importance for the soil user. If the American definition is fully adopted in Sarawak, many soils would be mapped and classified as one series, while the soil user would quickly find that soils within such a series will behave differently under such agricultural management as at present is practised in Sarawak. It has been noticed that soils within the series (U.S.A. def.) may be relatively rich in exchangeable calcium or totally lacking it because in the one case the soil was derived from calcareous sandstone while in the other it was formed from quartzitic sandstones. Morphologically and genetically however both soils are the same. The same can happen with potassium. Certain shales are rich in orthoclase, while others have no potassium - bearing minerals at all. Upon weathering, soils developed on these rocks appear to be the same, except for the total potassium content. If we want to follow the original intention of the definition of the soil series, which is to group soils together which are genetically identical and which should behave in the same manner under agricultural management, then we have to consider these - maybe for other countries small-differences, in our classification system.

It is for this reason that we prefer to give such a soil a tentative individual series name until it has been proved through crop experiments or practical experience by farming such soils, that the observed chemical differences are of sufficient importance for maintaining this separation. Such tentative series names are shown in inverted comma's such as 'Kayan' series.

The Soil family.

The soil family is a group of soil units (for this survey these are mainly series units) having certain properties in common which are regarded as important for the growth of plants.

The grouping of soils in families is done at a level between Great Soil Groups and soil series but the diagnostic properties of families are not fixed and those for the various Great Soil Groups are not consistent.

Depth of oxidation is, for instance, in a Hydromorphic soil important for plant growth whereas for the Group of Red-Yellow Podsolics internal drainage and depth of profile appears to be important features.

With one exception families, however, have not been mapped and they have only been added to table 4 to show relationships between soils.

Drainage phases of series.

Differences in topography and dip of bedding planes in the sedimentary rocks have caused a very complex internal drainage system in soils which should normally form one series. These differences in internal drainage are classified as drainage phases of the series. Certain drainage phases have been mapped separately because they occur extensively, others occur in a complex pattern within the series and are included in the mapped series.

Eroded phases of series.

For certain series eroded phases have been mapped. The only difference from the modal series is the soil depth to bedrock. Eroded phases do occur frequently in most residual series but they have only been mapped in areas where the eroded phase forms a large portion of the series thereby considerably limiting the agricultural value of the series.

The Soil Complex

The Complex is a mapping unit. In places where two or more series occur in such a complex pattern that even with detailed mapping methods no separation will be possible, the series are mapped as a soil complex. The name of the complex is derived from the names of the series forming the complex by coupling these with a hyphen e.g. Kakai-Bentang complex.

Simple Soil Associations.

Simple Soil Associations are also mapping units, formed by two or more series which could be separated if more detailed mapping is carried out. Often series are concerned which are found on different parent materials or which occur in different landscape units. Parent material and landscape units can occur, however, in so complex a pattern that with the semi-detailed methods employed either separation is impossible, or the small areas of the separate series cannot be shown on the map scale used.

The principles of classification suggested here and in the following paragraphs have been only used for the compilation of this report. Their use here does not imply that they will be adopted in the present form for a formal final classification of Sarawak Soils.

c. GENESIS OF SOILS.

(1) Introduction

An attempt was made to place the recognised and mapped soil types in the new classification system of the U.S.A. (7th Approximation) which has been proposed by the U.S.A. to serve as a basis for international classification of soils. (ref. 15).

It was only possible to place a few series with some certainty in this system. There are various reasons why the adoption of this system in Sarawak is at present beyond our means. This is firstly caused by the nature of the system itself. In it, totally different criteria are used to differentiate between soils from those which have so far been used in soil mapping in Sarawak. This new system is heavily dependent on detailed analytical data from the soils data which for the greater part is still lacking for Sarawak soils. Secondly, the system is based on morphological characteristics which are not always of genetic origin, hence agricultural activity (man) plays a considerable role in this system. This might be a very practical solution for classifying soils in intensively developed areas which are accessible and in which a great number of points can be used for drawing boundaries. In Sarawak, where many areas are inaccessible and observation difficult, the genetical soil-forming processes are the only possible basis on which to map soils because these processes are linked with parent material, topography, drainage etc., factors which we can distinguish in the field or on aerial photographs. Although one could say that this form of mapping is more a mapping of soil-forming processes than of soils it still remains to be seen whether any other system is feasible in areas such as Sarawak. Thirdly, the 7th Approximation is still not sufficiently developed to become useful for classifying tropical soils. Many of the soils in the area could be placed in several orders of this system while others cannot be placed at all because of the rigid limits of the characteristics used for differentiation in the system.

A more practical way of classifying our soils is to use the old U.S.A. system namely the classification into World Great Soil Groups which is based more on genetic considerations.

The genetic relationships between the recognised soils types have been schematically outlined in table 4 in which the Great Soil Groups have been used for a classification at the highest level.

(ii) Discussion of soils according to their genetic characteristics.

For the discussion the reader is constantly referred to table 4.

Skeletal Soils -

The only family in this Great Soil Group is the Sedong family which is characterised by a juvenile profile with little or no profile development, overlying a weathering Basic Igneous rocks. Colours range from strong brown to yellowish brown. The soil depth ranges from 0 - 2 feet: Texture is loamy with often a considerable amount of fresh rock pieces of gravel size which have been mixed with the soil down slope by erosion and colluvial wash. The soil often rests on hard bedrock, indicating a former removal of all soil material by erosion. The soils always occur on steep slopes.

TABLE 4

SUGGESTED GENETIC RELATIONSHIPS BETWEEN SOIL TYPES

World Great Soil Groups	Soil families	Soil series	Recognised phases of series
SKELETAL SOILS	Sedong family characteristics: juvenile shallow soils on basic igneous rocks	Sedong series ^x (modal series)	
REDDISH-BROWN LATERITIC SOILS	Tarat family characteristics: well developed moderately deep soils on basic igneous rocks	{ Tarat series { Antayan series ^x	red coloured and well structured yellow coloured and blocky structured
RED-YELLOW PODSOLIC SOILS and intergrades	Nyalau family (reddish coloured B-horizon well developed textural B)	{ Bayur series { Serin series { 'Ri-' series { Tabokang series { 'Suko' series	on schist on arkose of Triassic age on Triassic shales on Triassic sandstones on acid volcanic tuffs
	Semongok family (showing pseudo gleying, transitional to LOW HUMIC Gley)	Bedup series	'body drained phase' showing affinities with LOW HUMIC GLEY soils
	Malang family (yellow coloured B-horizon, well developed textural B)	{ 'Koran' series ^x { Mas series	on Triassic sandstones on coarse Cretaceous sandstones (quartzitic)
PODSOLIC SOILS and INTERGRADES (weakly developed)	Kerait family (white clays, without Humus B)	Kerait series (modal series)	on Triassic carbonaceous shales
	Triboh family (with textural B, hydromorphic, transitional to LOW HUMIC GLEYS)	Triboh series (modal series)	on poor terrace materials
	Semilajau family (weakly developed A2, juvenile, transitional to RECENT ALLUVIAL SOILS)	'Chupak' series (modal series)	on poor sandy terrace material
TROPICAL PODSOLS (PARA PODSOLS) and PODSOLIC SOILS (strongly developed)	Buso family (sands to clays with weak to strong developed Humus B)		phase 1: Humus B. very weakly developed ^x phase 2: Humus B. well developed but soft ^x phase 3: Humus B. strongly developed and cemented ^x
LOW HUMIC GLEY SOILS (Grey hydromorphic soils)	Byat family (on juvenile riverine alluvium)	{ 'Stabi' series { 'Simuja' series	sandy textured } P.M. mixed origin clay textured
	Samarahan family (on mixed riverine and colluvial material)	{ Kakai series { Paya Megok series { Samarahan series (modal series)	with soft and small Mn concretions, gritty subsoils, rich in bases. P.M. Basic igneous rocks. with peaty subsoils, floored by limestone. Mixed parent materials parent materials mainly sandstone and shale
	Plan family (on sandy quartzitic riverine alluvium)	Mundai series (sand over clays)	pale coloured, poor in bases parent material mainly quartzitic sandstones
Semi-hydromorphic soils showing features both of GROUND-WATER LATERITES and recent alluvial soils	Malang family (weak profile development reddish mottled)	{ Bentang series { Malang series	derived mainly from basic igneous rocks, rich in Mn and Fe. mixed parent materials
RECENT ALLUVIAL SOILS	Undup family (No profile development, levee soils, yellow coloured)	'Kayan' series	sandy textured, mixed parent materials
	Terbat family (Brown to red coloured, showing affinities with REDDISH-BROWN LATERITIC SOILS)	{ Terbat series { Ramun series	basic igneous rock derived, rich in bases and Fe. (well structured) gravelly and bouldery, basic igneous rock derived. (affinities with Sedong series)
Tropical mull	Kedadum family (humus deposits, dry)	Kedadum series ^x	on limestone, thin organic layers with sandparticles
Tropical Bog soils	Anderson family (lowland freshwater peat soils)	Anderson series	coarse, partly decomposed woody peats
			depthphases 1. 3-6 feet deep 2. 6-10 feet deep 3. more than 10 feet deep

Note: ^xNot mapped as individual units. Definitions are tentative. 'Stabi' - inverted coma's indicate tentative names.

Even this juvenile soil shows base-depletion which indicates that leaching in the early stages of profile development is considerable and is governing the soil forming process in subsequent stages.

Reddish-Brown Lateritic Soils

The name suggest that a laterization process has been largely responsible for its development. The name is misleading because the soils show in their analytical data certain podsollic features while the morphological characteristics suggest laterization. This name has been adopted because it has been used for soils in North America which show identical features in their morphology as well as in the chemical data. (Ref. 16) They must be regarded as intermediate between Red-Yellow Podsolics and Latosols. In the U.S.A. as well as in Sarawak the basic nature of the parent material has been largely responsible for the development of these soils.

Colours of the soils in the surveyed area are yellow and yellowish red. The yellow soils generally have a more blocky structure (Antayan series) than the red-coloured soils which are crumbly and friable. Acidity is high, and S. and T, values are very low. No eluviation of clay has been noticed. The amount of weatherable minerals is low to nil.

The silica/sesquioxides ratio's of the clay fraction show removal of sesquioxides from the upper horizons and an accumulation in the B. horizon. There are however no visible signs in the profiles. Structure of the Tarat series is very stable; the soils are self-mulching. It is suggested that the yellow blocky, Antayan series have developed under more wet conditions than existing in the Tarat series.

stable crumb surface.

Red-Yellow Podsollic Soils.

The great majority of the residual soils belong to the Red-Yellow Podsollic group. They are all characterised by podsollic features such as a textural B. Horizon, removal of sesquioxides from the top layers and accumulation of these in the B. Horizon. The podsollic features are however more expressed in one series than in another. They all show very low S. and T, values, and high acidity. Depletion of bases is one of the most typical features. The textural B. horizon is most expressed in the sandy soils derived from sandstones (Matang family), the removal of sesquioxides most visible in the Nyalau family (mainly shale-derived and richer in iron than the Matang family). A bleached A2 horizon is not common because a full profile development has often been disturbed by sheet erosion. Only in the Matang family a weak A2 horizon may have formed. In areas still covered with Primary forest very thin (less than $\frac{1}{2}$ inch). A2 horizons can sometimes be seen underneath an A1 (equally thin). Such thin podsolis have formed underneath a thick raw humus layer. With shifting cultivation these micro-podsolis, which have formed in the A1 - A2 of the major podsollic profile, are totally destroyed.

Colours of the B horizons range from pale yellow (Matang family) to reddish yellow (Nyalau family). In soils with very blocky structures (Semongok family) and very clayey textures, the internal drainage is imperfect to bad and pseudo-gley features have formed. Mottling of red, yellow and grey are common in these soils.

Podsollic soils and intergrades. (weakly developed)

The soils in this group are difficult to place in the system of World Great Soil Groups because they show features of several groups. They belong therefore typically to the intergrades.

They do, however, show certain features which suggests that with further profile development, pod sols will ultimately form if the profile is left undisturbed. Most soils in this group have in common the fact that the material on which they have formed is highly siliceous. Both the Triboh and Semilajau families are formed on old terrace material, while the Kerait family is residual and has developed on carbonaceous shale. The weathered material of the latter is almost pure white, the carbon having disappeared either by leaching or through oxidation. The material left over is almost pure kaolin (fireclay). On this material the profile has had little chance to develop distinctive horizons. Bases have leached and a textural B. horizon has formed in profiles which are not disturbed by erosion. That the clay is migrating from upper to lower layers by physical action can be seen by the thick clay coatings which have developed in cracks and along old root channels.

The Triboh family, occurring on quartzitic terrace material, is equally poor in iron and magnesium minerals and very pale colours are usually found. The textural B. horizon is here well developed owing to the large sand fraction in the parent material. The acidity is high. Clayskins and clay coatings in cracks and around planes of structural units can be observed in the B. Horizon. Owing to their location these soils are periodically wet. They receive much water from neighbouring hill slopes and the lower horizons therefore show hydromorphic features.

Finally, the Chupak series has developed on sandy levee deposits of moderately old age. Podsolization is in a very early stage. A weak A2 horizon can in places be observed. The textural contrast between the A2 and the B2 is also here present. There are no detailed analysis available to throw any further light on the genetic processes involved in the development of this soil. It is, however, most likely that the Chupak and the Semilajau are prototypes of the Humus Pod sols discussed in the following paragraphs.

Tropical Podsoils and podsollic soils (strongly developed)

This group comprises all soils with a weak to strongly developed humus B. horizon. The only family in this group which occurs in the area is the Buso family. The parent material of this family is invariably very quartzitic terrace material which is devoid of bases and iron. Textures in this material can range from coarse sands to clay. It stands to reason that in sandy material leaching and percolation of humus-rich water is considerably faster than in clayey material. In sandy material we therefore find a better developed humus B. horizon, while in clay soils the humus B. horizon is only a yellow-mottled and humus-stained layer. The dirty-white colour of the soil material is a typical feature of most Buso soils. The Buso family is tentively subdivided into three phases, the first phase showing a weakly expressed humus B. (mainly in clay soils), the second phase showing a well developed but not yet cemented humus B. horizon, while in the third phase are soils in which a hard pan has formed in the humus B. horizon (mainly in sandy material). These three phases could be regarded as separate series because they show three distinctive steps in the development of the Humus Podsol. All three phases occur however in very complex association because the drainage, which is a major factor in the development of the podsol, occurs in a very complicated fashion in the terrace soils. For practical reasons the Buso soils have been mapped as one family with three phases pending further studies.

It is still doubtful whether these siliceous white parent materials were deposited in that form or whether their character was similar to alluvial deposits which is accumulating now on the present cottonlands. The presence of Triboh and Chupak series however suggests, that the latter explanation appears to be the most likely one because both the Triboh and Chupak series can be regarded as intermediar between the recent alluvials and the very old ones now occupying the higher terraces.

Low Humic Gley Soils.

A large part of the area, comprising most of the river basins and the valley bottoms of small streams, are occupied by Groundwater Gley soils. (Low Humus Gley soils). These soils have all developed under hydromorphic conditions (high watertables, and frequent floodings.) In natural conditions the soils are all characterised by dark-often peaty-horizons resting on a redox horizon (the horizon in which alternatively reducing and oxidizing conditions are present), which grades downward into the gley horizon (horizon of permanent anaerobic conditions in which all iron compounds occur in the reduced state.)

The grey colours become more intense with increasing depth. The Group has been subdivided into families on the basis of several features but mainly on chemical characteristics and texture. The Byat family comprises all alluvial soils deposited in Basins along the main rivers. Genetically similar soils, occurring however in smaller valleys in which both riverine alluvium and colluvial material coming from neighbouring hills have accumulated, are grouped in the Samarahan family and the Plan family, the latter family comprising very sandy quartzitic soils and the Samarahan family soils of a clayey texture.

The Samarahan family has been subdivided into 3 series, namely the Kakai series, the parent material of which is alluvium derived from basic igneous rock. Accumulations of iron and manganese can be observed in the redox horizon. Kakai series is regarded as being more fertile than the remaining two series. Paya Megok series, the second soil in this family, has paler colours due to its lower iron and manganese content. The parent material is mixed. In the subsoil peaty horizons occur which give evidence of the former existence of mangrove and nipah swamps in these areas. The Samarahan series comprises the soils developed on material originating in shales and sandstones.

It is surprising that very few iron concretions are found in these hydromorphic soils. The iron content of the soils may be too low or the soils too wet throughout the year for a fixation of the iron in oxidized forms. Kakai series, being richer in iron than the others, shows iron accumulations in soft concretionary forms but this may also be caused by the generally better-drained conditions in the dry season.

All soils except for Paya Megok series show a high acidity, low base-exchange capacity and low base-saturation (although higher than the associated residual soils). It is suggested that yearly floodings contributed much to the present fertility of the soils, some of which are capable of maintaining moderate rice yields almost every year.

Semi-Hydromorphic soils - (Ground water laterites, weakly developed).

All soils in this group have formed on quite recent alluvial deposits. They occur however in the upper sections of the river courses and are therefore less subjected to flooding than the true hydromorphic soils. The watertables are much lower than in soils occurring further downstream and in the dry season the soils are adequately dried out. Oxidation of iron is therefore more intense in these soils and hardening of small iron and manganese concretions can be observed. The redox layer is profusely mottled and is of considerable depth (often more than 2 feet). The only family in this group, the Maleng family, has been subdivided into two series, namely Bentang series which occurs mainly on material derived from basic igneous rock and the Maleng series on parent material of mixed origin. Bentang Series shows darker colours and more manganese accumulation than Malang series. Bentang Series belongs to the richer soils in the area because of its juvenile character and its parent material. It has in places been used for wet padi cultivation. As a result of irrigation more hydromorphic features (gley horizon) have developed. This man-made soil difference has been classified at a phase level although there are many similarities between Kakai series and this phase.

Recent Alluvial Soils.

The Recent Alluvial Soils comprise mainly young levee soils showing little or no profile development. Material is still accumulating in some parts through annual flooding while erosion by the river is removing it in other parts. Two families are recognised. The Undup family is true levee soils, represented by Kayan series which are sandy. In Kayan profiles layering of sediments can be observed. Weak mottling in less sandy layers where water percolates slowly is the only sign of profile development. The Terbat family comprises more clayey soils which have derived from basic igneous rocks. The clay fraction of the parent material comes from old eroded material which once formed the Reddish-Brown Lateritic soils on the neighbouring hillslopes. Fresh rock material forms the coarse fractions of the soil material. The colour of the Terbat family soils is very similar to that of their counterpart soils on the hills from which they have been partly derived. The addition of fresh rock material is making them more fertile. No profile development can yet be noticed in these soils. Ramun series comprises more gravelly soils occurring in alluvial fans and on colluvial footslopes; they show affinities with skeletal soils (Sedong series.)

Tropical Mull

Shallow humus deposits were found in the crevices and dolines occurring in the almost pure limestone mountains. On the limestone itself little or no soil cover is found. Where this is present its occurrence has been traced back to sandstone beds in the limestone. The natural vegetation roots in the limestone their organic litter forming mull-like material. The occurrences of this type of mull cannot yet be satisfactorily explained. We have tentatively classified these humus deposits as "tropical mull" forming the Kedadum family.

Tropical Bog soils.

The Anderson family comprises true lowland peat soils (Bog soils). Here organic deposits of a woody nature have accumulated in swamps where anaerobic conditions together with the near absence of bases has given rise to the development of deep peats. The peat is very low in plant nutrients. When drained the mineralization is very slow because of the high C/N ratio of the organic deposits.

In the area a very wide range of soil types can be found. In fact most genetical soil types occurring in Sarawak can be encountered in this comparatively small area. It is of interest to note that most soil types are atypical for the tropics. There is evidence that podsolization appears to be the major soil-forming process in most of the residual soils while hydromorphic conditions have played a major role in soil development on the alluvial soils. Most soils are highly leached and they have a high acidity and a low to very low base status. The absence of any weatherable mineral in the solum suggests that all soils are highly weathered.

c. Detailed descriptions of mapping units.

The mapping units are described in the same sequence as that found in the map key.

The description for each mapping unit is subdivided into the following sections:

- a. Name, classification and approximate acreage
- b. Occurrence, altitude and parent materials.
- c. General description: the place of the mapping unit in the landscape, present land-use or vegetation, the average profile. Variations from the average profile.

Modal profiles with some analytical data of certain mapping units (soil series and phases of soil series) can be found in Appendix B. These cannot be given for complexes and associations because of the wide variations of soils found in such mapping units.

Unit 1. TARAT SERIES

- a. Tarat family, Reddish Brown Lateritic soils. Approximate acreage 2,560.
- b. Tarat series occurs typically on gentle to moderately steep slopes on hills formed by Basic Igneous rocks (such as basalts and allied rocks). Altitude ranges from 50 feet to almost 2,000 feet above sea-level although its occurrence seems to be restricted above a level of 150-200 feet.
- c. Tarat series comprises well drained, well structured generally deep clay to clay loam soils. In the top the colour can range from dark brown to dark yellowish brown while colours in the subsoil are usually more reddish. Only in exceptional cases can this be called red. Usually the colour is reddish yellow (5YR 6/8). Depth of profile ranges from 30 inches to 5 feet or more. Often colluvial action or erosion has either covered the profile or truncated it. In many profiles hard pieces of basic igneous rock has been mixed with the soil through colluvial action. The subsoil merges gradually into hard bedrock. Usually the weathering rock is of a dirty blackish-green colour with specks of red-coloured clay. White specks (possible feldspars) are common in this material. Structure of topsoil is crumbly to (sometimes) fine angular blocky (depending on the vegetation). The subsoils invariably have a granular to crumb structure and a very friable consistency. Internal drainage is good to very good, although during very wet spells temporarily the soil is almost saturated. In dry weather the soil tends to dry out quickly. The structure is very stable and the soils are of a self-mulching nature. Rooting of natural vegetation is often restricted to the top 10 inches, not because of unfavourable physical conditions but mainly because of the poor base status of subsoils.

Concretionary forms of iron are either absent or occur very infrequently.

One of the typical features of the Tarat series is the absence of much horizon differentiation. Profiles in upper slope sites are subject to erosion and truncated profiles occur. It is thought that the A horizon of lower slope profiles, which are generally deep, has partly been derived from material washed down from up slope B horizons. At present Tarat series is largely used for shifting cultivation and to some extent for permanent cultivation. Given the same stand of secondary vegetation yields under this type of cultivation (hill padi) are usually better on Tarat series than those obtained on most other residual soils occurring in the area. Permanent gardens are mostly planted with rubber or pepper (usually owned by Chinese). The favourable structure is reason that the soil is highly valued for the growing of tree crops and pepper vines. It can be rated as among the best of the residual soils in the area.

Unit 2. SERIN SERIES

a. Nyalau family - Red-Yellow Podsollic soils.
Approximate acreage 3,293.

b. The Serin series occurs mainly in the area from 25th mile to 34th mile, Kuching-Serian road. It seems to be restricted to a transitional belt between Triassic sedimentary rocks and those of Cretaceous age. Parent material is thoroughly weathered Arkose of Triassic age which almost has the constitution of a granite. In places it is mixed with material derived from sandstones occurring in the Triassic beds. The soils of such areas have been mapped as the Tebakang-Serin complex. The soils are found in association with a strongly dissected peneplain with hill tops of 150 - 200 feet high. The valley bottoms are often not more than 100 feet below the summits of the hills.

c. The Serin series comprises soils which are well structured and moderately well-drained. They are in general deeper than 5 feet; only on very steep slopes is the parent rock found within a depth of 4 feet. Three features are typical of the Serin series: the colour from surface to subsoil changes from yellowish brown to yellow with sometimes a dusky red at depth.

The texture changes from loam or clay loam in the topsoil to gritty or sandy clay in the subsoil.

There is often a considerable amount of quartz grit in the profile. This can form a stoneline but in certain residual profiles quartz occurs scattered throughout the profile.

The internal drainage is hampered by the increasing clay content at depth but topsoils are very rarely in a wet condition. The structure is crumbly to angular blocky. Structure becomes weaker with depth, mainly due to increasing wetness.

The parent material (weathered arkose) typically has a dusky red colour. In least weathered portions greenish hues can be noticed. In appearance it is sandy but in reality much of the material is clay. This porous looking material appears to have an unstable structure and it is very liable to erosion which can be noticed in some road cuttings. Because of the relatively high porosity of the loamy topsoil and poorer drainage in the subsoil during very wet weather the topsoils are quickly saturated with water. In this condition landslides can become a real danger.

The series is quite intensively used along the Kuching -Serian road where chinese gardeners are cultivating pepper vines and rubber. In the native owned areas it is mainly used for shifting cultivation (hill padi). At Kpg. Panchur (27th mile) an acreage of approximately 350 is still under primary forest.

Although not so well-structured as Tarat series, Serin Series appears to belong to the better hill soils of Sarawak. This is mainly due to the well-structured topsoil because the analyses suggest that the nutrients levels are very low in this soil.

In places a yellow variant of this series occurs. Here the change from brown over yellow to red is absent. Colours in the subsoil are more yellow. It is suggested that this variant is found in transitional areas between arkose and more quartzitic sandstone but the difference could also be related to internal drainage (hydration of iron compounds.)

Unit 3. SUKA SERIES

a. Nyalau family - Red-Yellow Podsolics.
Approximate acreage 615.

b. Suka series forms a narrow belt in the south-western part of the area covered by sheet 1. It forms high hills lying between a ridge formed by basic igneous rocks and lime-stone/sandstone formations of Cretaceous age. Parent materials are thought to be volcanic tuffs. Slopes are in places very steep (more than 30°).

c. The series is not of great importance because only a small acreage is found in the area. It shows great similarity to Bedup series, found on shales, which will be discussed under unit 6. It is however recognised as a separate series because it is formed from different parent materials.

The soils are moderately well drained. Drainage in the first two feet is good but is retarded near the base of the profile owing to the impermeability of the parent material.

Depth varies with degree of slope but in general profiles deeper than 4 feet are rare. The profile shows degradation in that leaching of clay is noticeable while the analyses indicate a very low base saturation. Textures are clayey throughout the profile. Structure is blocky to massive depending on the state of wetness. The present vegetation is mainly secondary forest, the area is almost entirely in use for shifting cultivation. According to the local population yields are generally poor but vary with the age of secondary vegetation.

Unit 4. 'RI-I' SERIES

a. Nyalau family - Red-Yellow Podsolics.
Approximate acreage: 2,286.

b. The series occurs in several parts of the area but is most widespread in the Serian-Tebakang road area. It is always found on low but strongly dissected terrain. Parent Material is invariably strongly weathered shales of Triassic age.

It occurs mainly at altitudes ranging from 50 - 150 feet.

c. Ri-i series could be regarded as the well-drained phase of Bedup series but owing to its importance in the area a separate but tentative series name has been given. There are differences other than just drainage but these are found below 4 or 5 feet of depth and are of little importance if we concern ourselves with agriculture only. Ri-i series is characterised by a grey brown to dark brown (depending on organic matter) top horizon which rests on a brownish yellow A2 horizon. The B horizon is of a reddish-yellow colour. Although the A2 horizon may be paler than brownish yellow the subsoils are always of a more reddish hue. Grey mottles are absent or very faint. Sometimes in the A1 a very faint grey mottling may be found, indicating a slow penetration of the surplus rainwater through this horizon. This is often caused by a thick root mat of a mor consistence. The texture is clay throughout, structure is often weak crumbly to granular in the top horizon and weak angular blocky to massive in the subsoil (depending on moisture conditions.) The reddish yellow B2 horizon merges gradually into a strongly weathered shale which is often multicoloured dark grey, yellow, red and brown, owing to iron compounds which have accumulated between the cleavage planes of the shales. (In this respect this series differs from Bedup series which in most cases shows a pallid zone between the reddish yellow coloured B2 horizon and the weathered shale.)

In dry condition the B horizon is very hard and blocky. The absence of mottling suggests that drainage conditions are moderately good. Leaching and translocating of clay can be observed in many profiles.

There are local variants on the main series. In some places, soft small iron concretions may be found in the B2 horizon. Also hard iron concretions may occur. These are of a laminar shape and are thought to have formed in the weathering shale. Through rejuvenation of the profile these concretions, which originally formed at great depth (15 feet or more), have come to the surface. Through solifluction or sheet erosion they have been mixed with the soil on the lower slopes. They have definitely not formed in the present profile but are relics of earlier stages in soil formation.

Depth of the series varies between 2 and 4 feet. In certain locations the soils have been eroded to such an extent that the weathering shale can be found at the surface. Areas where the soil depth is normally not deeper than 2 feet have been mapped as the eroded or truncated phase of the series.

All soils of the Ri-1 series are poor in bases, they have a low pH, mineral reserve is nil. They have been farmed for considerable times and show all the characteristics of degraded soils. Their use is therefore restricted to the farming of hill padi or cultivation of rubber. Pepper is grown by Chinese farmers but only with the application of fertilizers are good results obtained.

Unit 5. TEBAKANG SERIES

a. Nyalau family - Red-Yellow Podsollic soils. The badly drained phase of the series shows affinities with the Low Humic Gley soils (pseudo-gleying). Approximate acreage: 3,728.

b. Tebakang series is found in areas where triassic sandstones and sandy shales from the country rock. It is widespread in the area between Tebakang, Krusin and Kakeng. It is found in a low undulating - but in parts strongly dissected - landscape. Slopes vary from 10 to more than 35°.

c. The Tebakang series is characterised by a sandy topsoil and a sandy clay subsoil. Owing to the mixed occurrence of shales and sandstones topsoils can vary from sandy loam to sandy clay loams and subsoils from sandy clay loam to sandy clay. Structure in the top is often crumbly but is massive in the subsoils. The change in texture from topsoil to subsoil causes drainage difficulties and mottling is therefore a common feature in the lower horizons of this soil. Only on steep slopes where much surplus rainwater is drained by surface run-off, better-drained soils can be found. Based on these drainage differences the Tebakang series can be subdivided into drainage phases but their mapping appears to be impossible owing to the complexity of their occurrence. The mapped series therefore contains all drainage phases.

The better-drained soils are brownish yellow in the A2 horizon while reddish yellow colours appear in the B horizon. The badly drained soils show strong profuse mottling in the B horizon. In many cases the mottling starts in the A2 horizon. The soils show all signs of degradation such as low base saturation, low pH, and clay leaching and bear a very poor scrubby vegetation. They have been used for shifting cultivation for a long time and large areas have become useless for hill padi farming owing to lalang infestation. A considerable acreage has already been planted up with rubber.

In certain localities quartz grit occurs in the subsoil. This originates in quartz veins present in the original sandstones. The Geological Survey report of the area (ref. 8) mentions that a considerable amount of feldspars can be found in the fresh sandstone. Mineral analyses of the soils however suggest that no weatherable minerals are present in the soils.

Unit 6. BEDUP SERIES

a. Bedup series is the most important series in the Semongok family occurring in the area. The soils belong to the Red-Yellow Podsollic soils, while part of the series, namely the badly drained phase show affinities with the Low Humic Gley soils. (Pseudo-gleying).

Approximate acreage: 3,916.

b. Bedup series is found extensively over the whole area. In area it is the most important series which is found on the sedimentary rocks of Triassic age. Bedup series is mainly derived from shales and found in a low undulating landscape of which the hill tops are not higher than 200 feet. In parts the landscape is strongly dissected.

c. Bedup series is genetically quite similar to Tebakang series, the difference being mainly the texture which is more clayey in the former. Because of its clayey character structures are often more blocky than in the Tebakang series and drainage can be more impeded than in Tebakang series. Bedup series is subdivided into two phases, namely, the imperfectly drained phase, by far the most important phase and the badly drained phase. It was possible to map the badly drained phase partly as a separate unit, the remainder of the series comprising both the imperfectly drained and badly drained phases. Where sandstone and shale occur in a complex Tebakang Bedup series have also been mapped as a complex.

The soils are generally deep, weathering rock is usually not found within a depth of 5 feet. In certain places (e.g. road cuttings) it can be noticed that Bedup series is generally underlain by a pallid (white coloured) horizon which often has reddish or yellowish mottling. (see also section 2c page 10, 11). It is not certain whether this layer is typical for Bedup series because of the great depth of this layer. Although agriculturally of little importance, this layer may be of significance for a genetic classification of soils.

As is the case with Tebakang series, in Bedup series quartz and iron concretions may be found in the profile. These occurrences are caused by the same agents as discussed in the former series.

The soils are all poor in bases, of a low pH, and with no mineral reserves. Shifting cultivation was the only possible means of making use of these soils prior to the introduction of fertilizers. Large areas have been made valueless for hill padi because of the encroaching weeds, ferns and lallang. At present the soils are partly used for hill padi cultivation and partly for the cultivation of rubber (seedlings and R.P.S. rubber);

Unit 8. MAS SERIES

- a. Mas series forms part of the Matang family and belongs to the Red-Yellow Podsollic soils. There are however affinities with tropical Podzols. Acreage of the separately mapped series: 163.
- b. The Mas series occurs together with the Kedadum series in the south-western part of the area. Parent material is coarse quartzitic sandstones which either occur intermixed with the limestone of Cretaceous age or flanking the latter. The series is found on steep high hills with slopes mainly above 25°.
- c. Mas series is characteristically very sandy and shallow. The top is a loamy sand to sandy loam of a pale yellow to dark grey colour. The lower horizons are pale yellow to white. Often a considerable part of the soil material consists of quartz grit. On more level sites features of podsolization such as clay-leaching and accumulation of humus in the B horizon can be noticed. On steep slopes soils are shallow and eroded.

Most of the soils are still under primary forest, mainly because of the difficult terrain which makes agricultural activities impossible. The forest forms a source of timber and rattan for the local population.

Because of the small acreage and its very low agricultural value no samples of the series were collected.

Unit 9. KERAIT SERIES

- a. Kerait series forms part of the Kerait family and belongs to the Podsollic soils with certain features resembling the Tropical Podzols (Buso family). Acreage: 236.
- b. The series is widespread in the south-eastern part of the area on carbonaceous shales of Triassic age. It is found in a strongly dissected hilly landscape with variable slopes ranging from 10 to over 25°. Height of hills varies from 50 feet to 150 feet.
- c. Kerait series consists of deep clay soils with, in general, a more sandy top. In the lower horizons quartz grit may occur. Typical is the white colour of the lower horizons which can change into black quite abruptly at the boundary between soil and weathered carbonaceous shale. In the often pure white selum brownish yellow mottles occur at variable depth.

The structure is massive. The soil is very dense and water movement is very slow. Analyses previously carried out on this soil type indicate a very high content of pure kaolinite (fire-clay). Although genetically not the same as the tropical podsol (Buso family) the top 4 feet is so similar to certain soils in the Buso series that for agricultural purposes the soils could be placed in the same group. It is still not known what genetical process causes the soils to turn white from black. Probably the carbon in the carbonaceous shale is oxidized or leached out.

The soils are poor in bases, mineral reserve is nil, pH is low. A considerable acreage is still under primary forest, the remainder is mainly used for shifting cultivation.

Unit 10 - TRIBOH SERIES

- a. Triboh series belongs to Podsollic soils but shows similarities with the Low Humic Gley soils. It is at present the only known series in the Triboh family. Approximate acreage: 390.
- b. The series occurs in most valleys in the southern part of the area between the Serian-Balai Ringin road and the Kedup river. They are probably terrace soils because they are always found at certain height above the valley bottoms where the hill slopes show a break of slope. They are either remnants of old alluvial deposits or a mixture of these and colluvial material accumulated on foot slopes.
- c. The series is not only characterised by its typical location but also by certain profile characteristics such as an abrupt textural change from top to subsoil. (sandy loam over sandy clay). Colour changes from greyish brown (sometimes black) in the top to lighter grey or brown colours in the subsoil and pale yellow or white at depth. Mottles are very common and distinct in the lower horizons. They show a variety of colours ranging from grey, brown and yellow to reddish yellow and yellowish red. The textural change causes drainage difficulties in the soils and perched watertables are a common feature. Their location is the reason that they receive much surface run-off water from the slopes and in the wet season the soils are continuously wet. The soils appear to be highly leached and degraded (clay leaching, low base saturation, low pH). Mineral reserve is nil. The soils are at present generally used for shifting cultivation but poor rice yields are obtained. Most areas are infested with lalang and other weeds.

Unit 11. CHUPAK SERIES.

- a. Chupak series belongs to the Podsollic soils. Profile development is however weak. Its origin, location and profile characteristics suggest that further profile development will probably show increased podsolization. For this reason the series has been placed in the group of the Podsol Rankers. The Chupak series belongs to the Semilajau family in which weakly developed sandy alluvials intermediate between old terrace soils showing a podsollic profile development and recent alluvium have been placed. The acreage is small: 179.
- b. The series is mainly found in the Nyabet-Chupak area where it is found on medium old alluvial deposits above the present flood level. Its origin must be sought in the sandstones of Cretaceous age (Residual counterpart-Mas series). The series is only found near limestone mountains in which sandstone beds occur. Streams from these mountains have brought down sandy quartzitic material. On this material Chupak series has formed.
- c. In certain places podsolization is strong and a light grey A2 horizon has already formed. Erosion has clearly disrupted a normal profile development and other parts of the series show only a pale yellow A2 horizon. Leaching of clay is prominent and textures in the topsoil are

always lighter than in the subsoil. Topsoils are usually sandy loams which are well drained. Only a weak grey mottling can in places be found in the subsoil.

At present the series is either not used at all or is planted up with rubber seedlings. Although the soils are generally poor in nutrients, the drainage enhances the development of good root systems which are able to take up the small amount of nutrients which are available.

Unit 12. BUSO FAMILY

a. The Buso family comprises soils which can be placed under the Group of Tropical Podsoils or Para. Podsoils (in accordance with the terminology used in the Lower Amazon Basin. ref. 17).

Acreage: 204.

b. The Buso family has developed on highly quartzitic old alluvial materials of which remnants can still be found in the Sadong Valley. Areas are small and form, in general, low gently-undulating terrain which is usually found between 20 and 50 feet above sea level.

c. Depending on the texture of the parent material the family shows a range of soils with B1 (humus accumulation) horizons showing differences in degree of development. In the more clayey materials the B1 horizon has only pockets of dark-coloured material (grains coated with humus particles leached from the top horizon.) In lighter textured soils a continuous dark B1 horizon has developed; while in the very sandy soils the B1 horizon often forms a hard pan. Apart from the texture the development of the B1 horizon is also dependent on local drainage. Erosion plays also a role. Often whole horizons have been eroded, exposing the subsoils in which no podsol profile development can be detected. These series differences occur in a very complex pattern and although they may be great we have not yet used them as criteria for creating new series names. These differences are tentatively called phases 1, 2 and 3 of the family, in the order described above.

The topsoils are often of a peaty nature. A thick rootmat and partly decomposed litter forms the AO horizon. The A1 horizon is a dark grey often sandy horizon with weak grey mottling (surface gleying). The A1 rests on a deep A2 horizon which is frequently pure white in colour, sometimes showing weak yellow mottles and stains of humus material leached down through cracks. The latter feature is mostly found in soils of a clay texture. The A2 horizon rests abruptly on the Humus B horizon (if well developed.) The B2 horizon is often white and densely mottled with brownish yellow. The C horizon is formed by deep alluvial deposits mainly of a dirty white colour frequently mottled yellow and brown. Gravel layers in the horizon are common in the Sadong Valley.

These humus podsoils have a very low agricultural value and are nearly sterile. Some areas have been planted up with rubber, mainly by Chinese farmers who had no other soils to cultivate. The rubber grows but that is all. Trees are stunted, thin, diseased and low-yielding.

No samples have been taken owing to the small agricultural value that can be attached to these soils and the small acreage occurring in the area.

Unit 13. SIMUJA SERIES

a. The Simuja series belongs to the Byat family in which are grouped all the clayey basin soils of the large river valleys. All the soils in the Byat family belong to the low Humic Gley soils.

Acreage of Simuja series: 3,901.

b. The Simuja series is found in basins occurring along the Sadong-Kayan-Kedup rivers. These basins are filled by clays brought down by the Sadong river in flood. Owing to their location the soils in the Simuja series are liable to frequent floodings in the wet monsoon.

The source of these alluvial soils is mixed in nature and comprises basic igneous and acid igneous rock types, shales, sandstones and limestone all of which can be found in the catchment area of the Kedup-Kayan tributaries of the Sadong river.

c. Soils in Simuja series are typically hydromorphic soils characterised by dark grey to sometimes black, often peaty top horizons merging into a yellow and red mottled grey coloured so-called redox horizon which is alternatively dry and wet. Below the redox horizon a dark grey permanently wet zone or gley horizon can be found. Soils in the Simuja series are all heavy clays which are wet and sticky for considerable parts of the year.

The yearly floodings add fresh nutrients to the top-soil. This might in certain years be sufficient for one rice crop of moderate yield.

Where flooding is not too serious the series is used for wet padi cultivation.

Unit 14 - SLABI SERIES

a. The Slabi series has been provisionally placed in the Byat family because of its location. It could also be placed in the Undup family as an imperfectly drained Kayan series. The soils are recent alluvium with weak hydromorphic features. Acreage: 801.

b. The Slabi series is found on very low incipient levees resembling basins and are flooded in the wet season. The soils occur commonly along the Kedup and the Kayan river.

c. Textures in the Slabi series range from sandy loams to sandy clay loams. They are crumbly to subangular blocky structured. Watertables are found frequently within 4 feet from the surface but are rarely above 3 feet. Mottling in the lower horizons is dependend on texture. The heavier the texture the more pronounced the mottling. Parts of the series are used for wet padi cultivation. On other parts permanent cultivation is practised. Along the Kedup the areas are frequently found in virgin conditions mainly because of the severe flooding in the wet season. The area of soil is but small and the series is therefore of little importance for the area as a whole. No samples have therefore been analysed.

Unit 15. KAKAI SERIES

a. The Kakai series belongs to the Samarahan family which comprises all hydromorphic soils of a clayey character formed in the small valleys along the numerous small streams found in the area. The series belongs to the Great Soil Group: Low Humic Gley soils
Acreage: 3,244.

b. The Kakai series occurs in flat terrain formed by the numerous small valleys in the shale/sandstone country. The parent material is alluvial debris from Basic Igneous rock formations. The series is therefore extensively found around the Sedong and Simuja/Ampungan mountains.

c. The Kakai series is characterised by a clay to clay loam texture. The soils are submerged during the wet monsoon, either by artificial irrigation or by natural flooding. Groundwater-tables are usually high in the wet monsoon; in the dry season they are frequently found at 2 or 3 feet below the surface. The topsoils are dark greyish brown to brown peaty clays, frequently with weak light grey mottles. The topsoils merge into a redox layer which is mottled olive yellow and red. Typical for the Kakai series are the small manganese concretions found in this layer; they are often of a fine sand size and only visible as smears on the wall of the profile. The soft manganese concretions show up as black streaks. Another feature of the Kakai series is the bright bluish colour of the gley horizon indicating a highly reduced environment rich in iron.

The soils are mainly used for wet padi cultivation. They are yearly cropped which indicates that the soils are richer in plant nutrients than the other series of the small family but derived solely from sandstone/shale material. It is also suggested that the floodwater contains silt with a high content of plant nutrients. This yearly supply of nutrients may be sufficient to maintain moderate annual yields of rice.

Unit 16. PAYA MEGOK SERIES

a. The Paya Megok series is a member of the Samarahan family but is mapped as a separate series because it rests on limestone. Frequently peaty horizons, relics of old Mangrove and Nipah swamps, can be found in the subsoils. The series belongs to the Great Soil Group: Low Humic Gley soils
Acreage: 1,725.

b. The Paya Megok series occurs in the large alluvial plains formed by the Bukar and Kepayang rivers. The terrain is flat and lies between 20 feet to 0 foot above sea level. The series is frequently flooded in the wet monsoon. The sediments on which the Paya Megok series was formed originate mainly in the Triassic shale and sandstones and the Basic igneous rocks.

c. The series shows all the characteristics of ground water gley soils which are: a dark coloured top horizon resting on a redox layer rich in reduced and oxidised iron which gradually merges into the permanently wet grey-coloured gley horizon. It is very similar to the Kakai series, the difference being an absence of manganese concretions, less rich in iron and absence of the sand particles of basaltic origin which are frequently found in the Kakai series.

Typical for the Paya Megok series is that the sediments are floored by limestone which in places occurs as outcrops. Also remnants of old Mangrove/Nipah swamps are found in the lower horizons suggesting old marine activity in the area.

Chemically the series is characterised by a comparatively high content in exchangeable calcium and consequently a high pH. It is thought that the frequent floods enrich the topsoils with plant nutrients.

The series is mainly in use for wet rice cultivation but owing to frequent floods crop failures often occur. Trials on the Paya Megok wet rice Station revealed that the soils are capable of giving good rice yields provided that flooding could be stopped. The favourable results of experiments with cash crops in the dry season indicate that it would perhaps be better to advocate the growing of such crops on this soil type if flooding cannot be stopped.

Unit 17. SAMARAHAN SERIES

a. The Samarahan series is the major soil series in the Samarahan family and belongs to the Great Soil Group: Low Humic Gley soils
Acreage: 2,490.

b. The Samarahan series is found in the same type of landscape as the Kakai series namely in the bottoms of the small valleys intersecting the shale/sandstone country. Most areas are liable to flooding in the wet monsoon and receive thereby fresh material from the sources of the small streams which comprise, for this series, mainly sandstones and shales of Triassic age.

Apart from these alluvial sediments old soil material from neighbouring slopes is deposited in these valleys by colluvial wash.

c. The Samarahan series is the most important series in the Samarahan family. Its importance lies not in the agricultural value which is lower than that of the Kakai and Faya Megok series but because of its acreage which is considerable in the area. The profile characteristics are quite similar to those of the other series in the family except that the soils are mainly heavy clays, they are less rich in iron and manganese than the Kakai series and lack the organic-rich layer usually found in the subsoil of the Paya Megok series.

Iron concretions are usually absent although the soils are intensively mottled especially in the redox layer.

The soils are poor in bases and the acidity is generally high. A considerable acreage of the Samarahan series is used for wet padi cultivation but usually the areas are used in rotation, usually 1:4, the length of fallow depending on fertility.

There is no mineral reserve in these soils and it is thought that the annual flooding restores the fertility of the topsoil by adding nutrients.

In certain areas, especially where the Samarahan series merges into peat swamps the series is covered by peat or muck layers. This organic-rich top can sometimes be as thick as 3 feet. Such soils are classified as the organic phase of the Samarahan series which has not been mapped separately.

Unit 18. MUNDAI SERIES

a. The Mundai series belongs to the Plan family and is a Low Humic Gley soils
Acreage: 677.

b. The Mundai series comprises deposits of quartzitic nature often with gravels and quartz grit. The profile indicates that these are old river deposits. Certain features indicate that the Mundai series might be a drowned terrace soil. It always occurs in the neighbourhood of Limestone and Chert formations. The parent material of the series must be sought in the weathering products of sandstone, limestone and cherts. The limestone is almost pure calcium carbonate which implies that the Mundai series consists almost entirely of the weathering products of chert and sandstone.

Often limestone and chert outcrops occur in the flat alluvial areas in which the Mundai series has developed. Its occurrence is most widespread in the Chupak area. Smaller areas can be found in the Kedadum area.

c. The Mundai series has all the characteristics of the Plan family. A dark grey often mucky top-horizon resting on a redox layer which is densely mottled (yellow, grey and brown.) In the Mundai series the iron content is probably lower than in the Samarahan family due to the quartzitic nature of the parent material and pallid colours are therefore dominant. The redox layer merges gradually into the light grey to sometimes white-coloured gley horizon, which in certain locations contains peaty remnants of a former vegetation. Most of the series is flooded during the wet monsoon and the local population uses the series for wet padi cultivation where possible. Yields are always meagre because of the low fertility of the soils. Within the mapped area small areas of soils can be found with a high content of calcium carbonate. They are most likely to occur near or amidst outcrops of limestone. The high pH of such soils indicates that some soluble calcium oxide is probably present in the soil.

Unit 19. BENTANG SERIES.

a. The Bentang series is part of the Maleng family. Morphologically it shows similarities with both recent alluvial soils without much profile development and groundwater laterites.
Acreage: 2,382.

b. The Bentang series is found on alluvium mainly originating in basic igneous rock formations. It is located in areas which are not flooded for long periods in the wet season. It is mainly found in the Nyabeth and Bentang-Tai-i areas. Smaller areas also occur near Jenang, Lanchang and Ri-i (Kuhas river).

c. The alluvium on which the Bentang series has formed is of quite recent origin. Owing to its location, namely in areas where only floods of short duration occur, profile development is still in a juvenile stage. Deep, strong brown to yellow brown subangular blocky clay loam soils characterise the series. Only at depths of 3 feet red and grey mottles (often weakly expressed) give evidence of these infrequent periods in which drainage is slow and reduction of iron compounds takes place. In the subsequent drier periods the iron is allowed to oxidize again. Another typical characteristic of this series is the large amount of manganese concretions (soft and small) which can be found in the upper two foot of the profile.

Because of its location the series is well suited for irrigation and the local population has not hesitated to make full use of this potential. Large areas which are used for wet padi planting (Bentang-Tai area) are occupied with soils which originally were the same as the Bentang series just described.

Due to the artificial inundations a soil profile has developed which shows all the characteristics of an incipient ground-water laterite. The topsoil is dark grey or greyish brown, while iron and manganese have accumulated in a defined zone (a redox horizon), the typical gley horizon is only present in areas where the water-table is found within a depth of 4 feet.

The mapping and classification of this series has presented some difficulties because land use is here largely responsible for the variety in profile characteristics. For mapping purposes we have regarded the soils as being one natural unit, while the padi soils are to be regarded as wet phases. As soon as parts of the Bentang series are used for wet padi cultivation, features similar to those found in ground-water laterites may develop, such as accumulation of iron and hardening of mottles in concretionary forms in a certain horizon. In this condition it is very similar to the Kakai series.

The value of the Bentang series lies in its fertility inherited from the parent material (basic igneous rocks) which is enhanced by the youthful stage of the soil forming process. From the parent material it also inherited the large amount of iron and manganese present in the soil.

The series proper (dry phase) is used for mainly rubber while the wet phase is used for wet padi cultivation. Yields are always higher than on any other series occurring in the area.

Unit 20. MALENG SERIES

a. The Maleng series is the main series in the Maleng family. The series is an intergrade between recent alluvial soils and groundwater laterities.

It is tentatively classified as a semi-hydromorphic soil, indicating that certain hydromorphic features are weakly developed.

Acreage: 2,030.

b. The series is usually found on recent alluvium found on flat to low undulating levees along certain streams. It is found mainly along the Serin river.

The parent material of the alluvium is varied but comprises mainly weathered shale, arkose and sandstone to a minor extent also basic igneous rocks have contributed to this soil.

c. The series is very similar to the Bentang series the difference being mainly the lower content of iron and manganese, the generally paler brown colour of the solum and the parent material. The latter may be the reason why the Maleng series is in general less fertile than the Bentang series. At present the series is used for rubber planting, vegetable growing and for the cultivation of some coffee and citrus mainly for domestic use.

Unit 21. KAYAN SERIES

a. The Kayan series belongs to the Undup family comprising alluvials with little or no profile development of medium texture.

Acreage: 1,001.

b. The Kayan series is mainly found along the Kayan and Kedup rivers where they have built up well-developed levees along their courses. The parent material is sandy recent alluvials of varied origin depending on the catchment area of the river along which they are found. The parent material of the Kayan series should however count among its sources basic or acid igneous rocks types. The series is found as a narrow strip along the river and is subject to erosion during high floods.

c. The Kayan series is characterised by its location, its stratification visible in the profile, weak or no profile development, and its in general sandy texture. Textures can range from sandy loams to coarse sands. In the profile layers of different textures can often be seen. The only profile development may be a faint greyish mottling in more clayey layers in which the drainage is slower than in the other layers.

The natural vegetation of the series consists of a typical riverine lowland dipterocarp forest, of which the 'Tapang' is at present found as the only remaining tree. Bamboo seems to have taken the place of this forest type in places where the natural vegetation has been removed. In localities where the area covered by this series is sufficient citrus, coffee and rubber are planted with success. The soils are well drained to

excessively drained, while the juvenile character of the sediments may contribute to the fertility of the soils. The extensive root systems which develop in the soils might indicate that plants cultivated in this medium are able to get to all the food they need for a healthy growth. It may therefore appear that it is more a matter of soil volume than fertility in itself which makes this series such a good agricultural soil.

Unit 22. TERBAT SERIES

a. The Terbat series is the main series in the Terbat family. The series is formed by recent alluvium of mainly clay texture and solely derived from basic igneous rock material. A considerable part is eroded material from the Tarat series. Although the soils are recent alluvials, the material however has derived partly from the Reddish Brown Lateritic soils occurring on the hills (Tarat series). This is the reason why the series shows similarities with the Reddish-Brown Lateritic soils. We have therefore placed these series intermediate between the recent alluvium and the Reddish Lateritic soils. Acreage: 958.

b. The series occurs on the alluvial fans along the upper parts of the main streams coming from the basic igneous rock mountains. It is widespread in the Lanchang area and near Tarat Agricultural Station. The total acreage to be found in the whole area is small, however. The series occurs on flat land found immediately along the streams. It is sometimes flooded for short periods during the wet season.

c. The series is rated among the best soils occurring in Sarawak. It combines a favourable structure with moderate fertility and farmers obtain excellent results with a variety of crops grown on this series. The top 3 or 4 feet is formed by a sediment of crumbly, friable clay loams to clays, part of which being colluvial material from the Tarat series occurring on neighbouring hill slopes; the remainder is fresh material derived from basic igneous rocks. This part undoubtedly contributed most to the fertility of the soils. Unfortunately only in minor areas can such a favourable mixture be found, the yellowish red to brown coloured alluvial sediments generally being derived from older material on the hills. Profile development is weak owing to the recent deposition of this material. A weak mottling may in certain places be noticed owing to impeded drainage. The clay sediments are often underlain by gravelly or bouldery layers (fan deposits) which if occurring near the surface hinder root development but on the other hand they give the soils excellent internal drainage conditions. The local population grows mainly rubber on these soils; minor crops are pepper, citrus, coffee and market-garden crops.

Unit 23. RAMUN SERIES

a. The Ramun series belongs to the Terbat family. The topsoils are very similar to the Terbat series but the soil as a whole is much shallower and is therefore classified as an intergrade to skeletal soils. Acreage: 3,583.

b. The Ramun series has formed typically in the numerous boulder fans occurring where small streams debouch from the basic igneous mountains they can also be found on the foot slopes of hills formed by basic igneous rock types.

The terrain is often very dissected, the erosive activity of the streams at these points being very strong. Only in the fans of larger stream can some flat, gently sloping and not yet dissected land still be found. (e.g. Ta-i, Ramun, Lebor areas.)

c. The Ramun series comprises shallow gravelly and bouldery soils. The smaller fractions of the deposited material are often red clays derived from the Tarat series, the coarse fraction being gravels and boulders, fresh and partly decomposed. The depth of the profile is very variable owing to the mode of formation of the series. In certain places drainage difficulties give rise to wet conditions in these normally well-drained soils. This feature is of very scattered occurrence and has not been mapped. The Ramun series is a fertile soil but depth and topography limits its use. Of the total acreage to be found in the area not more than perhaps 50 per cent can really be used for agriculture. Wild fruit trees appear to be associated with these soils. It may be that the local population has in the past realised its value for the growing of fruit trees and has planted many fruit varieties in these localities rather than that this is the natural vegetation. Rubber is grown in certain areas where the soil depth is not so variable while on Tarat Agricultural Station, coffee, cacao and citrus have been successfully established on these soils.

Unit 24. KEDADUM SERIES

a. The Kadadum series is at present the only known series in the Kedadum family and is tentatively named: Tropical Mulls (a term not found in the World Great Soil Groups.) Acreage:

b. The Kedadum series occurs on the steep limestone hills occurring in the southern and western part of the surveyed area. It occurs in crevices within the limestone formation.

c. The Kedadum series comprises humus deposits developed on the pure limestone formations of Cretaceous age. It is suggested that these limestones support a vegetation which is lacking in bases (or may be high in calcium only.) Organic litter from this vegetation accumulates in crevices and small pockets between the rocks. Usually a small amount of sand particles of quartzitic nature can be found in humus.

The humus is normally not thicker than 6 inches but in certain places it can be more than 2 feet deep. The series has no agricultural value because of the bad topography and soil condition and for this reason no samples have been taken in the course of this survey. A further study of these for tropical areas uncommon humus deposits would be of interest but of rather academic value.

Units 25-27 ANDERSON SERIES, phases 1, 2 and 3.

a. The Anderson series is the typical series of the Anderson family forming parts of the Tropical Lowland Peat or Bog Soils.

Acreage: 1,648, 4,241, 7,015.

b. The Anderson series occurs mainly in the eastern part of the area where the low hilly landscape merges into peat swamps which continue almost to the sea. The parent material of these organic soils is formed by woody matter from the vegetation growing on it (or rather, from the former vegetation), but for certain reasons we prefer to call the underlying soil material the parent material because this has supported the former vegetation which has inherited characteristics from it. The peat swamps are flat and usually submerged in the wet season, but dry in the less wet season.

c. The peat swamps have been grouped together under the Anderson series, the only phase differentiation has been on depth of peat, as follows:

phase 1:	3 - 6	feet deep peat
"	2:	6 - 10 feet deep peat
"	3:	peat deeper than 10 feet.

This phase difference is purely a practical subdivision based on a possible agricultural use. In general peat deeper than 6 feet cannot be drained adequately, while 3 - 6 feet deep peat can in certain instances be drained.

It would carry us too far to give here a detailed account of the development of these lowland peats. It would therefore suffice to indicate that the low base status of the original soil material has contributed much to the formation of peat. The vegetation poor in bases consequently gives a raw humus poor in bases. The anaerobic conditions of the peat is in itself not responsible for its development because under dry conditions bacteria would mineralize this raw humus if they had sufficient energy available to them. The high C/N ratio of the peat, the low phosphorus content and low base status is responsible for the almost sterile environment in which very little bacteriological activity is possible. The decomposition of the peat is therefore very slow even under dry conditions.

With the Anderson series the detailed description of the soil series present in the area is completed. The remaining mapping units, the soil complexes and soil associations cannot be described in the same way because of their heterogeneity.

For a description of the series found within a complex the reader is referred to the descriptions of the individual series making up the complex. The same applies to a description of the associations.

It would however be of practical use to complete this picture on soils by adding a few words on the topographical situation of certain complexes and associations to enable the map user to orientate himself. There are also two series mapped as part of complexes which have not yet been described among the individually occurring series, namely the Antayan and Sedong series.

Unit 28. ANTAYAN-SEDONG-BOULDERY AND ROCKY LAND COMPLEX.

This mapping unit is in area the most important one. The total acreage is 31,250. It is found on the mountains formed by basic igneous rocks, the complex comprising in general areas with slopes of more than 25°. The Antayan series, not yet described, resembles the Tarat series, the difference being the more yellow colour and the less crumbly structure. Structures are usually massive.

The Antayan series is at present mainly used for shifting cultivation. The topography sets a severe limitation to its use but if proper conservation measures are taken the series could be used with advantage for three crops such as rubber. A reforestation project with the object of extracting timber in future would also be a good way to make these soils productive.

It should however be mentioned that the Antayan series occurs together with the Sedong series described below and with bouldery and rocky land. A careful site selection is therefore necessary for locating an area of the Antayan series which is sufficiently large for economic crop production.

The Sedong series comprises the very shallow soils on basic igneous rocks. They are among the most juvenile soils formed on these rocks and are therefore likely to be richer in bases and weatherable minerals. The shallowness of the soils and the topography, which is very steep and irregular, are the reasons that only a very limited use can be made of these soils. Part of the series is used for dry padi cultivation. Good yields can be obtained.

Erosion on the steep slopes is serious under shifting cultivation practises. It would be best to cover this series with forest plantations, with the possibility of extracting timber in future. The reforestation of these large areas of steep and eroded lands will also have an impact on the whole drainage of the area. If run-off could be stopped and the water intake by soils could be increased by a forest cover, the rainwater falling during the wet season will then only gradually be drained into the numerous streams and valleys surrounding these mountains. The yearly floods now causing havoc in these areas would be less intense and better use can then be made of the generally high quality soils found in these valleys.

Finally the Bouldery and Rocky land comprising the most steep slopes and tops of the mountains are still covered by primary forest. A large area is covered by rock outcrops. Such land has no agricultural value.

It appears that in this complex valuable soils do occur but careful selection is needed. The small pockets of good soils are impossible to delineate on the maps but every village should be able to find for themselves what can be used if they are told what to look for.

UNIT 29. RAMUN-TERBAT COMPLEX

This complex occurs in valleys of some main streams coming from the basic igneous rock mountains. The bouldery and gravelly material forming the Ramun series form a complex with the deeper and more clayey soils of the Terbat series. A site selection is needed in such areas to locate the soils with any agricultural potential. Acreage: 1,468.

Unit 30. TEBAKANG-BEDUP COMPLEX

The Tebakang-Bedup complex is found in areas where sandstones and shales of Triassic age occur in such a complex pattern that a separate mapping of the soils occurring on these different rock types is impossible. The agricultural value of both series is about the same; i.e. mainly for rubber, so that in practice there will be little difficulty in selecting in this complex. Acreage: 5,116.

Unit 31. RI-I TRUNCATED RI-I.

This complex occurs in a low undulating landscape resembling little islands or shields in a complex pattern of small valleys. The soils are partly eroded, often leaving the weathering shale at the surface. Much of this area could be used for rubber cultivation but the occurrence of the great number of wet valleys makes it impossible to find large continuous blocks of land. Therefore, on selected sites, the cultivation of pepper could better be attempted because the economic holding would be much smaller. The fertility of the soils is however so low that considerable amounts of fertilizers will be needed to make pepper-growing a success. It is however already done by the Chinese population along the Kuching-Serian Road with reasonable success. Acreage: 1,432.

Unit 32. CHUPAK-BUSO COMPLEX

This complex comprises soils in variable stages of podsolization. Pockets of the Buso family occur on the higher ground whereas on the lower ground the soils are of the Chupak series. The Chupak series can be used for rubber and possibly with sufficient fertilizers for citrus whereas the pockets of Buso soils would be better left unused. Acreage: 137.

Unit 33. SIMUJA-SLABI COMPLEX

This complex is found along the Kayan-Sadong river on the landward side of the levees where they merge into the bottomland. The soils belong texturally to the levee but owing to their deposition in low-lying areas wet conditions have allowed the development of hydromorphic soils. The areas of the individual series in the complex are very small and cannot be mapped on the scale used.

Unit 34. KAYAN-BENTANG COMPLEX.

The Kayan-Bentang complex occurs along secondary streams. These streams have no well-developed levees, and pockets of higher-lying ground bearing Kayan soils occur with the Bentang soils, the latter occupying more low-lying localities. In the wet season the Kayan soils are mostly dry even when the streams are in flood, while the Bentang series are then submerged. If one wants to use the areas of this complex for agriculture the risk of flooding of each parcel of land should be known before deciding on the choice of crops. The local population can probably give valuable information on this while the soil difference described above can also serve as a means for selecting the proper place for the crops which one intends to grow. Acreage: 989.

Unit 35. SERIN-TEBAKANG COMPLEX

This complex occurs in areas where sandstones and arkose of Triassic age are intermixed. A separate mapping of soils developed on sandstone and arkose is therefore not easily possible. The landscape offers no key to a possible boundary. From the description of the individual series in this complex it can be seen that the Serin series can be used for pepper cultivation whereas the Tebakang series could best be used for rubber only. In this area, decision on the choice of crop must therefore be taken in the field. Acreage: 2,221.

Unit 36. KEDADUM-MAS COMPLEX.

This complex occurs on the limestone mountains of Cretaceous age. Limestone occurs here together with beds of sandstone on which the Mas series has developed. Both series are useless for agriculture because of soil characteristics and bad topography and it therefore serves little purpose to attempt a separate mapping of the two units on a larger scale. Acreage: 2,346.

The following map units are soil associations defined on page 23.

Unit 37. RAMUN/BEDUP ASSOCIATION.

The Ramun-Bedup Association occurs in transitional areas where shales of Triassic age border basic igneous rock formations. The boundary, which is usually a distinct topographic one, has in certain places been disturbed by erosion, especially at the debouching points of the streams coming from the basic igneous rocks mountains. The Ramun series, which comprises colluvial soils of basic igneous rock origin occur here mixed with the Bedup series found on the Triassic shales. Rivers have dissected the landscape and remnants of Ramun series soils can be found on hills indicating former stream activity in these areas. With a larger scale of map and much field work the two series could be separated; the small importance of these small areas however would not justify the undoubtedly high expenses of such a mapping. Acreage: 200.

Unit 38. KAYAN/BENTANG/RAMUN ASSOCIATION.

The morphology of the landscape in this association is quite similar to the one described under mapping unit 37, but the landscape is less dissected. Here colluvial material from the basic igneous rock mountains (the Ramun series) has been spread over flat areas in which Bentang and Kayan soils occur. Such colluvial wash often only follows a long spell of heavy rain and is not continuous. In these areas, therefore, we can expect to find thin layers of gravelly or clayey material of basic igneous rock origin resting on the Kayan or Bentang series, which generally means an enrichment of the topsoil. Acreage: 41.

Unit 39. TEBAKANG/RAMUN ASSOCIATION.

This association occurs in the same type of landscape as described under mapping unit 37, the difference being that the parent materials are here sandstone of Triassic age and basic igneous rocks. For all practical purposes one could regard associations numbers 37 and 39 as being one. Acreage: 152.

Note:

In the first quarter of 1964 the field work carried out by soil survey assistants in sheet 2 area was checked and it became apparent that certain new mapping units had to be created for giving a more accurate picture of the soil pattern occurring in the area covered by sheet 2. Certain series originally mapped as separate units by field assistants have to be shown as occurring in association because not enough field data is available for an accurate separation. One soil type developed on schists appeared to be of sufficient importance in that area for justifying the establishment of the new series, namely the Bayur series.

This development occurred after sheet 1 had been completed and the new mapping units can therefore not be incorporated in the key shown on that sheet. The mapping units described now are therefore only of importance in the area shown on sheet 2.

Unit 40 BAYUR SERIES.

a. The series belongs probably to the Red-Yellow Podsollic Great Soil Group but may be an intergrade to the Reddish Brown Lateritic soil. Insufficient data is available for a definite placing in any group. Morphologically it shows similarities with both the Tarat family soils and the Nyalau family soils. Acreage: 1,404.

b. The series occurs typically in the Rasau, Triboh, Ramun and Blimbin areas situated in the east of the area. Near Ramun it covers a considerable area situated in the middle of the swamps, while along the Serin-Simanggang road it seems to occur only in scattered locations indicating that probably dykes of schist run through the Triassic sediments at these places. There it can only be mapped in association with other series occurring on the Triassic sediments. The series

forms typically steeper hills than those normally found in the Triassic shales. Probably the hardness of the schists in comparison with the shales has caused this feature. The height of the hills never exceeds 150 feet and the series is commonly found between this elevation and the 50 feet contour.

c. The Bayur series is characterised by a yellowish brown to frequently a dark brown top (depending on organic matter content.) Textures in the topsoils are mainly sandy loam to sandy clay loam, while the structure is crumbly to fine subangular blocky.

The topsoil gives way to a more yellow coloured subsoil which becomes gradually redder with depth. For this reason the Bayur series has frequently been mistaken for the well drained phase of the Tebakang series which occurs on Triassic sandstones. The structure in the subsoil is angular blocky to massive depending on wetness stage of the soil. Typical for the series is the quartz gravel which in most profiles was encountered in the subsoil. In deep profiles seen in road cuttings the series shows stonelines of quartz gravel while in other phases it can be noticed that this quartz originates from quartz veins in the parent rock. On exposure the whole soils attains an orange colour. In certain localities (road cuttings) bauxite nodules were encountered in the lower horizons, frequently in the C. horizon.

The profiles do not show mottling of any significance which indicates that the soils are well drained. Only in sites where much run-off water accumulates imperfectly drained phases of the series do occur.

The Bayur series appears physically to be similar to the Serin series and could be used for pepper and rubber with advantage. The nutrient content is generally very low and in this respect it is not better than most other residual series found in the area.

Unit 41. BEDUP/BAYUR ASSOCIATION.

The Bedup/Bayur Association occurs commonly in the Triboh Blimbin area where dykes of schists run through the Triassic shales on which the Bedup series has developed. Acreage: 156.

Unit 42. KERAIT/BEDUP ASSOCIATION.

The Kerait/Bedup association occurs mainly in the eastern part of the area covered by sheet 2. The series making up the association have formed on shales of Triassic age but it is suggested that the Kerait has developed over shales of a more carbonaceous nature than is the case with the shales on which the Bedup has developed. Acreage: 555.

Unit 43. KERAIT/TRIBOH ASSOCIATION.

This association occurs in the eastern part of sheet 2. The area comprises mainly low hills with gentle slopes on which the Kerait series can be encountered. At the lower slopes which grade into the hydromorphic soils occupying the bottom lands situated between the hills, the Triboh series has developed. The irregular occurrence of the latter series makes it impossible to map it as a separate unit. Acreage: 281.

Unit 44. TRIBOH/BEDUP ASSOCIATION.

This Association occurs mainly in the Berok and Blimbin areas. The land is very low and gently undulating. In general the Triboh series is found on the flat land while on the somewhat steeper land the Bedup series can be encountered.

Acreage: 1,140.

Unit 45. MALANG/KAKAI ASSOCIATION.

Only a small acreage of this association occurs in the Triboh area. The land is flat and generally situated below the 50 feet contour. The soils comprise recent alluvials of basic igneous origin; in places it is mixed with material from sedimentary rock sources. In the lowest localities hydromorphic soils of the Kakai type are found while in higher areas with lower watertables the Malang series has developed. Both soils are of value for agriculture and can be used intensively. A separation of the series appeared to be impossible as little use could be made of air photograph interpretation, the land being all nearly flat.

Acreage: 172.

Unit 46. BEDUP/SAMARAHAN ASSOCIATION.

This association occurs in areas where the hilly landscape of shale country peters out into the peatswamps. The elevation of the hills is extremely low in these areas and hills could not be separated from flat swamp land using air photographs. The primary forest covering such areas tends to obscure any land forms which may exist. Only by laborious rentis-cutting could a separation of the two series be attempted.

Acreage: 510.

Unit 47. SAMARAHAN/ANDERSON 2 ASSOCIATION.

This association occurs in the flat swamp-land in the extreme north-eastern part of the area (Ramun area). The Samarahan series merges gradually into the Anderson series and there are no land or vegetation features, which could be used to separate the two on air photographs. An exact boundary could only be drawn after much more field observations.

Acreage: 213.

d. Fertility aspects of the main soil series.

(i) General

Fertility studies have thus far only been carried out on a few soil series, namely on Paya Megok series (in the former wet rice research station) and on Serin series. Studies on the former series entailed investigations into the growing of wet rice and off-season crops while studies on the latter are mainly confined to pepper. Fertiliser trials for hill padi were also laid down on various residual soils. An evaluation of these series based on agronomic studies of these soils can be found at the end of this chapter.

Studies on crop behaviour carried out in Tarat Experiment Station were mainly confined to the Terbat and Ramun series. Most studies however consisted of observations only and no statistically reliable fertilizer trials were carried out. Our crop recommendations for these series are mainly based on the work at Tarat.

Although the aforementioned studies are of importance they cover only a small portion of the total number of soil series found in the area and many more agronomic studies will be necessary before giving any definite recommendations. It would however be unrealistic to postpone development until such information is available because such studies are necessarily of a long term nature.

Analyses are available from previous surveys carried out in the area. These mainly comprise data on available or extractable nutrients. Because it is physically impossible to incorporate all the data in a report of this nature their most significant aspects only are selected and discussed. The interpretation of the analyses is difficult because no studies of any significance have yet been undertaken to correlate soil analyses with crop behaviour. It is mainly for these reasons that the relative fertility of the series is discussed rather than their absolute fertility levels.

It was found that the difference in available nutrients between most series was obscured by landuse because these nutrient levels appeared to be more directly related to the organic matter of topsoil than to the inherent characteristics of the solum.

For the purpose of this survey the soils were analysed for their "reserve" nutrient content (ignition at 800°C and digestion with 35.4% W/S HCl) in order that field differences between series could be correlated with chemical composition. They do not necessarily indicate fertility levels, although, as may appear in the discussion, there is some evidence that for certain soil groups the total extraction of nutrients seems to be indicative for the availability of some nutrients (e.g. phosphate in hydromorphic soils). Analyses of "reserve" nutrient contents can be found in Appendix B under the respective series names.

Acidity

All soils appear to be highly acid with pH values ranging from 4 to 5. Generally pH in topsoils is 1 unit lower than in the subsoil which indicates that most soils have been thoroughly leached. A higher pH in the subsoil may also indicate that weathering rock material is present, this is specifically so with the soils derived from basic igneous rocks. Paya Megok series is only moderately acid in the subsoil which is mainly due to the presence of limestone beneath the soil. A high pH often indicates the proximity of limestone outcrops; this also has an effect on the exchangeable calcium content.

Cation Exchange Capacity.

Cation exchange capacity in topsoils is directly related to the organic matter content. C.E.C. in subsoils however is related to clay minerals and is generally very low, seldom more than 10 m.e./100 gms. This may be an indication that kaolin is the most important clay mineral in all soils, which is supported by some clay mineral analyses carried out on 7 series (Tarat, Bedup, Kerait, Serin, Paya Megok, Malang and Kakai series). In the Tarat series C.E.C. is seldom more than 6 m.e./100 gm. and analyses on sesquioxides reveals that the total iron and aluminium oxide content is above 40%. This indicates that the very large clay fraction is dominated not by Kaolin but by oxides.

Exchangeable cations.

Base saturation in all soils is very low (generally 20 - 10% and sometimes lower) indicating severe leaching. Only under primary forest can values of more than 25% be found in the topsoils. The favourable nutrient content of these topsoils is quickly destroyed under shifting cultivation. Alluvial soils under wet conditions have generally higher base saturation values than the residual soils and dry alluvium. Presumably the nutrient level in the former is maintained by yearly-occurring floods. Favourable exceptions are therefore the Bentang, Paya Megok, Kakai and Simuja series and to a lesser extent the Samarahan series.

As indicated above, the amount of exchangeable cations in the absorption complex is directly linked with organic matter content and land use, so much so that e.g. the Tarat series which may contain relatively high amounts of exchangeable cations under primary forest, is poorer in such cations than e.g. a poor shale soil if the former has been used for shifting cultivation practises for a considerable time and the latter occurs under primary forest. Nitrogen is also related to the organic matter content and land use and is generally very low. As is the case with base saturation leaching and land use have affected the exchangeable nutrient contents to such an extent that differences between soil series, if they ever existed, have been levelled out. To some extent only in the wet alluvial soils they can be used to discriminate between series.

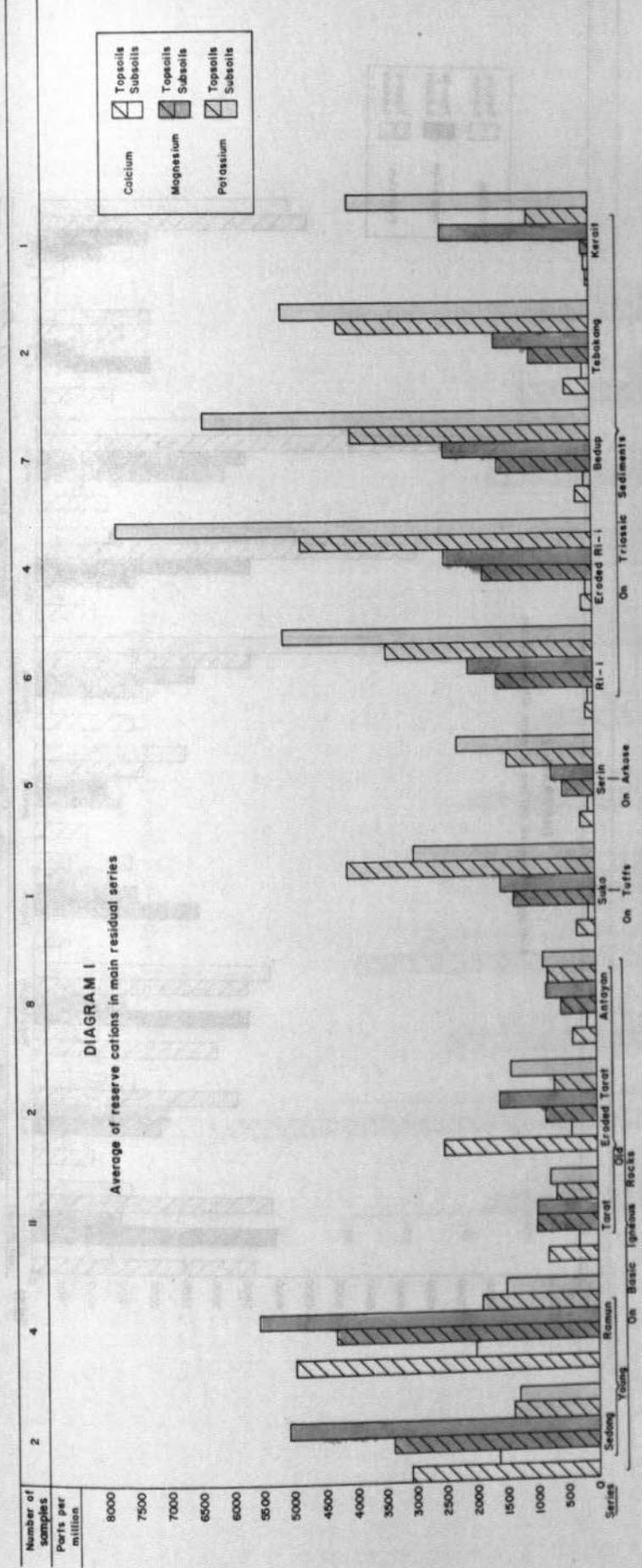
"Reserve" nutrients

A study of the total ("reserve") chemical composition of the soils has given a better insight of the different chemical characteristics of the soil series. Diagrams 1 and 2 show that the levels of calcium, magnesium and potassium vary significantly in the various soils. The residual soils derived from basic igneous rocks are all characterised by higher total calcium than in any other series. The same applies to the total magnesium content. Most probably the high content of calcium-and magnesium-bearing minerals in the latter have caused this difference. Also the younger soils on basic igneous rocks, such as the Sedong and Ramun series, show higher contents of total calcium and magnesium than the mature soil on these rocktypes (Tarat and Antayan series). On the other hand all series on sedimentary rock material of Triassic age are characterised by significantly higher potassium contents than the ones found in the soils on basic igneous rock types. The Tarat and Antayan series together with the Serin series derived from arkose appear to have the lowest contents of total "reserve" nutrients of all the residual soils, which points to a highly weathered and highly leached stage in soil development. The high total potassium content in the soils derived from Triassic sediments is possibly caused by their high amount of potassium-bearing minerals, (see page 12). Analyses from similar soils but derived from Cretaceous sediments show lower values of total potassium and it is known that these sediments differ from the Triassic sediments in content of potassium-bearing minerals.

It is possible that the potash fixation of soils on Triassic sediments is sufficiently high to prevent their complete leaching. Most soils are highly weathered and leached and one would not expect that potassium would still appear to be present in the soils as the principal cation.

In the alluvial soils the same trends can be noticed. In the Bentang, Paya Megok and Kakai series (derived from base igneous rock source material) total calcium and magnesium appear to be higher than in the other alluvial series, the Samarahan series may be an exception. It was not possible to have more than 1 profile analysed for each alluvial series and the single value of one pit may not be representative of the general trend which has been found for the residual series. Less importance can therefore be attached to the figures in diagram 2.

Diagram 3 showing "reserve" phosphate content in the soil series indicates that the residual soils derived from basic igneous rocks contain more reserve phosphate than the other residual series. It is also evident that the younger soils (Ramun) are higher in reserve phosphate content than the mature soils (Tarat and Antayan). It was expected that the Sedong series would show the same trends as found in the Ramun but surprisingly the Tarat and Antayan showed higher values. It may be possible that colluvial material washed down from upper slope areas have enriched the topsoils of the Tarat and Antayan series.



Number of samples
Parts per million

8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0

Series

2 4 8 10 12 2 4 6 1 5 6 4 7 2 1 1

Sedony Young
Raman
On Basic Igneous Rocks

Tarat
Eroded Tarat
Antayan
On Tuffs

Suko
On Arkose

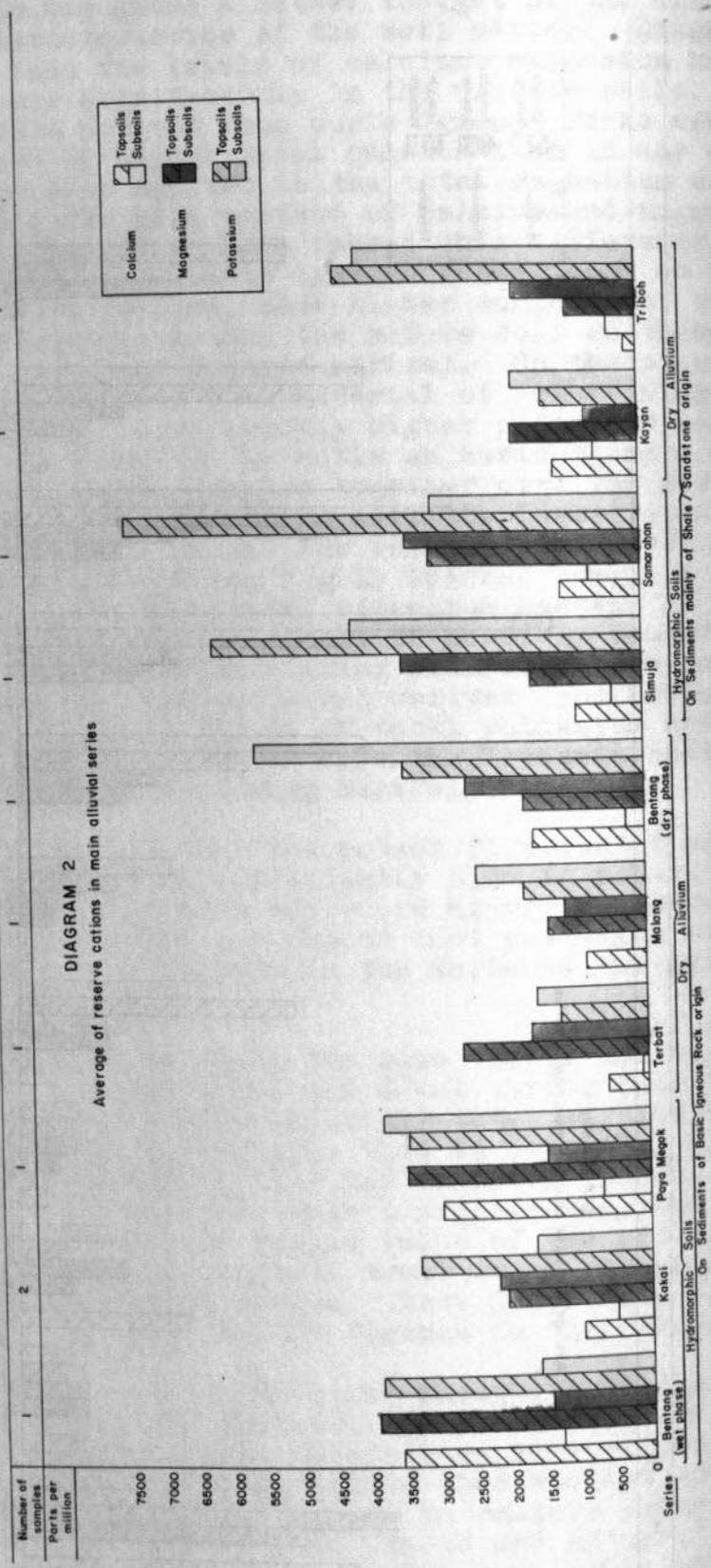
RI-1
Eroded RI-1
On Triclastic Sediments

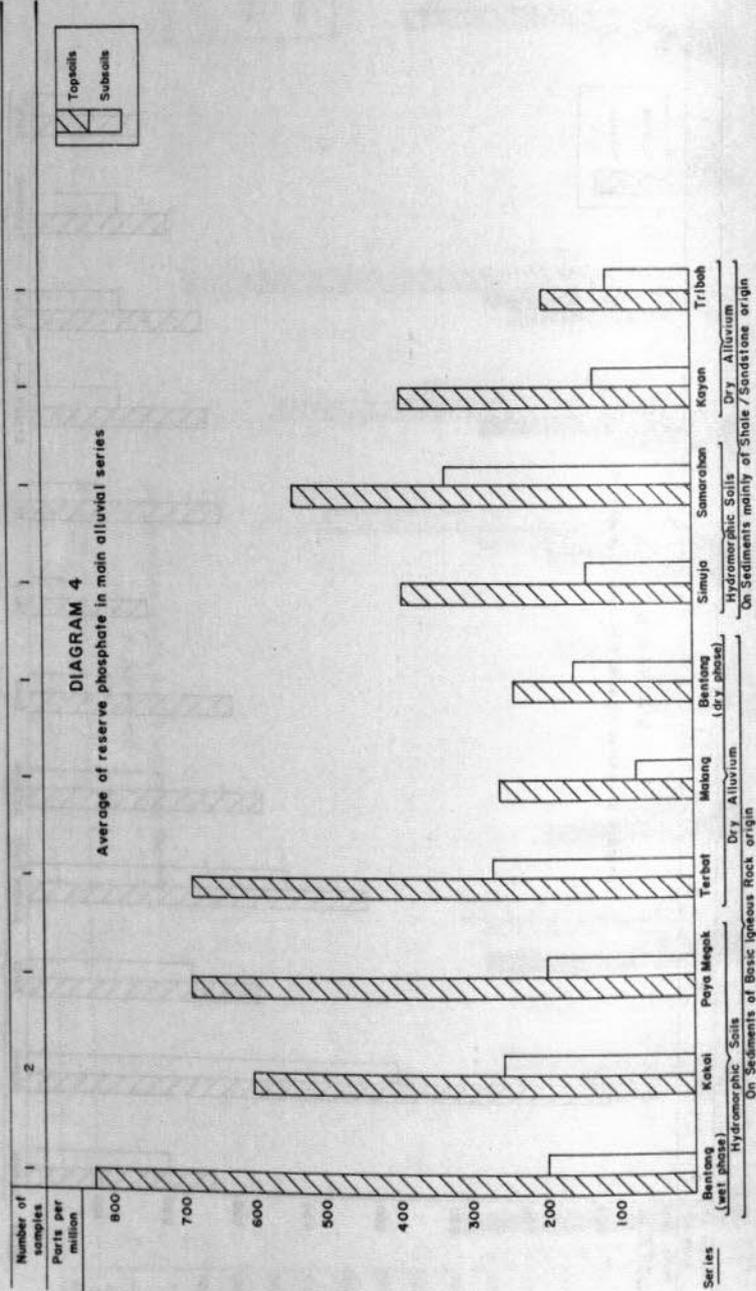
Bedup
Tabokong
Kerall

Legend:

- Calcium (white)
- Magnesium (diagonal lines)
- Potassium (cross-hatch)
- Ca Subsoll (horizontal lines)
- Mg Subsoll (vertical lines)
- K Subsoll (diagonal lines)

DIAGRAM 2
Average of reserve cations in main alluvial series





Topsoils
Subsoils

Series

Number of samples
Parts per million

On Sediments of Basic Igneous Rock origin
On Sediments mainly of Shale / Sandstone origin
Dry Alluvium

In the alluvial series the reserve phosphate contents (diagram 4) again show a significantly high level in the soils developed on basic igneous material (Bentang, Kakai, Terbat and Paya Megok.) It is also clear that the levels in all the alluvial soils are appreciable higher than in the residual soils. This is in general also true for the total cation content as shown in diagrams 1 and 2.

Summarizing, it appears that the chemical composition of the residual soils on basic igneous rock material appears to be different from the residual series found on sedimentary rock material. This is also the case for the alluvials derived from these two rocks types. Apart from the potassium content levels the bases seem to be generally highest in basic igneous rock derived material. Whether or not this difference will have any agronomic significance will need testing in the field. It is possible that the phosphate fixation is high in the soils on basic igneous rocks because of the high free iron content, while it is expected that e.g. the shale soils with their generally lower levels of free iron will respond better to phosphate fertilizer in the first instant. Shales however may fix considerable amounts of phosphate if the soils are rich in exchangeable aluminium. Differences in fertilizer requirements can therefore be expected mainly between the group of series found on the basic igneous rocks, and possibly the Serin series on arkose, and the soils derived from sedimentary rock material. It is difficult to give similar indications for the alluvial soils due to the important role of soil drainage.

Although the fertility of soils should not be gauged solely by levels of reserve nutrients in the soil it is still noteworthy that all soils on basic igneous rocks and their alluvial counterparts also appear to be superior soils when cropped. This observation may be an indication that the total nutrient levels in soils of the nature occurring in the Serian area appear to be related more to inherent fertility than one would normally think. Further studies into these "unavailable" sources of plant nutrients are at present carried out and they may well prove to be valuable in future fertility studies.

Physical fertility.

Physical fertility is related to soil characteristics other than the purely chemical ones namely, structure, drainage and consistency.

Again it appears that all soils derived from basic igneous rocks have better physical characteristics than the soils found on shales and sandstones. This is also true for the alluvials derived from basic igneous rock sources. These soils are all more crumbly and structure is better developed. Most other series have no structure at all in the field condition, being continuously wet. They develop however very strong blocky macro structures when dried out. This is particularly the case with the soils on shales. Structure seems to be significant in relation to root development. In a chemically poor soil where root development is not hindered by a bad structure the plant may be able to reach more nutrients than in a chemically richer soils where root development is hampered by a bad structure. Structure appears therefore to be an important factor in plant growth in the area.

To conclude this chapter an attempt has been made to place the main soil series in 6 classes showing different fertility levels.

This classification (table 5) is based purely on field observations supported by some chemical analyses of the nature discussed in foregoing paragraphs. Such a classification may be unscientific but where development cannot wait for more scientific evidence a practical way should be followed to indicate which soils have most potential. This fertility rating has in fact been used for the compilation of the advisory landuse map discussed in the next section of the report.

TABLE 5.

Grouping of series according to fertility based mainly on field - observation.

Fertility	Residual soils	Alluvial soils
Level	1. Sedong, Ramun	Bentang (wet)
Level	2. Tarat, Antayan	Paya Megok, Kakai Bentang (dry)
Level	3. eroded Tarat, Serin, Bayur	Terbat (probably 2 for certain crops) Malang.
Level	4. Ri-i, Suka	Simuja, Kayan
Level	5. eroded Ri-i, Bedup, Tebakang	Samarahan
Level	6. Kerait	Triboh.

In the next section an account is given of the agronomic studies which have so far been carried out on known soil series in the Serian Area.

This work which was carried out by the Rice Agronomist, Pepper Agronomist and Fieldcrop Agronomist has been digested from the 1962 Annual Report of the Department of Agriculture. The results of the trials are in themselves sufficiently conclusive and no further comments are needed.

(11) Fertilizer trials on Serin series for pepper.

The following is an extract from the annual report of the Department of Agriculture for 1962. (ref. 18)

ORGANIC FERTILIZERS vs INORGANIC FERTILIZERS IN COMMERCIAL GARDENS.

Treatments:	A Blood-and bone meal	B N.P.K. mixture	C N.P.K. Plus trace elements
1.	3 lb/vine	1.5 lb./vine	(B1) plus 0.5oz/vines
2.	6 "	3 "	(B2) " 1.0 "
3.	9 "	4.5 "	(B3) " 1.5 "
4.	12 "	6 "	(B4) " 2.0 "
5.	15 "	7.5 "	(B5) " 2.5 "

ORGANIC vs. INORGANIC FERTILIZERS
(Green berries, lb./acre)

Level	Treatment Group		
	A Blood and Bone Meal	B N.P.K. Inorganic Fertilizer	C N.P.K. Inorganic + Trace Elements
as above			
1	6,156	5,644	9,044
2	7,310	6,834	9,520
3	6,970	8,296	9,860
4	6,698	6,936	10,370
5	6,868	6,834	10,268
		Least sig. diff., $p=0.05$	1,666
		Coeff. of variation	16.8%

The yields show that on the Serin series there is a significantly greater response to inorganic fertilizers plus trace elements than to both organic and inorganic fertilizers.

N.P.K. trials in commercial gardens.

Treatments: N_0, N_1, N_2 - 7, 21, 35 oz urea/vine/year resp.

P_0, P_1, P_2 - 14.5, 43.4, 72.5 oz double super/vine/year

K_0, K_1, K_2 - 1.6, 9.6, 17.6 oz muriate of potash/vine/year.

All manurial treatments were given in four split dressings.
Yields: green berries, lb. per acre)

FERTILIZER TRIAL, YOUNG PEPPER VINES.
(Yield green berries, lb. per acre)

	N ₀	N ₁	N ₂	Mean
P ₀	8,925	10,030	10,001	9,651
P ₁	8,981	8,330	7,847	8,386
P ₂	9,151	9,321	10,710	9,727
K ₀	6,997	8,925	9,066	8,330
K ₁	10,142	8,755	8,782	9,228
K ₂	9,918	10,001	10,710	10,210
Mean	9,019	9,226	9,520	9,254
=====				
	P ₀	P ₁	P ₂	Mean
K ₀	8,840	8,585	7,565	8,330
K ₁	9,887	7,621	10,171	9,228
K ₂	10,229	8,952	11,446	10,210
Mean	9,651	8,386	9,727	9,254
Least sig. diff. marginal means, p = 0.05				1,241 lb.
Least sig. diff. means in body of table, p = 0.05				2,203 lb.
Coeff. of variation:				17.7%

The experiments shows that on the Serin series a significant response (at p=0.01) could be obtained only to potassium. No other treatment difference reached significance although there is a tendency for nitrogen to increase yield.

(iii) Fertility trials for hill padi.

For a number of years the Rice Agronomy Division of the Department has carried out fertility trials for the growing of hill padi on a number of residual soil series. The series involved were mainly: Tarat, Bedup, Kerait, Tebakang and Serin (in the old classification placed in the Bayur Association).

The trials involved the mixing of two pounds of Ammophos 11.48 (11% N, 21% P) per gantang of seed prior to planting and the fertilizer was therefore placed in the soil together with the seed. Although the coefficient of variation generally has been variable over the years in which the trials were carried out the results have on the whole been sufficiently encouraging. The Rice Agronomist in his report over the year 1962 (ref. 18) states 'that the results obtained from the use of ammophos over the last few years have warranted its large scale trial in the 1962/63 season as a preliminary to its being recommended for general application with dry rice.'

Simple trials to test the effect on yield of hill padi by a number of major elements (N.P.K.) were carried out in 1962 in a number of soils; the series involved in the Serian area were the Serin and the Tarat series mainly. The 1962 report states that the general picture which emerged from these results is of a response to nitrogen and phosphorus and of increasing responses when these two nutrients are applied in increasing quantities in combination, up to the limits of the experiment (highest level of N. was 40 lb. per acre, P 36 lb. per acre. On the Serin series there appeared to be a response to potassium (10lb. potassium per acre mixed with the highest levels of N. and P.) It is interesting to note that both for pepper and hill padi a response to potassium was obtained on this series. According to the analytical data (see diagram 1. in this chapter) the Serin shows also the lowest reserve potassium content for all residual series.

(iv) Off-season cropping.

Trials on off-season cropping were carried out on Paya Megok series. The report for 1962 states 'At Paya Megok an experiment on tobacco variety Virginia Gold compared the following factorial combinations: cultivation on beds vs. the flat, presence vs. absence of inorganic fertilizer (25 lb phosphorus and 20 lb. potassium per acre) and presence vs absence of cattle manure (5 tons per. acre). Vegetative growth of plants on beds was notably superior to those cultivated on the flat; there was a marked response to a combination of organic and inorganic manure and either alone was better than none. It was unfortunate that the crop was destroyed by flood in its later stages just as harvesting begun. Other crops included sweet potatoes, maize, chillies, cucumber, ground-nuts, spinach, soya bean, angle loofah and long bean.

Mixed farming on the Paya Megok series (cattle and the growing of off-season crops together with a stock-feed) may be the answer to make the most of the potential of this series which suffers annually from heavy flooding. This has been considered in the compilation of the land advisory use map discussed in the next section.

(v) Observations on crop-growth in Tarat.

A large number of crops are grown at Tarat Agriculture Station to observe their behaviour under local conditions. Unfortunately the departmental annual reports make no reference to the soil type on which the observations were carried out. The most interesting trial in this context is the banana variety observations and the cocoa observation trial located on the Ramun series. Also of interest is the soya bean variety observation which was carried out on the Terbat series.

All three observations were reported in the departmental annual report over 1962 and an extract of this report reads

Banana Varieties Observation.

'The banana varieties planted in April 1961 at three different spacings according to the size of the mature plants have come into bearing. The following table shows the performance of the varieties planted.

BANANA VARIETY OBSERVATION, TARAT.

Variety	Spacing	Average weight bunch (lb.)	Maturation time (months)	Potential Yield/acre/year (lb.) +
Serendah	8 ft. x 8 ft.	28	9	64,348
Embun	12 ft. x 12 ft.	41	10	43,573
Otel	8 ft. x 8 ft.	14	5½	39,133
Pisang	10 ft. x 10 ft.	29	10½	36,543
Nipah	10 ft. x 10 ft.	24	10½	28,868
Mas	8 ft. x 8 ft.	16	6½	21,403
Mađu	10 ft. x 10 ft.	20	8	16,468
Keling	10 ft. x 10 ft.	13	12	14,894
Bontal	10 ft. x 10 ft.	12	7½	9,397

+ The potential yield calculated on the number of plants per acre at the spacing shown. The number of plants recorded varied from 5 to 63.

The popular varieties are Serendah, Otel, Mas Keling, Tandok, Embun and Rajah of which Serendah, Embun and Otel appear to have a high yield potential.

Cocoa observation Plot.

The Amelonado variety of cocoa, planted in 1950 at two spacings, 15 feet x 15 feet and 10 feet x 10 feet, has now been harvested for three seasons. The cocoa beans were processed at Tarat Station and both sun drying and drying using a Samoan cocoa drier were tried.

The following table gives a summary of the potential yields.

COCOA OBSERVATION PLOT, TARAT (Ramun series)
(Yield dry beans, lb. per acre)

Spacing	1959-60	1960-61	1961-62	Mean
15 ft. x 15 ft.	821	1,424	2,187	1,477
10 ft. x 10 ft.	742	529	3,028	1,433

Over the three harvests there was little difference in the yields of the trees at the two spacings. On a per acre basis twice as much fertilizer was applied at the 10 feet square spacing. The beans were of inferior quality to those of West Africa and efforts are being made to improve their processing and storage.

Soya Bean Varieties Observation. (on Terbat series)

Six varieties of soya bean were grown at Tarat in small plots of 0.01 acre in size.

Nonok and Tenom are early short-term varieties, Java No.1, Java No.2 and Kudat intermediate and Goshen late. Nonok and Tenom gave the highest yields. About a fifth of the crop from Goshen could not be harvested as it was spoilt by wet weather.

SOYA BEAN VARIETIES, TARAT

Variety	Yield/acre clean seed (lb.)	Maturation Period (days)	Remarks on seed
Tenom	849.5	86	Large, greenish.
Nonok	801.0	86	Slightly tinged with green.
Java No.1	697.6	93	Slightly tinged with green.
Java No.2	509.7	93	Slightly tinged with green.
Kudat	388.3	93	Larger than Goshen and less shiny.
Goshen	242.0	120	Small, regular and golden yellow.

SECTION 4 -

THE ADVISORY LAND USE MAP.a. Basic criteria used for the compilation of the Advisory Land Use Map.

The following factors were taken into consideration for the compilation of the Advisory Land Use Map.

(1) What crops can at present best be grown in the area? The climate which is continuously wet limits the range of crops which can be grown. Soil suitability sets again a limit. Apart from climate and soil there are economic reasons why it is better not to grow certain crops.

(ii) What soil and land type is the most suitable for these crops?

For this we have used characteristics such as soil depth, soil structure and texture, drainage, liability of flooding, morphology of the terrain and inherent fertility of soils. Factors such as liability of flooding and fertility are difficult to evaluate because for the former we have no reliable sources for obtaining information while for the latter insufficient agronomy studies have yet been made on the soils concerned to give a reliable forecast on crop behaviour from analytical data only.

(ad i) The main cash crops for the area are undoubtedly pepper and rubber. Although not much pepper is at present grown by the Dayaks in the area, they have shown interest in this crop. It is mainly lack of cash and knowledge on which most of these trials have foundered. Rubber, which not so long ago was not planted by the Kayan Land Dayaks because of religious reasons (see page 18), appears now to have been accepted by most kampongs as the best crop for obtaining a cash income.

Although certain soils are suitable for the growing of oil palm this crop is however not considered of value for the area because in general suitable low undulating land is very limited and scattered. The difficulty of transportation would appear to be the main reason why oil palm cannot be recommended for the area.

Fruit crops such as papaya, bananas, citrus and improved varieties of mango, jackfruit and rambutan are valuable, especially because of the nearness of the comparatively large market in Kuching. There is a danger of over-production. Home consumption may take up some of the over-production but the amount will be small. If planted in small lots these crops could, however, form valuable subsidiary cash crops.

Coconut is suitable for growing on a larger scale than at present for home consumption.

For the lowlands due consideration has been given to a continuous growing of wet rice. Only such areas, where an improvement in irrigation and drainage is within the possibilities, have been marked as having potential for this type of farming.

Areas where flooding occurs frequently, thereby causing partial or total crop failures, have been classified as such and advice has been given on their future useage. This can be either a switch over to dry farming in the less wet season when crops such as tobacco, vegetables, pastures and fodder-crops can be grown, or, where the soils appear to be less suitable for these crops, a continued growing of wet rice can be practised. Only with heavy applications of fertilizers can the latter soils in future also be used for dry farming.

(ad ii)

Where soil depth and slopes are considered unfavourable for agriculture but the soils are otherwise moderately good (e.g. in nutrient status), such areas have been recommended for reafforestation. Generally these areas, which are mainly used for shifting cultivation, are too remote from present kampong sites for the cultivation of permanent crops which need daily attention. In certain locations rubber could be grown.

Areas with very bad topography or very bad soils which can be considered permanently unsuitable for agriculture have been marked as such. If the primary forest has been removed it might be advisable to reafforest such areas where possible. It will appear that most of these areas are still covered with primary forest because they are regarded as unsuitable for even shifting cultivation.

The limits beyond which agriculture is regarded as an uneconomic proposition under the present conditions, has been set rather high for the obvious reason that if limiting conditions defined and classified in other parts of the world or other parts of Malaysia were to adopted there would be hardly any land left which was officially classified as worth developing.

b. Detailed description of the legend used for the
Advisory Map.

The area has been divided into two parts:

Part 1 - comprising all areas of flat to low undulating and hilly or rugged topography, not or very little affected by flooding.

Part 2 - comprising all flat land affected by flooding in the wet monsoon.

This division gives us an immediate breakdown into two conditions suited for quite contrasting types of farming.

Part 1 has been further subdivided into 7 categories, while Part 2 has been subdivided into 5 categories. In the range 1 upwards the categories show a decrease in possible agricultural useage, i.e. crop choice. This does not necessarily imply a decrease also in land value, although under the present conditions this may also be so.

Part 1 Flat to low undulating, hilly and mountainous terrain not or slightly affected by flooding.

This included practically all hill or residual soils and those high lying parts of terraces and levees soils which are not or very little affected by flooding.

1.1 - Category 1.

Land suitable for a wide variety of shallow and deep rooting crops of which are recommended:

pepper as primary cash crop
rubber as secondary cash crop.

Additional crops: Fruit trees such as papaya, bananas, rambutan, mango, jackfruit, coffee.

All crops need fertilizers for maximum crop production. Conservation measures are needed in parts of the area especially when no cover crops are used.

1.2 - Category 2.

Land suitable for a wide variety of shallow and deep rooting crops with resistance to occassional flooding of short duration. In general all crops recommended for category 1 could be grown with the exception of pepper. On the Terbat soils in this category the growing of cacao and coffee would also be possible.

1.3 - Category 3.

Land mostly suitable for rubber and in selected places for pepper and rubber. With good management, which involves proper drainage and conservation methods, cover crops and fertilization, the range of crops could be increased.

1.4 - Category 4.

Land with moderate possibilities for rubber only.

1.5 - Category 5.

Land with limited agricultural possibilities owing to bad topography. In selected places perennial crops can be grown with advantage. Recommended use: If occurring near villages, rubber. For the remaining part reafforestation with the object of timber extraction in the future is recommended. In selected places and near kampongs pepper could be grown.

1.6 - Category 6.

Land with very low agricultural potential because of low soil fertility and/bad topography. Recommended use: rubber can be grown if necessary. In places soil conservation is needed.

1.7 - Category 7.

Land with no agricultural potential. Recommended use: to be left under primary forest or to be reafforested for improvement of water supplies.

At present most of these categories are used for shifting cultivation, the best results being obtained on land categories 1, 2 and 3. In the gradual process of changing over from shifting cultivation to permanent cultivation difficulty may be experienced in releasing the best soils for permanent cultivation because they are also the highest yielding hill rice soils.

Part 2 - Flat land, affected by flooding in the wet monsoon.

This includes all land which is affected by floods or is inundated during most part of the wet monsoon. Most areas are at present in use for wet rice cultivation, some every year, others in a 3 to 9 year rotation.

2.1 - Category 1.

Land on which flooding occurs very infrequently if at all and which has fertile soils. Recommended use: either wet rice cultivation in wet season, if better control of irrigation water and drainage can be achieved, or, in dry monsoon, suitable for pastures, market gardening, maize, tobacco. Double cropping might be possible under good management.

2.2 - Category 2.

Land liable to uncontrolled flooding but with fertile soils. In dry season suitable for a wide variety of crops with a short growing season. Recommended use: Either pastures (cattle farming) or tobacco, maize and market garden crops. Mixed farming would be advantageous. Cattle should be stall-fed in the wet season while in the dry season the pastures could be used. This possibility needs further study. If there is no other alternative, wet padi cultivation can continue but crop failures will occur frequently and, because of the uncontrolled flooding, the application of fertilizers for raising yields would be wasteful.

2.3 - Category 3.

Land liable to uncontrolled flooding and with soils of moderate fertility.

Recommended use: as for category 2.

In general heavier applications of fertilizers will be necessary so that this land would be less economic to farm than category 2 land. If there is no other alternative wet padi cultivation can continue but rotations of 3 or 4 years will be needed for sustained moderate crop yields. Irrigation cannot be improved owing to unfavourable topography.

2.4 - Category 4.

Land liable to uncontrolled flooding with soils of low fertility.

Recommended use: Only to be used if no other flat land is available. The use of the land in the dry season has advantages above useage for wet padi cultivation but management will be difficult and costly. At present the soils are best left untouched if there are other soils available for wet padi cultivation. In places the growing of sago for pig fodder might prove to be the most advantageous use of this land category.

2.5 - Category 5.

Land with no agricultural value. Mainly deep peats.

The categories with their schematic definition are shown in table 6 which is identical to the key used for the Advisory Land Use Map.

c. Practical application of the advisory map.

The map could best be used for overall regional planning purposes.

For these purposes it will be necessary to make some calculations on the land which might be available for the various crops or land use systems. Some words about the accuracy of the map are therefore appropriate.

One should firstly keep in mind that, as with mapping units on the soils map land categories on this map contain small areas of other land categories which are unmappeable on the map scale used because of their small size. According to international standards it is still within the permissible limits if in an area mapped as one unit a maximum of 20% of this area is formed by areas of another mapping unit. The accuracy of this map is well within these limits. The error will be less important in the areas mapped as categories with low suitability because the map then underestimates the value of such land. For categories 1 and 2 it would however be best to deduct 20% from the total mapped area.

It is also necessary to deduct from all measured areas a certain percentage for land which will never be used for a variety of reasons, (small streams, bad topography, paths etc.) In certain areas this could be as much as 20%. This depends largely on topography and it will be most in the areas of low agricultural value. It is suggested to allow for Category 1 land a percentage of 5%, class 2 a percentage of 10%, class 3 land 15% and for the remainder 20%.

Part 1

Flat and hilly land not or slightly affected by flooding during the wet monsoon.

Category 1.1 - Land with high agricultural potential. Recommended crops: pepper, fruit crops such as bananas, papayas, rambutan, mango, citrus and rubber.

Category 1.2 - Land with high agricultural potential but with a few restrictions in crop choice owing to floodings of short duration or difficult terrain. Recommended crops: as for category 1 but excluding pepper, and including coffee and probably cacao.

Category 1.3 - Land with moderate agricultural potential owing to topographic limitations and soil-fertility. Recommended crops: Rubber, in selected places pepper. Soil conservation is needed in most of the area.

Category 1.4 - Land with moderate to low agricultural potential. Recommended crops: rubber only. Soil conservation is needed in most of the area.

Category 1.5 - Land with limited potential for agriculture owing to bad topography and in places due to bad soil conditions. Recommended use: reforestation or the planting of commercial tree crops such as rubber where soil conditions are better. Pepper in selected places. Soil Conservation is essential throughout the area.

Category 1.6 - Land with very low agricultural potential because of low soil fertility and/bad topography. Recommended use: rubber can be grown if necessary. In places can conservation is needed.

Category 1.7 - Land with no agricultural potential owing to bad topography and bad soil conditions.

Part 2

Flat land affected by flooding in wet monsoon

Category 2.1 - Land with high agricultural potential; suitable for pastures, market gardening, tobacco, maize and other annuals in the dry season. Suitable for wet rice cultivation in the wet season. Drainage and irrigation should and can be improved.

Category 2.2 - Land with high potential for agriculture but which cannot be used during the wet season with advantage because of flooding. Recommended use: either annuals such as tobacco, maize, market garden crops, fodder crops or pastures. Rotation is recommended. Wet rice cultivation is possible but cropfailures due to flooding may occur frequently.

Category 2.3 - Land with moderate agricultural potential owing to risk of flooding and low fertility of soils. Recommended use: either for annual crops having short growing season as for category 2.2. or pastures. Fertilizers are essential. Wet rice can be grown but frequent cropfailures can be expected due to flooding.

Category 2.4 - Land with low agricultural potential owing to serious risk of flooding and bad soil conditions. Recommended use: should be used mainly in the dry season for annual crops having short growing season. Heavy applications of fertilizers may be necessary. Only to be used for wet rice if no other land is available. In places sago is recommended for pigfodder.

Category 2.5 - Land with no agricultural potential. Mainly deep peats.

In practise it would appear that from all measured areas a total of 25% should be deducted to arrive at a reliable estimate of the land which can definitely be used for agricultural purposes.

Village plans can than be compiled because from the advisory map it can readily be seen what type of farming and what crops would be the most appropriate for the village.

It is recommended that for all wet padi land in the village a reliable survey should be carried out in the liability of flooding. In the advisory map we have used terrain knowledge, experience gained during surveying and by inquiring. A more detailed plan for a village will definitely need more detailed investigation of this nature.

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TABLES OF LAND CATEGORIES IN KAMPONG AREAS

Kampong areas shown in map, Land Advisory Use (Sheet 1) Map	Cate- gory 1.1	Cate- gory 1.2	Cate- gory 1.3	Cate- gory 1.4	Cate- gory 1.5	Cate- gory 1.6	Cate- gory 1.7	Cate- gory 2.1	Cate- gory 2.2	Cate- gory 2.3	Cate- gory 2.4	Cate- gory 2.5	Cate- gory 1.1+ 1.2	Cate- gory 1.2+2	Cate- gory 1.6+ 1.4	Cate- gory 2.1+ 1.1	Cate- gory 1.1+ 1.5	Cate- gory 1.3+ 1.1	Cate- gory 1.2+ 1.4	Total acreage
NYABET	-	-	117	437	105	422	405	13	531	-	37	-	-	152	292	-	-	-	-	2,508
SIRA (kampong outside area)	-	44	23	310	307	32	840	-	-	-	-	-	-	46	-	-	-	-	-	1,602
TAI-I	301	308	890	1187	364	138	465	472	776	165	39	-	-	-	-	-	-	-	74	5,179
BARU/BUNGA	173	179	631	137	165	-	693	88	-	7	-	-	-	-	-	-	-	-	-	2,073
KAKENG	217	66	273	465	829	839	1351	-	-	84	10	-	-	330	98	-	-	-	-	4,562
BENTANG	184	113	42	208	235	55	728	237	-	-	-	-	-	-	-	-	-	-	86	1,888
LANCHANG	386	243	736	45	1431	-	1521	471	97	-	-	-	-	-	-	-	83	-	-	5,013
PIKCHING	250	125	755	1202	764	546	1040	238	141	273	152	-	-	409	-	-	-	-	14	5,909
KPG. TEBAKANG	40	103	69	513	12	-	8	-	83	89	-	-	-	38	-	-	-	-	-	955
JENANG	196	198	-	336	304	132	407	177	-	34	17	-	-	88	-	15	-	96	-	2,000
TANGGA	55	214	167	266	127	-	901	123	-	136	-	25	-	-	-	-	832	-	-	2,846
TARAT (MELAWI/ MAWANG)	355	182	389	-	77	-	2109	13	-	9	-	-	114	-	-	-	-	-	-	3,248
RI-I/(MAWANG/DASO)	465	343	487	153	293	-	720	447	165	25	-	163	-	-	-	-	830	-	-	4,091
KPG. SEKADUK	-	418	700	-	-	-	-	131	129	-	102	-	-	-	-	-	-	-	-	1,480
KPG. CHUPAK	-	-	511	-	-	295	172	475	339	34	206	-	-	-	-	-	-	-	-	2,032
SLABI	4	206	-	189	-	-	132	-	351	67	-	168	-	-	379	-	10	-	-	1,506
KAKAI	71	10	-	18	-	-	384	127	-	26	-	7	-	-	106	-	114	-	-	863
TARAT AGRIC. STATION	33	158	147	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	344
PANCHOR (outside mixed zone)	-	-	194	3	-	-	-	-	15	-	-	-	-	-	-	-	-	-	-	212
PANCHOR (inside mixed zone)	50	-	435	-	-	-	-	44	26	40	-	-	-	-	-	-	-	-	-	595
MIXED ZONE	96	262	1299	43	-	6	182	299	345	290	127	-	-	-	-	-	-	-	-	2,949
TOTAL ACREAGES	2876	3172	7865	5512	5010	2465	12058	3361	2998	1279	690	363	114	1063	875	15	1869	96	174	51,855

A P P E N D I X A
TABLES OF LAND CATEGORIES IN KAMPONG AREAS

Kampong areas shown on Topographic Map (Sheet 2)	A P P E N D I X A												Total acreage							
	Cate- gory 1.1	Cate- gory 1.2	Cate- gory 1.3	Cate- gory 1.4	Cate- gory 1.5	Cate- gory 1.6	Cate- gory 1.7	Cate- gory 2.1	Cate- gory 2.2	Cate- gory 2.3	Cate- gory 2.4	Cate- gory 2.5		Cate- gory 1.2+ 2.2	Cate- gory 1.6+ 1.4	Cate- gory 1.1+ 1.6	Cate- gory 1.6+ 2.3	Cate- gory 1.4+ 2.3	Cate- gory 2.5+ 2.3	Cate- gory 2.5 (a)
1. KPG. TANAH PUTEH			7					148	979			2680							1430	5,244
2. LEBOR	332	814	1245	421	803	96	1711	891	1060	178		5049				293			1035	13,958
3. SEBENKOL/AMPANGAN	373	175	381		735	6	2114	147	692											4,623
4. TRIBOH	181	680	104	307	88	75	574	20	123	234			172	105			217		1634	4,577
5. BELIMBIN		437	181	230		229			96	104	252	238		1146				213		3,126
6. RASAU	92	342	6	283	210	121	838						10							1,962
7. SLABI	405	52		39	291	104	969	25	66			51								2,002
8. LONGGO/BEROK	339	957		2051	345	801	1477		237	38				366	96					6,707
9. TEBAKANG		74		235		49			53		34									445
10. SOBOK/KORAN	519	545		1460	547	143	1678	381	321	51	23	369								6,037
11. MERINGGAU/PRANGKAH	545	415		1049	555	50	330	51	261	65		78								3,459
12. PARIDAN (outside area)		23		663		25		90	33	131		75								1,040
TOTAL ACREAGES	2786	4514	1924	6801	3574	1699	9841	1753	3921	801	309	8540	182	1617	96	293	217	213	4099	53,180

APPENDIX B.

1. Tarat Series, Profile S.2177/80 - on map pit number 52.

- 0 - 5" Pale brown to brown fine angular blocky clay loam, friable, abundant fine to medium roots, charcoal, earthworms, rich in organic matter, moist, abrupt irregular change into
- 5 - 18" Reddish yellow crumbly clay. Friable. Few dead roots, manganese staining (along planes of dusky red soft weathering rock pieces. Moist. Diffuse wavy change to
- 18 - 27" Reddish yellow crumbly to weak subangular blocky clay. Friable, few soft rock pieces. Moist. Diffuse wavy change to
- 27 - 60" Reddish yellow, weak subangular blocky clay mixed with soft to hard weathering rock, firm consistency, few roots. Moist.
- 60"+ Hard rock.

Parent Material: Basic Igneous rocks

Vegetation: Secondary forest 5 - 6 years old.

Topography: foot of high hill (Bukit Tarat)

Analytical data.

Laboratory No.	Depth of sample in inches	pH-H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2177	0 - 5	4.0	355	982	1146	500	n.a.
2178	9 - 14	5.0	215	375	745	342	n.a.
2179	26 - 37	5.4	213	181	903	320	n.a.
2180	50 - 60	5.3	127	234	887	319	n.a.

2. Serin Series, Profile S 2192/95 - on map profile 54.

- 0 - 4½" Strong brown granular loam, friable, moist. A very thin more sandy layer is found at the surface. Well rooted, earthworms, diffuse irregular change to
- 4½ - 22" Reddish brown crumbly loam to clay loam, friable, well rooted, some quartz pieces, earthworms. Moist. Gradual, irregular change to
- 22 - 42" Weak red, weak subangular blocky sandy clay to gritty clay, firm. Moist. This horizon merges into weathering material, which is soft and earthy containing quartz pieces. Gradual wavy change to
- 42 - 68" Red, gritty to sandy clay, granular porous appearance. Weathering arkose. Few toproots at 62 inches.

Parent Material: Arkose

Vegetation: Old rubber, groundcover-ferns.

Topography: High hilly terrain.

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2192	0 - 3	n.d.	230	130	743	1650	18.8
2193	7 - 20	n.d.	135	30	827	2000	22.8
2194	26 - 28	n.d.	87	130	899	2850	23.3
2195	50 - 68	n.d.	65	140	845	4050	24.1

Suka series, Profile S 1911/14 - on map profile 5.

0 - 4" Dark brown weak crumbly silty clay, friable, wormcasts of darker colour, well rooted, small and few rock pieces (hard), gradual change to

4 - 23" Brownish yellow massive to weak angular blocky clay, weak friable, slightly plastic, moderately well rooted, scattered red coloured rock pieces in places. Infiltration of clay along cracks and in old rootchannels. Gradual change to

23 - 35" Brownish yellow with reddish yellow and some light yellow mottles, clay, massive in profile. When broken up weak angular blocky, friable, much leached clay along fracture planes. Iron coatings of rock pieces at 28 - 35", few roots. Rock pieces become more abundant until horizon merges into weathering rock of dusky red colour with light green and yellow hues. Slightly plastic and sticky.

35 - 48"+ Profile in general well drained. Drainage retarded at 35" owing to P.M.

Parent Material: Volcanic Tuff

Vegetation: Secondary forest approximately 5 years old

Topography: Lower slope hill 20 - 25°.

Analytical data

Laboratory No.	Depth of sample in inches	pH H2O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 1911	0 - 3	3.9	287	300	1438	4125	16.9
1912	14 - 19	3.7	133	50	1809	2500	16.9
1913	28 - 34	4.1	115	150	1959	5350	23.3
1914	44 - 48	3.9	115	100	1557	3000	21.9

4. Ri-i Series, Profile S 2205/08 - on map pit 57.

Thick layer of dead leaves and litter on surface.

- 0 - 7" Grey brown granular clay loam, loose, abundant fine to medium roots, charcoal, earthworm activity. Moist. Gradual irregular change to
- 7 - 18" Pale brown crumbly clay loam, slightly firm, clay fillings in cracks, charcoal, few dead roots, moist, abrupt smooth change to
- 18 - 40" Reddish-yellow weak subangular blocky clay, very firm, in old rootchannels infiltrated clay from above, weak light grey and brown mottles, moist diffuse wavy change to
- 40 - 58" Reddish-yellow massive clay, sticky and slightly plastic, moist.

Parent material: shales of Triassic age

Vegetation: Secondary vegetation of 7 years old.

Topography: undulating hill terrain.

Note: profile sampled at wettest period of the year.

Analyses.

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2205	0 - 5	4.5	252	130	1557	3300	18.6
2206	10 - 16	4.5	235	40	2174	3450	22.6
2207	27 - 38	4.8	144	70	2132	4100	26.2
2208	45 - 58+	5.0	137	60	1360	4550	28.0

46. Truncated Ri-i series, Profile S 2084/87, on map pit 25.

- 0 - 2" litter layer of leaves
- 4 - 5" Yellowish brown, weak crumbly, clay loam, friable, well rooted, smooth gradual change to
- 5 - 17" Brownish yellow massive clay loam, friable if broken, well rooted, scattered few brown coloured weathered rock pieces, gradual change to
- 17 - 31" Reddish yellow massive clay loam, hard many brown coloured weathered rock pieces of fs. texture. Moderately well rooted, gradual smooth change to -
- 31 - 48+ 50% reddish massive clay and 50% weathered parent material of a fine sandy appearance with dark gray and red colours.

Parent material: sandy shales of Triassic age

Topography: Strongly dissected low lying terrain, slope 25 - 55°.

Vegetation: Secondary forest (12 years).

Analyses.

Laboratory No.	Depth of Sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2084	0 - 2	n.d.	300	170	1498	3500	10.2
2085	8 - 15	n.d.	125	90	1509	3850	3.9
2086	20 - 28	n.d.	125	50	1689	4500	13.1
2087	35 - 40	n.d.	150	50	3342	6650	15.7

5. Tebakang series, moderately well drained profile S 1902/06

- on map pit 3.

- ½" rootmat
- 0 - 4" Grayish brown, weak crumbly sandy clay loam, friable, well rooted, abrupt change to
- 4 - 16" Yellowish brown massive sandy clay loam, weak friable, weak gray mottling, moderately well rotted, gradual change to -
- 16 - 28" Brownish massive yellow sandy clay loam, weak reddish yellow mottling becoming increasingly stronger with depth, no roots; on
- 28 - 47" Brownish-yellow massive sandy clay with strong reddish-yellow mottles, no roots, quartz pieces in pockets, gradual change into
- 47 - ? Reddish yellow strongly weathered sandstone with strong yellow mottling

Parent Material: Sandstone of Triassic age

Vegetation: near rubber garden, lallang and ferns

Topography: On gentle sloping low hill.

Analyses.

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 1902	0 - 3	n.d.	180	200	1102	3750	6.3
1903	9 - 14	n.d.	170	1210	252	2950	3.7
1904	19 - 28	n.d.	110	80	1677	6750	8.7
1905	34 - 42	n.d.	100	90	1611	7750	11.9
1906	47 - 50	n.d.	95	70	1312	5800	11.2

Well drained Tebakang - Profile S 1894/97 - on map pit 1

0 - 3" Very dark brown, weak crumbly, sandy clay loam, friable, weak grey mottles, well rooted, moist, quite abrupt over

3 - 30" Very pale brown massive fine sandy clay with brownish and intensive light gray mottles, few roots up to 10" deep, small quartz pieces, clay infiltration along cracks (coating of darker coloured material), gradual change to

30 - 46" Very pale brown massive, sandy clay, with reddish yellow and very pale yellowish brown mottles, lenses of quartz (31-34"), at 37" iron concretions brown and soft. Gradual change into.

46 - 62" Very pale brown massive silty clay, with strong light gray and yellow mottles. Very silty to fine sandy feeling.

Parent material: probably sandy shales and sandstone of Triassic age.

Vegetation: Mainly lallang

Topography: Gentle sloping low hill.

Analyses.

Laboratory No.	Depth of sample in inches	pH-H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 1894	0 - 3	n.d.	202	660	899	4600	6.5
1895	18 - 25	n.d.	100	110	952	6500	9.8
1896	34 - 40	n.d.	127	95	2232	8900	12.9
1897	49 - 54	n.d.	145	150	1815	4400	12.1

6. Bedup series, profile S 2334/2338 - on map pit 90.

Imperfectly drained phase.

- 0 - 8 " Yellowish brown crumbly, clay loam, friable, dry, with many fine roots. Clear over
- 8 - 13" Yellowish brown blocky clay, dry and hard. Many cracks filled with alluvial clay. Few roots, gradual change to
- 13 - 23" Brownish yellow clay with fine light grey to white mottles, massive in profile, slightly plastic, moist, few fine roots, smooth gradual change to
- 23 - 38" Yellow clay with common fine light grey to white mottling. Plastic, slightly sticky, gradual change to
- 38 - 56" Yellow clay with much small quartz grit and few weathering shale pieces.

Parent material: Shales of Triassic age

Vegetation: Lallang

Topography: Slope of low hill.

Analyses

Laboratory No.	Depth of Sample in inches	pH-H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2334	0 - 7	4.2	220	280	2899	7100	15.2
2335	9 - 12	4.4	116	140	3199	8200	17.9
2336	14 - 20	4.7	90	80	2995	9750	21.5
2337	27 - 30	5.1	105	250	2594	9650	16.6
2338	41 - 48	5.0	77	20	2995	7750	21.0

Badly drained Bedup (showing affinities with Kerait)

Profile S 2071/74 - on map pit 21.

root/litter layer of fern vegetation

Dark gray, weak crumbly to single grain, clay loam, friable, well rooted, gradual change to

Light brownish-gray massive silty clay with weak gray mottles, hard, moderately well rooted. Gradual change to

Light gray massive silty clay, with few weak gray mottles. At 18 - 20" charcoal accumulations. Transition horizon of weak brownish mottling from 20 - 26"

Yellow silty clay, very compact with very pale brown mottles, very hard material. This material changes into weathering shale of the same colour.

Parent material: Probably carbonaceous shales of Triassic age.

Vegetation: Mainly ferns.

Topography: Nearly on top hill, slope 10 - 20".

Analyses.

Laboratory No.	Depth of sample in inches	pH-H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2071	½ - 5	n.d.	195	130	1282	3850	5.2
2072	6 - 9	n.d.	115	40	1252	3700	5.7
2073	9 - 13	n.d.	105	60	1312	4100	5.3
2074	33 - 39	n.d.	115	50	1653	5000	8.6

9. Kerait series, profile S 2287/2291 - on map pit 78.

- $\frac{1}{2}$ - 1" litter and leaves, partly decomposed
 0 - 5" Very dark grayish brown crumbly, sandy loam, well rooted, moist; gradual change to
 4 - 12" Grayish brown crumbly sandy loam, with faint white mottling, infiltration of clay particles. Moist, Gradual change to
 12 - 32" White angular blocky, sandy clay, with orange yellow mottles, moist, infiltration of clay along root channels, few small quartz pieces, gradual smooth change into
 32 - 45" White silty clay with strong orange and yellow mottles. (50% white, 50% mottles.)
 45 - 50+" White silty clay with pale grayish mottles. Compact.

Parent material: Carbonaceous sandy shales of Triassic age.

Vegetation: Weeds, such as ferns, cyperaceae, melastomae. Secondary forest.

Topography: low gently undulating.

Analyses.

Laboratory No.	Depth of Sample in inches	pH-H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2287	1 - 4	n.d.	150	2625	90	1000	1.4
2288	5 - 11	n.d.	55	30	150	700	1.5
2289	13 - 30	n.d.	50	60	982	2450	5.1
2290	34 - 44	n.d.	55	60	1989	5300	13.2
2291	45 - 49	n.d.	55	120	2097	4000	12.7

Triboh series, Profile S 2357/61 - on map pit 96.

4" Gray brown (10YR 5/2) sandy loam, many fine roots, charcoal pieces, moist, smooth change to

10" pale yellow (2.5Y 7/4) fine sandy clay with light gray to white mottles (2.5YN /7) (many) and common fine yellow mottles, wavy change.

29" White (10YR 8/1) fine sandy clay with many fine yellow mottles, few quartz pieces, smooth change to

38" White (2.5YN/8) sand mixed with sandy clay loam to sandy clay, wet, gradual change to

50" White fine sandy clay with many red yellow and few olive yellow mottles, moist. Quartz pieces present.

Parent material: Possibly terrace deposits.

Vegetation: Mainly weeds, Cyperacea, ferns.

Topography: Footslope of low hill near small valley.

Analyses.

Laboratory No.	Depth of sample in inches	pH-H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2357	0 - 3	n.d.	202	140	1006	4300	5.7
2358	5 - 9	n.d.	132	110	1096	5500	7.5
2359	14 - 22	n.d.	132	290	2162	6300	10.0
2360	30 - 34	n.d.	55	200	790	2300	4.0
2361	39 - 43	n.d.	115	370	1755	4000	8.2

11. Chupak series, Profile S 1943/46 - on map pit No.54

- 0 - $\frac{1}{8}$ " fine white sand on surface
- $\frac{1}{8}$ - 8" Yellowish brown (10YR 5/4) crumbly, friable sandy clay loam, well rooted, gradual change to
- 8 - 20" Sandy clay loam, (10YR 5/6) compact, well rooted. In places weak gray mottling, gradual change into
- 20 - 44" Yellow (10YR 7/6) sandy clay, moderately well rooted, moist. Alluvial clay accumulations along root channels, wormcasts, gradual change into
- 44 - 52+" Yellow (10YR 7/6) gravelly sandy clay, compact, structureless, much quartz, few weak red mottles, moderately well rooted, moist.

Parent material: Probably riverine alluvium of intermediate age

Vegetation: Old rubber, undergrowth-mainly ferns

Topography: Low gentle undulating shield between two rivers.

Analyses.

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 1943	0 - 2	4.3	137	180	5151	700	6.3
1944	12 - 16	4.2	80	550	887	750	7.0
1945	30 - 35	4.6	68	300	1042	900	9.7
1946	46 - 52	4.3	70	280	1438	1800	15.6

Simuja series, Profile S 2343/2346 - on map pit 92.

- 0-7" Light gray (N7/) clay loam to clay with many distinct yellow and gray mottles along root channels. Many fine roots, moist and sticky.
- 7-33" Light bluish gray (5B7/1) silty clay, many fine olive and few fine yellow mottles along root channels, sticky, slightly wet.
- 33-37" Olive (5Y 5/6) with bright yellow and light bluish gray (5B 7/1) mottled silty clay, plastic, sticky.
- 37-60" Gray to light gray (10YR 6/1) silty clay with few fine olive mottles, wet, plastic and sticky. Watertable at 38".

Parent material: Recent riverine alluvium

Topography: flat basin behind levee

Vegetation: grasses

Analyses

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2343	3 - 6	n.d.	395	960	3438	6200	15.5
2344	10 - 20	n.d.	460	1090	3061	7900	17.6
2345	33 - 37	n.d.	723	480	2648	7200	20.6
2346	39 - 43	n.d.	145	420	1605	4200	10.4

15. Kakai series, Profile S 1907/10 - on map pit number 4.

- 0 - 2" Dark gray (5Y 4/1) crumbly, clay loam, friable, many rice roots with red coatings along root channels, moist, abrupt over
- 2 - 15" Yellowish brown (10YR 5/4) dense structured, silty clay loam with reddish yellow (5YR 6/8) and olive gray (5Y 6/2) mottles; many black coloured Fe/Mn concretions. Red coatings along many old rice roots, gradual change to
- 15 - 33" Yellowish brown (10YR 5/4) with dense strong light gray (2.5Y 7/10) and reddish yellow (7.5 YR 6/8) mottled sandy clay.
- 33 - 45" Bluish gray (5BG 5/1) sandy clay with along roots only light olive brown (2.5Y 5/6) mottling. Gley horizon. Wet. Watertable at 45".

Parent material: Recent alluvium of basic igneous rock origin.

Vegetation: Rice stubble and grasses

Topography: Flat valley bottom

Analyses

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 1907	0 - 2	n.d.	330	1320	3414	5450	14.2
1908	7 - 13	n.d.	122	700	1701	3100	13.2
1909	18 - 26	n.d.	175	480	1246	3700	12.9
1910	25 - 42	n.d.	137	330	1731	2100	12.3

Paya Megok series, Profile S 2133/36 - on map pit 38.

5" Very dark brown subangular blocky, loam, weak gray mottles (surface gleying), many earthworms, abundant fine to medium size roots, clear smooth change to

16" Gray brown weak subangular blocky clay loam with distinct gray and rusty coloured mottles, in cracks soil material from above has accumulated, along rootchannels gray and rust coloured coatings, diffuse wavy change to

32" Gray to light gray massive, silty clay with distinct gray mottles, sticky and plastic, rich in decayed peaty wood remnants. Watertable at 30". Gradual wavy change to

52" Light greenish gray silty clay with olive green and rust coloured coatings along rootchannels. Wet, very sticky and plastic. Rich in peaty material.

Parent material: Recent alluvium of mixed origin.

Vegetation: One year old secondary growth.

Topography: Flat riverine valley.

Analyses:

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2133	0 - 3	n.d.	687	3000	3474	3450	16.2
2134	7 - 13	n.d.	524	1850	3720	6100	17.0
2135	19 - 28	n.d.	444	1180	1929	3800	14.2
2136	35 - 52+	n.d.	197	700	1486	3850	10.4

17. Samarahan series, profile S 2068/70 - on map pit no.20.

- 0 - 2" Dark gray (10YR 4/1) massive, silty clay, slightly plastic, much organic matter (raw), very well rooted, red coatings along old rice roots. Clear over
- 2 - 18" Light gray (5Y 7/1) silty clay, slightly wet, plastic, sticky. Bright orange coatings along root channels. Many old and new roots.
- 18 - 36" Grayish Green (5GY6/1) silty clay, (gley horizon), few orange coloured coatings along root channels (18 - 24"). Sticky and plastic. Many roots. Some large old roots.
Water-table 37"

Parent material: Recent alluvium and colluvium of mainly shales origin

Vegetation: Padi stubbles and weeds

Topography: In middle of flat, small riverine valley

Analyses

Laboratory No.	Depth of sample in inches	pH H2O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2068	0 - 2	n.d.	545	1170	3025	7500	14.0
2069	7 - 12	n.d.	295	240	2995	5700	17.3
2070	26 - 32	n.d.	335	730	3360	3000	17.6

Mundai series, profile S 2141/43 - on map pit no.41

0" Raw humus and rootmat of fine to medium size roots.

5" Dark grayish brown (10YR 4/2), single grain structure, sandy loam with gray mottling, loose, abundant fine or medium size roots, charcoal, moist. Few taproots at 14". Abrupt smooth change to

16" Gray (10YR 5/1) massive, sandy clay loam with distinct light gray mottles, moist to wet, much aluvial humus from top, charcoal. Gradual but irregular change to

36" Light grey to white (10YR 7/1-8/1) massive, sandy clay with yellow (rust) mottles. Wet, sticky, non-plastic, much quartz grit and gravel. Mottling continues along rootchannels. Few dead roots. Watertable at 34".

Parent material: Supposed to be old riverine alluvium.

Vegetation: 9 year old secondary forest

Topography: Flat riverine plain.

Analyses

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2141	0 - 3	6.40	950	35300	815	900	5.6
2142	5 - 8	6.00	875	10240	1329	800	13.7
2143	12 - 18+	6.50	650	3900	635	750	11.4

Note: Influenced by nearby occurring Limestone outcrop.

19. Bentang series, profile S 1925/28 - on map pit 9

(wet phase)

- 0 - 5" Dark yellowish-brown (10YR 4/4) weak crumbly clay; weak friable to slightly plastic, many roots with red coatings. Gradual change to
- 5 - 13" Dark yellow-brown fine, weak angular blocky, silty clay with weak dark gray mottling, slightly plastic, many roots, moist, gradual change into
- 13 - 19" Dark yellowish - brown silty clay with light gray (7.5YR 7/1) and yellowish brown mottles. Much like 5 - 13 but more iron oxide accumulation (soft brown concretions.) At 19" Mn. concretions. Water pours in through channels at 30". Channels surrounded by gray coatings.

Parent material: Recent alluvium of basic igneous rock origin.

Vegetation: Padi

Topography: Flat riverine plain.

Bentang series, profile S 2055/58 - on map pit 17.

(dry phase, probably associated with Malang)

- 0 - 6" Dark brown (7.5 YR 3/2) weak, fine subangular blocky to crumb, clay loam, large prism if dried out, friable, well rooted, slightly moist, gradual change to
- 6 - 20" 50% Yellowish-brown (10YR 5/4), 50% very pale brown (10YR 3/4) massive, clay loam, hard specks of Mn, sparsely rooted, gradual change to
- 20 - 34" Brownish-yellow (10YR 7/6) clay loam, with weak many (7.5YR 5/6) strong brown mottles, massive, slightly hard, very few roots, gradual change to
- 34 - 48" Reddish-yellow (7.5YR 6/6) with strong yellowish red (5YR 5/8) clay loam, massive, very few roots, moist to slightly wet. During dry weather topsoil shows polygon structure.

Parent material: Recent riverine alluvium of basic igneous rock origin.

Vegetation: Secondary forest

topography: Low riverine plain.

Analyses Wet phase

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 1925	0 - 2	n.d.	825	3630	3923	3850	25.4
1926	7 - 12	n.d.	580	2700	3486	4500	25.4
1927	14 - 18	n.d.	390	2490	3528	3500	28.5
1928	26 - 30	n.d.	197	1280	1413	1600	18.4

Analyses. Dry phase (probably associated with Malang)

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2055	0 - 2	n.d.	242	1600	1773	3450	12.0
2056	10 - 18	n.d.	177	360	2348	4500	11.9
2057	24 - 30	n.d.	145	250	2150	4550	13.5
2058	41 - 48	n.d.	137	250	2546	5600	15.7

20. Malang series, profile S 2148/50 - on map pit 42.

- 0 - 3" Pale brown subangular blocky loam, loose, abundant fine to medium roots. Earthworm activity, moist, clear smooth boundary to
- 3 - 16" Very pale brown (10YR 7/4) weak angular blocky loam to clay loam, slightly firm, few fine roots, charcoal, some infiltrated material from top layer through cracks. Gradual irregular change to
- 16 - 44" 50%, weak red and 50%, strong brown subangular blocky clay loam, with very weak light gray mottling. Few fine roots, slightly sticky and plastic.

Parent material: Recent riverine alluvium of mixed origin

Vegetation: Old Rubber garden (40 years).

Topography: Incipient levee.

Analyses.

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2148	0 - 3	n.d.	262	830	1444	1750	11.8
2149	4 - 8	n.d.	207	250	2312	1550	3.7
2150	22 - 44+	n.d.	78	200	1162	2450	20.7

Kayan series, profile S 2063/2067 - on map pit 19.

- 6" Very dark brown (10YR 2/2) weak crumbly, weak friable to loose, slightly wet, well rooted, overlying.

- 14" Dark yellowish brown (10YR 4/4) structureless sand, spots of dark coloured material (worm casts), few roots, overlying.

- 38" Dark yellowish brown structureless, loamy sand, loose, few roots gradual change to

- 48" Structureless, coarse loamy sand, loose.

Parent material: Recent riverine alluvium of mixed origin

Vegetation: Mainly bamboo

Topography: Slightly undulating levee approx. 50 feet from river bank.

Analyses.

Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2063	0 - 2	n.d.	395	1250	1851	1400	4.8
2064	9 - 14	n.d.	95	270	791	2300	4.0
2065	16 - 19	n.d.	197	610	1480	3100	7.5
2066	22 - 29	n.d.	127	380	1234	1500	4.2
2067	41 - 48	n.d.	132	360	773	1850	4.3

22. Terbat series, profile S 2094/96 - on map pit no.28.

0 - 4" Dark brown (7.5YR 3/2) crumbly, clay loam, friable, well rooted, smooth change to

4 - 48" homogeneous horizon of strong brown (7.5YR 5/6) friable, weak angular blocky clay, moderately well rooted. Moist.

Parent material: Recent riverine alluvium of basic igneous origin

Vegetation: Young rubber garden with undergrowth of weeds and ferns.

Topography: Slightly undulating alluvial land along river.

Analyses.

Laboratory No.	Depth of sample in inches	pH H2O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2094	0 - 2	n.d.	687	590	2630	1250	30.6
2095	15 - 18	n.d.	345	100	2085	700	38.7
2096	26 - 42	n.d.	270	50	1635	1600	42.8

23. Ramun Series, Profile S 2181/83 - on map pit 124

0 - 4" Dark brown (10YR 4/3) nutty loam, moist, loose abundant undecomposed rock pieces. Earthworms abrupt, irregular change to

4 - 14" Strong brown (7.5YR5/6) granular gravelly clay. Very loose, abundant hard rock pieces of gravel size. Few fine roots. Diffuse broken boundary to

14 - 36" Dark brown (7.5YR 4/4) gravelly clay. Abundant hard partly weathered gravels. Moist.

Parent material: Recent alluvial/colluvial gravel size material from basic igneous rock sources

Topography: Undulating alluvial fan.

Vegetation: Secondary forest, much bamboo.

Analyses.

Laboratory No.	Depth of sample in inches	pH-H2O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2181	0 - 3	4.8	763	4750	5062	1350	28
2182	6 - 12	5.2	435	700	7476	1250	38.9
2183	20 - 36+	4.2	505	840	6385	900	39.2

Bayur series, profile S 2471/75 - on map pit 124.

0 - 6" Brown (10YR 5/4) crumbly fine sandy loam. Al horizon. Fine and medium roots, moist, gradual change to

6 - 17" Brownish yellow crumbly fine sandy clay loam. Fine and medium roots, few charcoal pieces, moist, gradual change to

17 - 28" Brownish yellow, crumbly to weak fine angular blocky, fine sandy clay, few fine roots. Quartz pieces few and fine, moist. Gradual smooth change to

28 - 40" Reddish yellow, angular blocky, fine sandy clay with abundant fine quartz pieces. Massive, moist. Gradual smooth change to

40 - 51" Reddish yellow fine sandy clay. Massive. Abundant quartz, fragments of red coloured weathered rock. Moist.

Parent material: Schist

Vegetation: Secondary forest, bamboo and scattered trees.

Topography: On top low hill (50 - 60 feet high.)

Analyses.

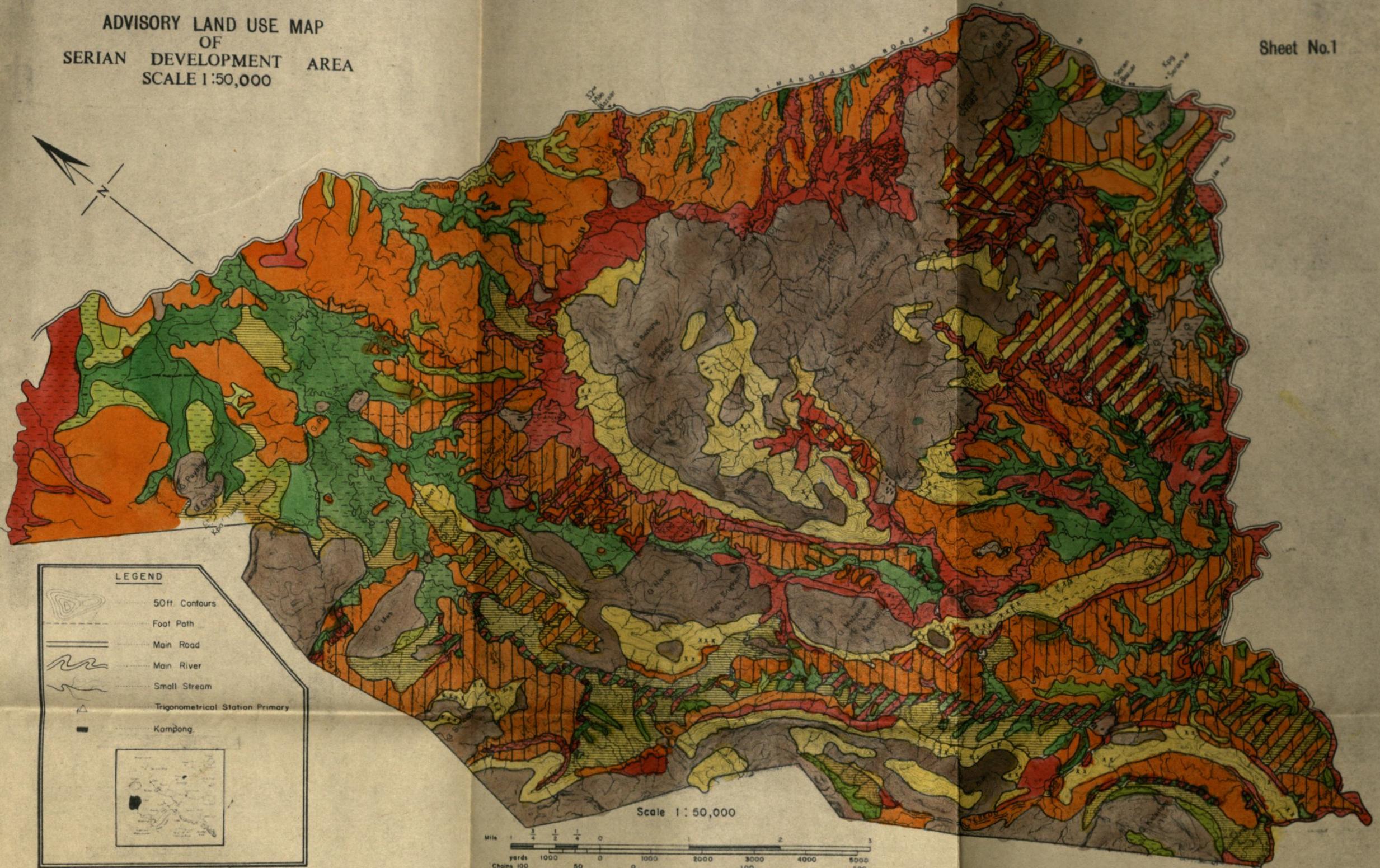
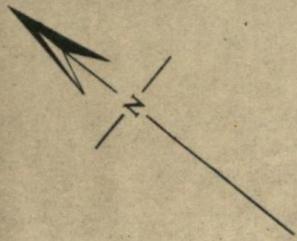
Laboratory No.	Depth of sample in inches	pH H ₂ O	P Total	Ca Total	Mg Total	K Total	% Group III (sesquioxides)
S 2471	0 - 6	n.d.	65	100	1162	2900	8.82
2472	6 - 17	n.d.	28	130	1240	2400	11.36
2473	17 - 28	n.d.	16	100	1354	2900	12.96
2474	28 - 40	n.d.	9	50	1408	3200	13.86
2475	40 - 51	n.d.	11	100	1503	2900	20.08

Printed at the Government Printing Office, Kuching, Sarawak,
F. W. GOODWIN, O.B.E., Government Printer.

1964

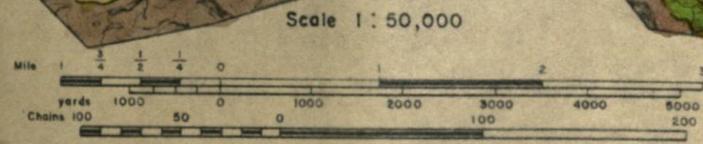
ADVISORY LAND USE MAP
OF
SERIAN DEVELOPMENT AREA
SCALE 1:50,000

Sheet No.1



LEGEND

- 50ft Contours
- Foot Path
- Main Road
- Main River
- Small Stream
- Trigonometrical Station Primary
- Kampung

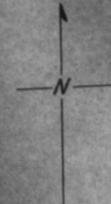


Part 1 Flat and hilly land not or slightly affected by flooding during the wet monsoon		Part 2 Flat land affected by flooding in wet monsoon	
	Category 1.1 Land with high agricultural potential. Recommended crops: pepper, fruitcrops such as bananas, papayas, rambutan, mango, citrus and rubber.		Category 2.1 Land with high agricultural potential, suitable for pastures, market gardening, tobacco, maize and other annuals in the dry season. Suitable for wet cultivation in the wet season. Drainage and irrigation should and can be improved.
	Category 1.2 Land with high agricultural potential but with a few restrictions in crop choice owing to floodings of short duration, or difficult terrain. Recommended crops: as for category 1.1 but excluding pepper, and including coffee and probably cocoa.		Category 2.2 Land with high potential for agriculture but which cannot be used during the wet season with advantage because of flooding. Recommended use: either annuals such as tobacco, maize, market garden crops or pastures. Rotation is recommended. Wet rice cultivation is possible but crop-failures due to flooding may occur frequently.
	Category 1.3 Land with moderate agricultural potential owing to topographic limitations and soil fertility. Recommended crops: Rubber, in selected places pepper. Soil conservation is needed in most of the area.		Category 2.3 Land with moderate agricultural potential owing to risk of flooding and low fertility of soils. Recommended use: either for annual crops having short growing season as for category 2.2 or pastures. Fertilizers are essential. Wet rice can be grown but frequent cropfailures can be expected due to flooding.
	Category 1.4 Land with moderate to low agricultural potential. Recommended crops: rubber only. Soil conservation is needed in most of the area.		Category 2.4 Land with low agricultural potential owing to serious risk of flooding and bad soil conditions. Recommended use: should be used mainly in the dry season for annual crops having short growing season. Heavy applications of fertilizers may be necessary. Only to be used for wet rice if no other land is available. In places sago is recommended for pigfodder.
	Category 1.5 Land with limited potential for agriculture owing to bad topography and in places due to bad soil conditions. Recommended use: reafforestation or the planting of commercial tree crops such as rubber where soil conditions are better. Pepper in selected places. Soil conservation is essential throughout the area.		Category 2.5 Land with no agricultural potential. Mainly deep peats.
	Category 1.6 Land with very low agricultural potential because of low soil fertility and/or bad topography. Recommended use: rubber can be grown if no other land available. Soil conservation is needed in most areas.		Indicate mixed occurrence of different categories.
	Category 1.7 Land with no agricultural potential owing to bad topography and bad soil conditions.		
	Scattered occurrences of category 1.1 land.		



TOPOGRAPHIC MAP OF SERIAN DEVELOPMENT AREA WITH SURVEY DATA

SCALE 1:50,000



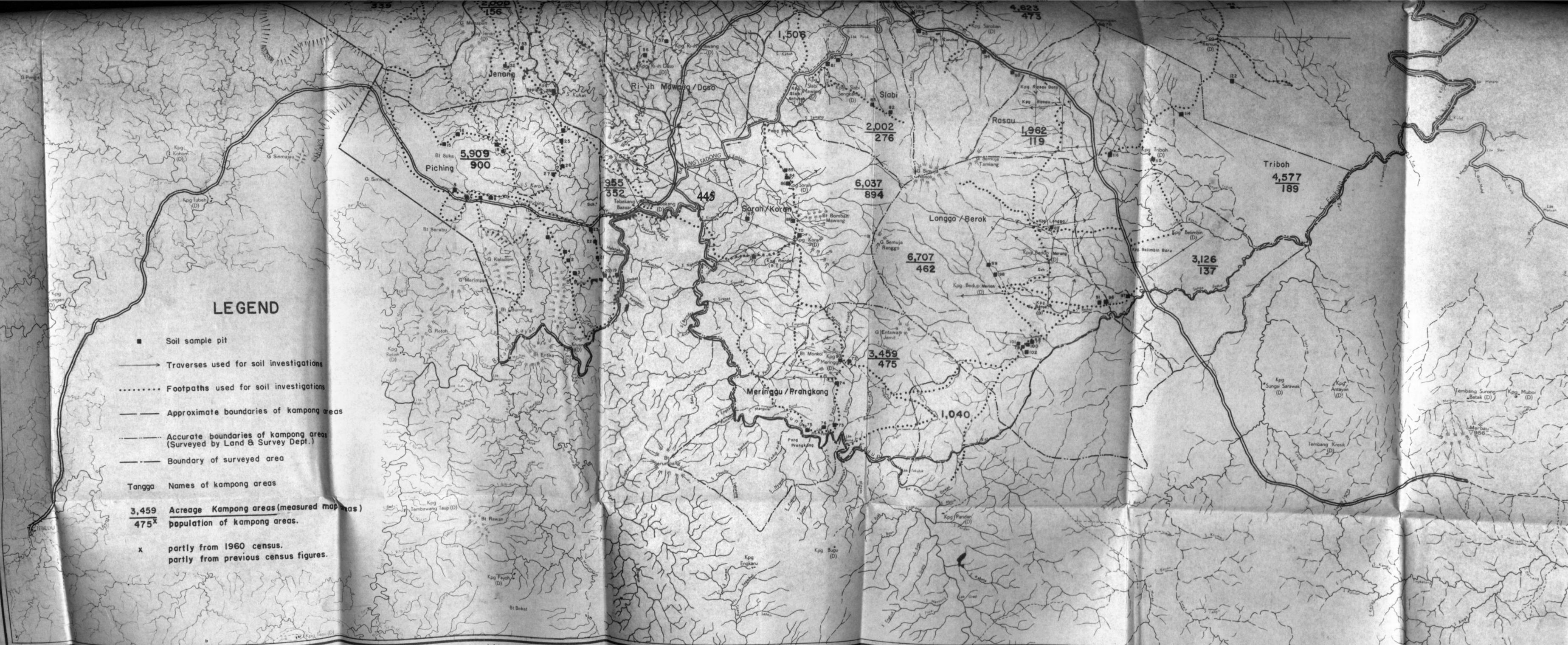
LEGEND

- Soil sample pit
- Traverses used for soil investigations
- Footpaths used for soil investigations
- Approximate boundaries of kampong areas
- Accurate boundaries of kampong areas (Surveyed by Land & Survey Dept.)
- Boundary of surveyed area
- Names of kampong areas
- Acreage Kampong areas (measured map as)
- Population of kampong areas.

partly from 1960 census.
partly from previous census figures.

LEGEND

- Soil sample pit
- Traverses used for soil investigations
- Footpaths used for soil investigations
- Approximate boundaries of kampong areas
- - - Accurate boundaries of kampong areas (Surveyed by Land & Survey Dept.)
- Boundary of surveyed area
- Tangga Names of kampong areas
- 3,459** Acreage Kampong areas (measured map areas)
- 475^x** population of kampong areas.
- ^x partly from 1960 census.
partly from previous census figures.



LEGEND

- Soil sample pit
- Traverses used for soil investigations
- Footpaths used for soil investigations
- Approximate boundaries of kampong areas
- Accurate boundaries of kampong areas (Surveyed by Land & Survey Dept.)
- Boundary of surveyed area
- Tangga Names of kampong areas
- $\frac{3,459}{475^x}$ Acreage Kampong areas (measured map areas)
population of kampong areas.
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partly from previous census figures.



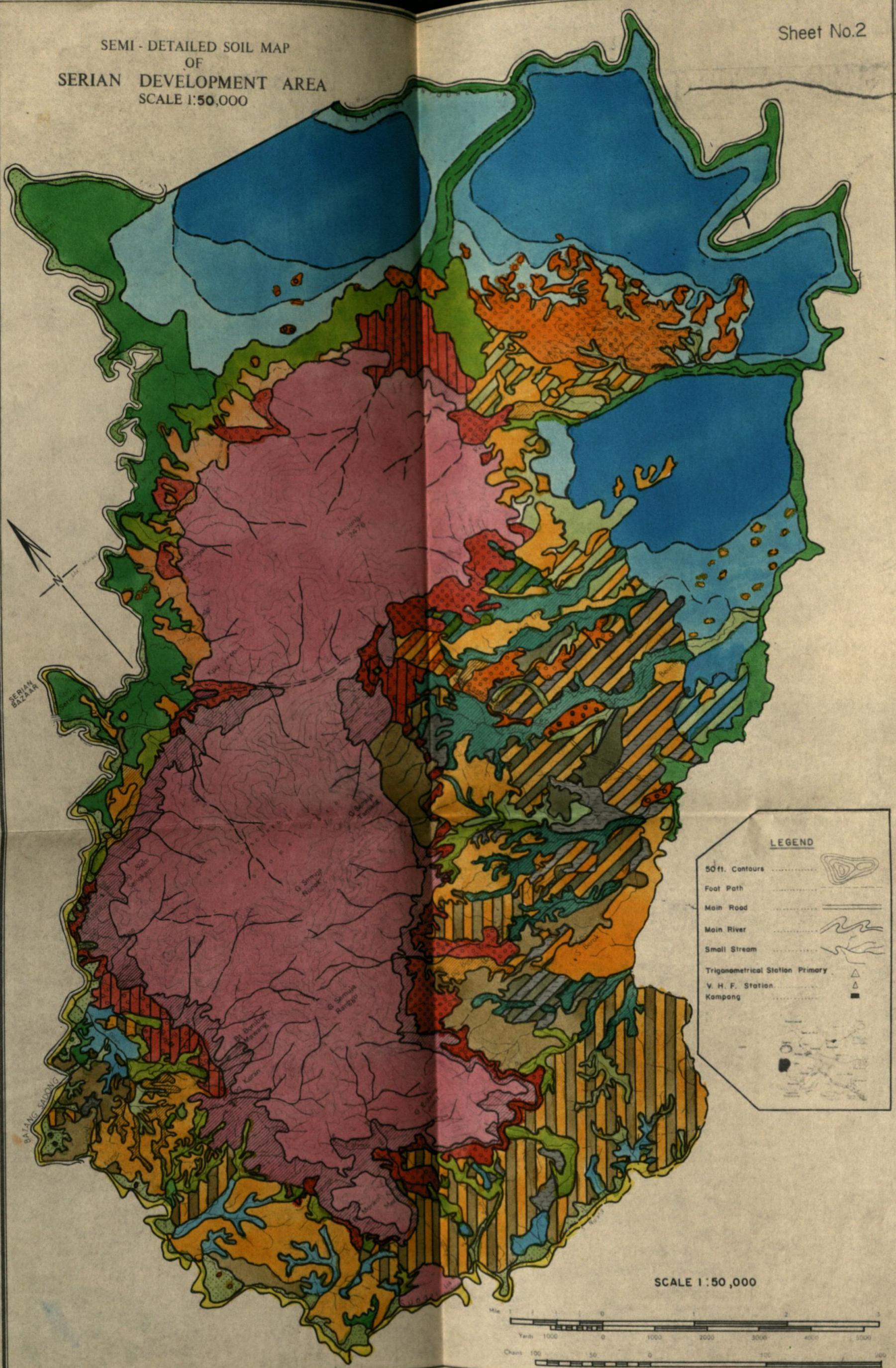
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Base map derived from Land & Survey Dept. Sarawak - Serian

Compiled by J.P. Andriese

Drawn by Hafsa Hj. Bolhassan

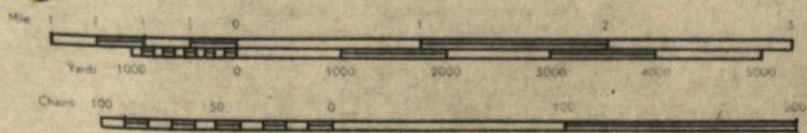
SEMI - DETAILED SOIL MAP
OF
SERIAN DEVELOPMENT AREA
SCALE 1:50,000



LEGEND

- 50 ft. Contours [Symbol]
- Foot Path [Symbol]
- Main Road [Symbol]
- Main River [Symbol]
- Small Stream [Symbol]
- Trigonometrical Station Primary [Symbol]
- V. H. F. Station [Symbol]
- Kampung [Symbol]

SCALE 1:50,000



KEY FOR MAP UNITS			
The same key as used in sheet No.1 applies to sheet No.2 except the following additional mapping units.			
PEDOLOGICAL		DEFINITION	
GREAT SOIL GROUPS	MAPPING UNITS	SOIL SERIES	PHASES OF SERIES
Probably REDDISH BROWN LATERITIC SOILS	40 [Symbol]	BAYUR	
	SIMPLE SOIL ASSOCIATIONS		
	41 [Symbol]	BEDUP / BAYUR	
	42 [Symbol]	KERAIT / BEDUP	
	43 [Symbol]	KERAIT / TRIBOH	
	44 [Symbol]	TRIBOH / BEDUP	
	45 [Symbol]	MALANG / KAKAI	
	46 [Symbol]	BEDUP / SAMARAHAN	
	47 [Symbol]	SAMARAHAN / ANDERSON 2	
Mixed soils (etc)			
AGRICULTURAL		DEFINITION	
SHORT FIELD DESCRIPTION OF MAP UNITS IN AGRICULTURAL TERMS.			
			Well drained, well structured; deep loams over clays; occasionally with quartz grit.
			Mixed soils, on mixed landscapes. (etc)