RECONNAISSANCE SOIL SURVEY OF NEGERI SEMBILAN

By
B. GOPINATHAN
and
S. MAKESWARAN

Malayan Soil Survey Report No. 2/1969

MALAYAN SOIL SURVEY REPORT

NO. 2/1969

RECONNAISSANCE SOIL SURVEY

OF

NEGERI SEMBILAN

by

B. GOPINATHAN

&

S. MAKESWARAN

SOIL SCIENCE DIVISION
DIVISION OF AGRICULTURE
MINISTRY OF AGRICULTURE AND FISHERIES
KUALA LUMPUR
MALAYSIA

CONTENTS

CONTENTS (CONTINUED)

LIST OF FIGURES

1. INTRODUCTION

The reconnaissance soil survey of the State of Negeri Sembilan is part of a nationwide project to ascertain the type of soils present and their distribution. The soil map indicating the soil resources will form the basis for a sound land utilization programme.

The soil survey was carried out by the Soil Science Division of the Department of Agriculture, West Malaysia. It provides information on the location, distribution and nature of the various kinds of soils in the area. The soils consist mainly of upland soils on a variety of parent materials, and alluvial soils developed both on marine and brackish water sediments, and on riverine alluvium. Areas where topography is generally too steep for agricultural development has been mapped as Steepland.

In Negeri Sembilan, about 37 percent of the land is suitable for agriculture, the rest being mainly steepland. About 10 percent of the soil suitable for agriculture are Class I soil i.e. soil having no limitation to agricultural development and suitable for a wide range of crops.

A soil map of the State on a scale of 4 miles to 1 inch (1:253,440) is enclosed, together with a soil suitability map on the same scale.

The survey was started in June 1966 and completed in July 1967. The soil survey of the area east of the road linking the towns of Durian Tipus, Simpang Pertang, Batu Kikir, Bahau, Rompin and Gemas was carried out by Dumanski and Ooi when they conducted the soil survey of the Temerloh-Gemas region (1966).

../2

Soil Survey Method

The survey was conducted on a reconnaissance scale. The base maps used in the survey were 1 mile:1 inch (1:63,360) New Series topographic maps published by the Directorate of National Mapping, Malaysia. The area is covered by map sheets 95, 96, 97, 102, 103, 104, 105, 112, 113 and 114. Vertical aerial photographs (1:25,000) were used to supplement the topographic maps.

Traverses were made along most of the roads and tracks. As the western half of Negeri Sembilan has to a large extent been developed, the good system of roads and tracks rendered most of this area accessible. In the forested areas in the eastern half of the State rentis-rentis were cut and traversed. The distance between rentis-rentis ranged from 2 to 2½ miles and soils were examined along the rentis-rentis at 1/4 mile intervals. Soil profiles were examined and fully described from road cuttings and pits. Soil examination was carried out by means of the 1½ inch screw augur, and the 6 inch post hole auger. Analyses of soils were carried out in the soils laboratory of the Soil Science Division, Department of Agriculture, West Malaysia.

Mapping units were generally associations of soil series. The density of observation was variable depending upon the complexity of the soil pattern. For example fewer observations were made in areas where the soils were derived from granites, than in areas where the soils were derived from shale and sandstones.

The final map was reduced to a scale of 4 miles to one inch (1:253,440).

..3/

II. GENERAL DESCRIPTION OF THE AREA

Location

The State of Negeri Sembilan is in West Malaysia, enclosed between latitude 2° 23'N and 3° 10'N and longitudes 101° 42'E and 102° 43'E (Figure 1). It is bounded in the west and north-west by the State of Selangor, in the north and north-east by the State of Pahang, and in the south by the State of Malacca. The south western area has about thirty miles of coast-line, facing the Straits of Malacca. The State covers a total area of 2765 square miles (1,641,600 acres).

The largest town in Seremban which is also the state capital. Port Dickson is a fast developing tourist resort on the coast, about 20 miles from Seremban. These two towns are in the western half of the State. In the eastern half, the towns are less populous. Among these, Kuala Pilah, Gemas, Rompin and Kuala Kelawang are the more important towns.

Physiography

Based on topography, the State can be divided into three broad physiographic regions (Figure 2):- the mountainous region, the hilly to undulating region and the alluvial plains. Slope and terrain classification used in this report (Table 1) is that described in Leamy and Panton, 1966, p. 15:-

..4/

Fig. 1 LOCALITY MAP

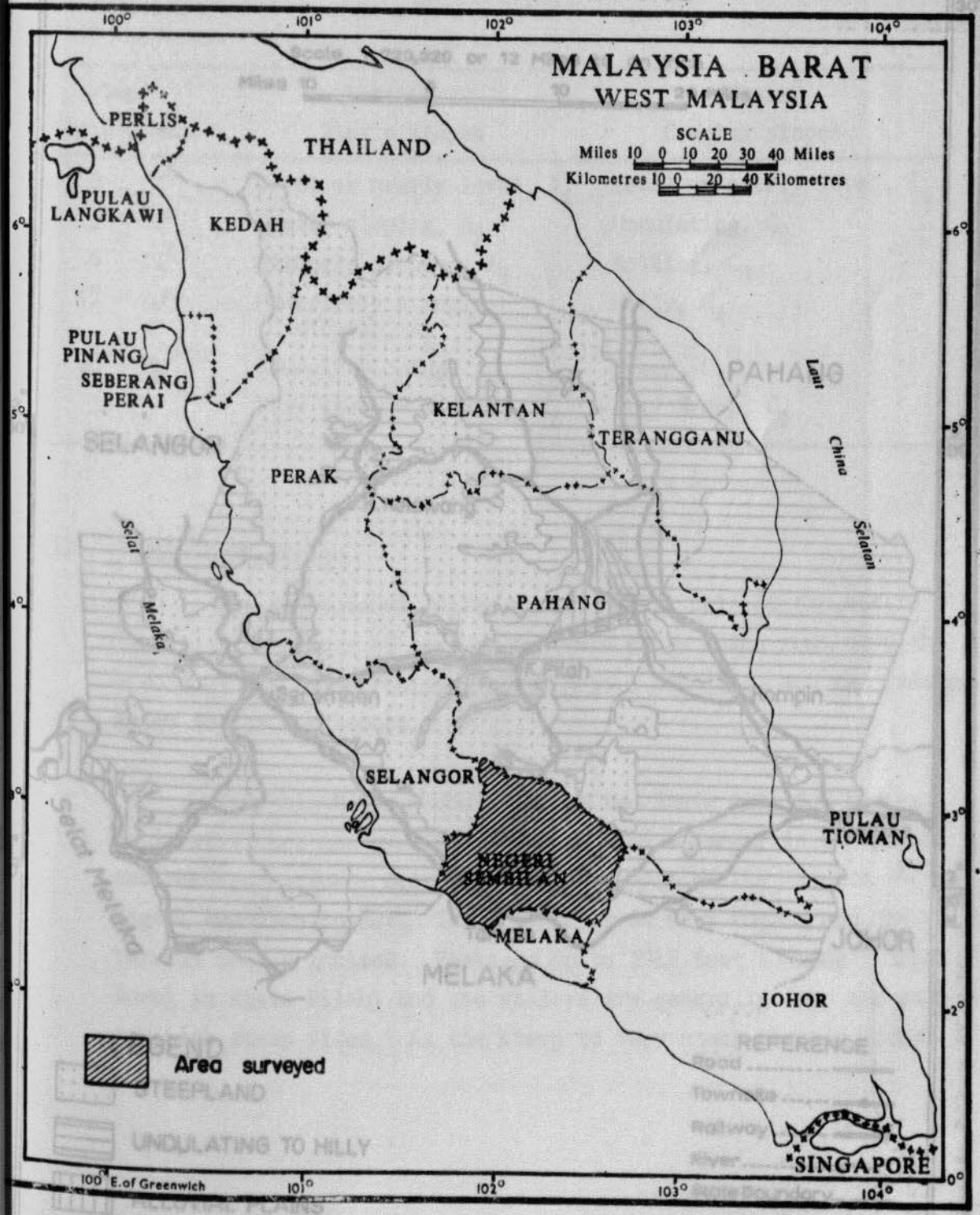
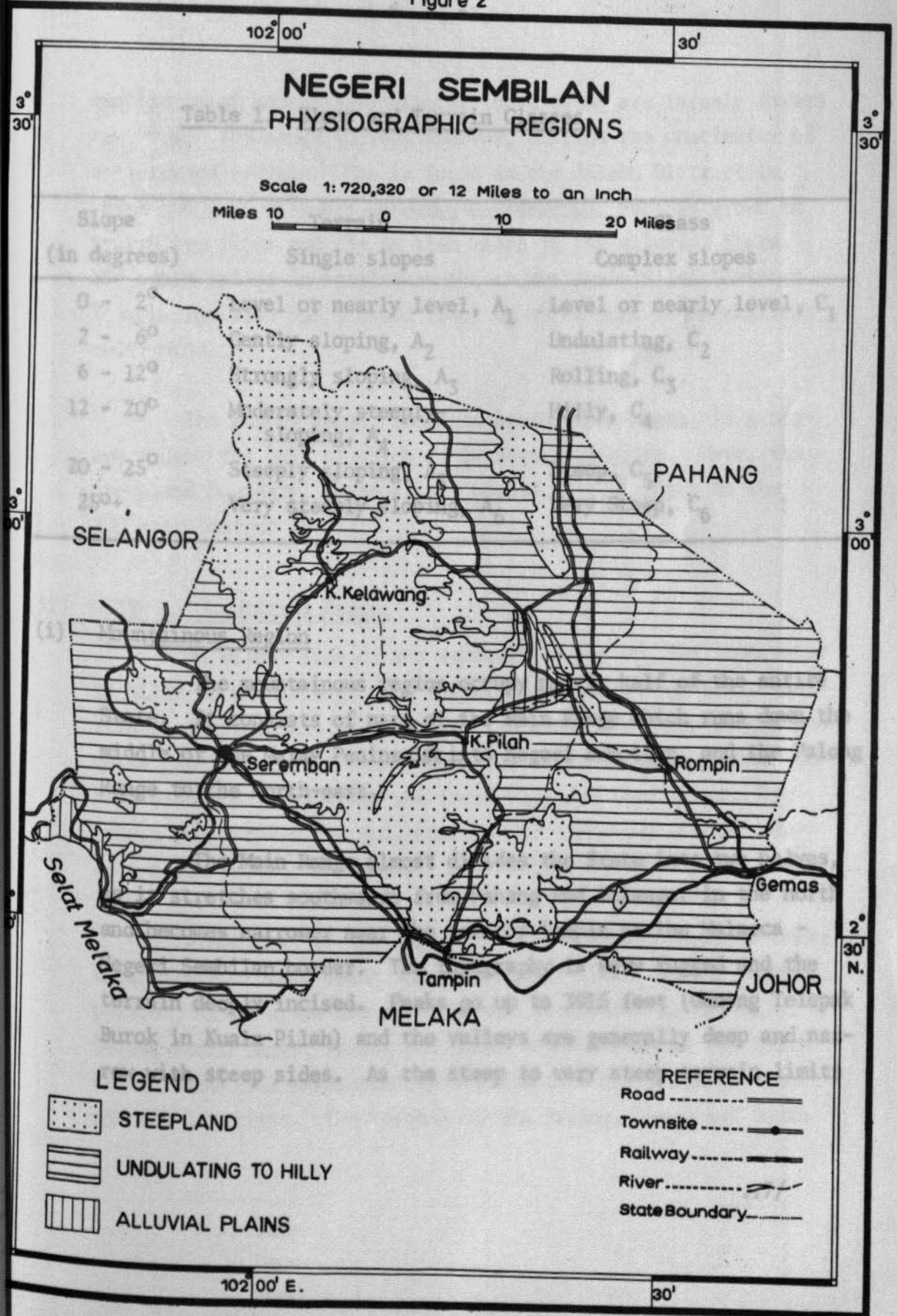


Figure 2



Division of Agriculture 5-69

Table 1. Slope and Terrain Classes

Slope (in degrees)	Terrain Class	
	Single slopes	Complex slopes
0 - 2°	Level or nearly level, A_1	Level or nearly level, C_1
2 - 6°	Gently sloping, A_2	Undulating, C_2
6 - 12°	Strongly sloping, A_3	Rolling, C_3
12 - 20°	Moderately steeply-sloping, A_4	Hilly, C_4
20 - 25°	Steeply sloping, A_5	Steep, C_5
25°+	Very steeply sloping, A_6	Very Steep, C_6

(i) Mountainous Region

The mountainous region occupy nearly half of the entire State. It consists of part of the Main Range which runs down the middle of the Malay Peninsular into Negeri Sembilan, and the Palong Range to the North-east.

The Main Range almost divides the State into two halves, as it stretches southwards from Pahang and Selangor in the north and becomes narrower near the town of Tampin at the Malacca - Negeri Sembilan border. The topography is very rugged and the terrain deeply incised. Peaks go up to 3915 feet (Gunong Telepak Burok in Kuala Pilah) and the valleys are generally deep and narrow with steep sides. As the steep to very steep terrain limits

..7/

Table 1. Slope and Terrain Classes

Slope (in degrees)	Terrain Single slopes	Class Complex slopes
0 - 2°	Level or nearly level, A_1	Level or nearly level, C_1
2 - 6°	Gently sloping, A_2	Undulating, C_2
6 - 12°	Strongly sloping, A_3	Rolling, C_3
12 - 20°	Moderately steeply-sloping, A_4	Hilly, C_4
20 - 25°	Steeply sloping, A_5	Steep, C_5
25°+	Very steeply sloping, A_6	Very Steep, C_6

(i) Mountainous Region

The mountainous region occupy nearly half of the entire State. It consists of part of the Main Range which runs down the middle of the Malay Peninsular into Negeri Sembilan, and the Palong Range to the North-east.

The Main Range almost divides the State into two halves, as it stretches southwards from Pahang and Selangor in the north and becomes narrower near the town of Tampin at the Malacca - Negeri Sembilan border. The topography is very rugged and the terrain deeply incised. Peaks go up to 3915 feet (Gunong Telepak Burok in Kuala Pilah) and the valleys are generally deep and narrow with steep sides. As the steep to very steep terrain limits

..7/

many forms of normal agriculture, these areas are largely forest reserves. Two broad valleys however, disrupt the continuity of this rugged terrain. One is found in the Jelebu District in which the town of Kuala Kelawang is situated. Padi is grown on the valley floor and tin is also mined in the alluvial flats. The other valley is further south, in the Kuala Pilah District. This valley also has a broad floor on which padi is extensively cultivated.

The Palong Range, reaching south from Pahang, is a narrow ridge, the bulk of which is in Negeri Sembilan. Here, the steepland boundary, where slopes exceed 20°, conforms to the 500-foot contour level.

(ii) Hilly to Undulating Region

On either side of the mountainous region, the topography is hilly to undulating. The terrain consists of low hills and ridges of predominantly shale and sandstone and whose slopes are quite gentle, generally not exceeding 18°. Isolated patches of high steep hills, however are found in a few localities. Prominent among these are conglomerate and sandstone ridges trending north-west to south-east, near Bahau.

Almost all of the region west of the Main Range is under agriculture, rubber being the predominant crop. In the eastern portion, large areas are under Forest Reserves. In the Jelei - Gemas, South Gemas, Palong and Bahau Forest Reserves the soils are derived from predominantly argillaceous rocks and are frequently lateritic. The terrain in the Palong, Bahau and South

Gemas Forest Reserve consist of low hills rarely exceeding 250 feet. The terrain in the Jelei - Gemas Forest Reserve is rolling to hilly. In the Pasoh Forest Reserve fringing the Palong Range, the soils consist of the Rengam - Tampin association, derived from granite. This is on a rolling to hilly terrain and offers good potential for agricultural development.

The South Eastern portion of Negeri Sembilan is drained by Sungei Jelei and Sungei Muar. Central Kuala Pilah is drained by Sungei Serting which starts off flowing south from Serting Ulu, makes a U-shaped loop at Bahau and then meanders north into Pahang. West of the Main Range, Sungei Linggi drains the districts of Seremban and Port Dickson as it flows south from Seremban and empties into the Straits of Malacca.

Alluvial Plains

The alluvial plain is relatively much smaller compared to the other two physiographic regions. In Kuala Jempol, the flood plains of three major rivers in Kuala Pilah merge to form an alluvial flat of about 1,400 acres. This alluvial flat is made up of a raised subrecent alluvial terrace where the soils are Holyrood and Lunas series, and a lower active flood plain where padi is cultivated. Proper development of a coastal plain occurs only to a limited extent between the towns of Sepang and Port Dickson, a distance of about 8 miles and extends to about 2 miles inland at its broadest point. The coastal plains become extensive northwards in the State of Selangor.

..10/

Geology

The granite of the Main Range extends into Negeri Sembilan from the north, constituting a major physiographic feature. The granites are coarse grained, often with large porphyritic feldspars. Biotite granite is the most widespread, although muscovite is often associated with the biotite to give a muscovite-biotite granite at various localities. Although the bulk of the distribution of the granite is limited to wihtin the main massif, the granite also occurs over a large area west of Seremban and south of the Galla Forest Reserve. It also extends as a narrow belt in the low foothills fringing the Main Range. Both porphyritic and non-porphyritic varieties of granite are reported to occur in the Palong Range, displaying a gneissose arrangement of dark minerals (Willbourne, 1922 p. 35).

Small pockets of volcanic rocks, mainly andesite, occur near Juasseh and in the Southern edge of Kepis Forest Reserve. The soils developed on these volcanic rocks have distinctive red colours.

Among the sedimentary rocks, shales and sandstones occur widely. Argillaceous sediments are found in the western part of Negeri Sembilan in the districts of Rembau, Port Dickson and Seremban. Here phyllites and talc schists are also common. Some serpentine rich rocks are found in the Kampong Petasseh area in Jelebu, along the Kuala Pilah - Johol road and in the Jelei - Gemas Forest Reserve (Extension) just south of See Kee estate. The soils developed on these rocks also have distinctive dark red colours. Interbedded sandstone and shale are found within the Mukim of Jimah, in

..10/

Port Dickson District. Arenaceous rocks are more widespread in the eastern part of the State, being made up of sandstone, quartzites and conglomerates. Sandstone ridges are common in these areas.

There has been very little metamorphism, and this is limited within a narrow metamorphic aureole close to the granites. Andalusite and chiastolite schist were found in the eastern granite contact zone and is reported to occur in the valley floor in the Jelebu District (Willbourne 1922 p. 17).

Vegetation

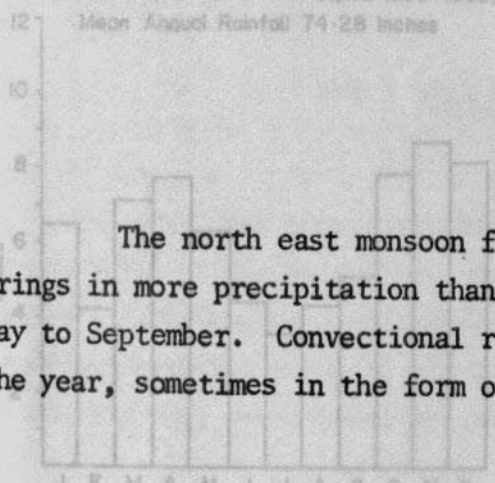
The natural vegetation in the well drained upland areas is the dipterocarp rain forest. The lowland dipterocarp forest is dominant up to 2000 feet. Among the important timber producing trees are Chengal (Balanocarpus heimii), Kaput (Dryobalanops aromatica), Kempas (Koompassia malaccensis), Kedondong (Canarium and Santire spp), Nemesu (Shorea pauciflora), Red Meranti (Shorea acuminata and other species) and Keruing (Dipterocarpus baudii and other species) (Wyatt-Smith,1964).

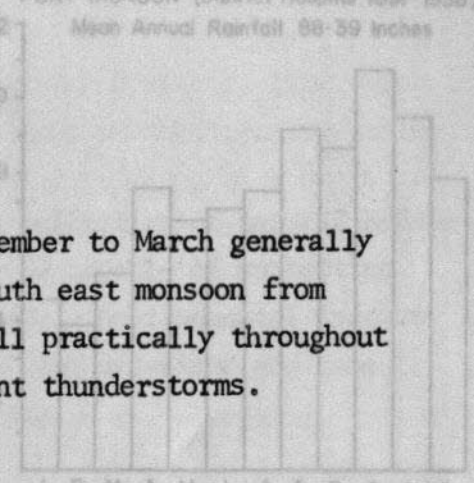
In the coastal swamp, the natural vegetation is the mangrove forest of Avicennia, Sonneratia, Rhizophora and Bruguiera.

Climate

Malaysia is situated in an Af or tropical wet (rain-forest) climatic zone according to Koppens world classification of climate (Trewartha, 1954). The climate is essentially hot and wet, there being no marked dry season. Maximum daily temperatures are usually in the high 80's to low 90's. Relative humidity is almost always nearly 100 percent.

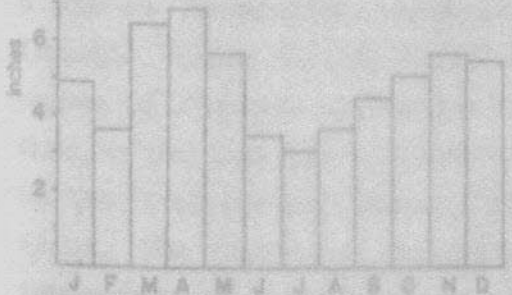
..11/

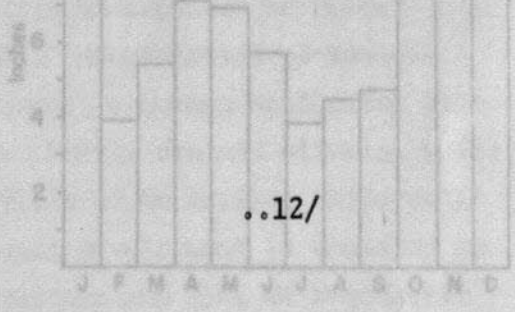




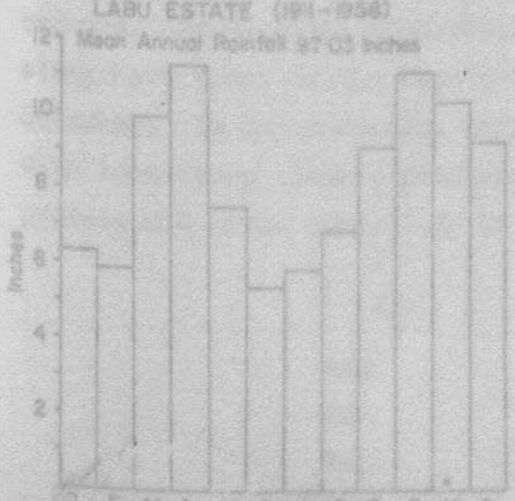
The north east monsoon from November to March generally brings in more precipitation than the south east monsoon from May to September. Convectional rains fall practically throughout the year, sometimes in the form of violent thunderstorms.

Mean monthly rainfall of six selected sites in Negeri Sembilan is shown in Figure 3. There is a relatively dry belt in the central and eastern parts of the State, where the rainfall is less than 70 inches. 'Dry' and 'very dry' soil conditions are most common during the months of February, June, July and August, and dry spells of nearly three weeks duration are common during these months (Dumanski and Ooi, 1966).





..12/



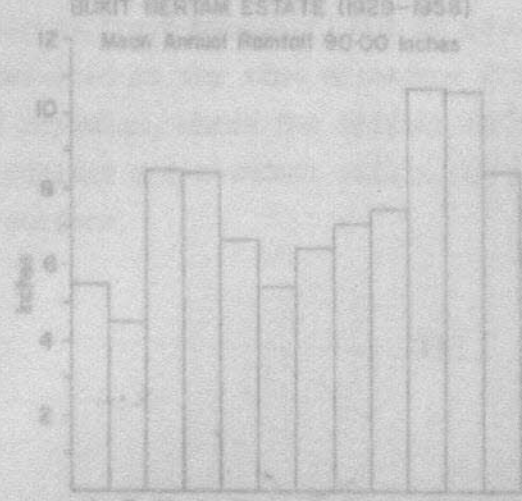
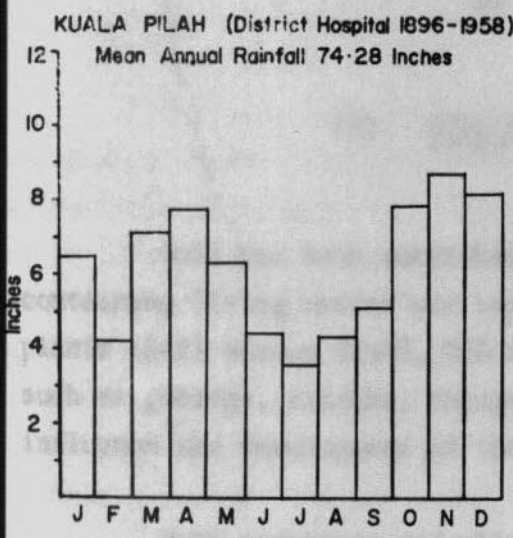
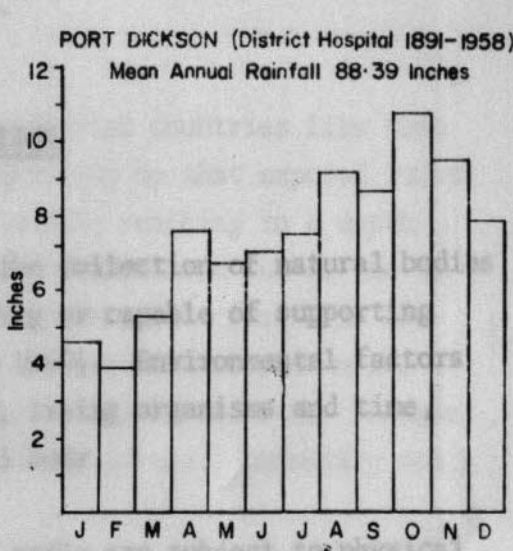
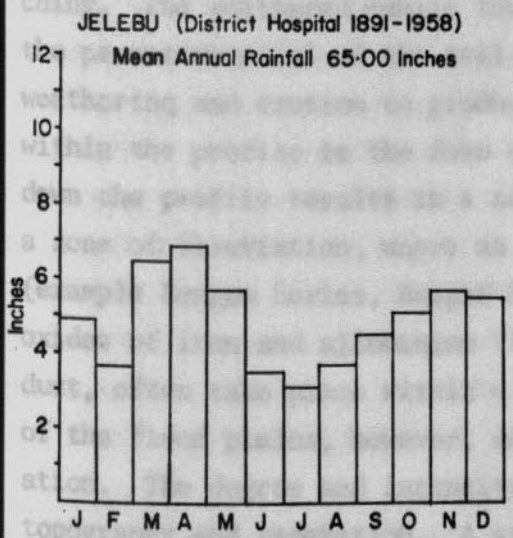
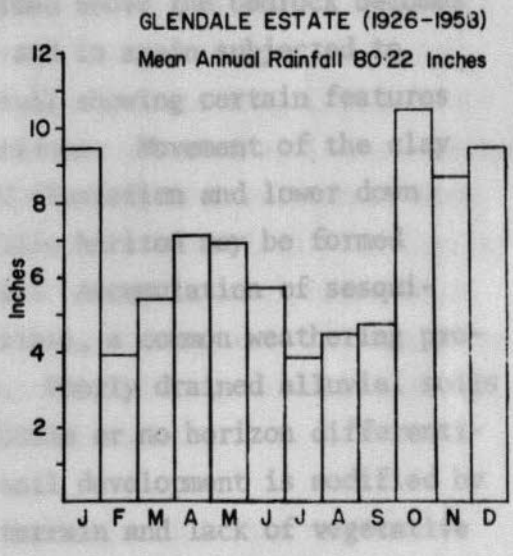


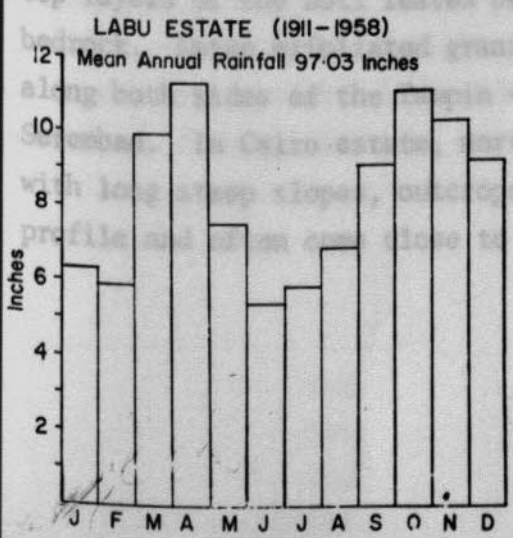
FIG. 3. MEAN MONTHLY RAINFALL OF SIX SELECTED SITES IN NEGERI SEMBILAN

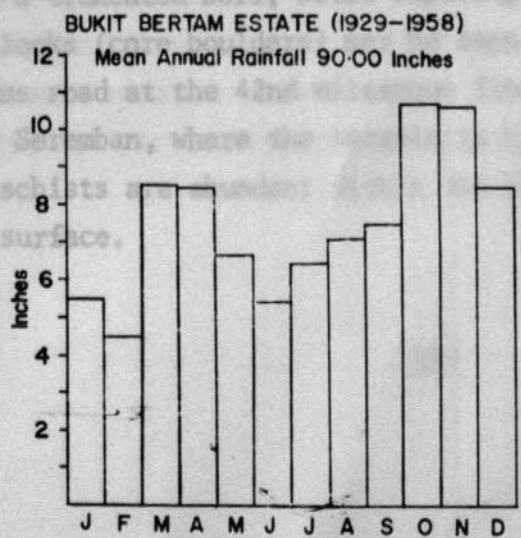












III. SOIL FORMATION

Soil has been described as the collection of natural bodies containing living matter and supporting or capable of supporting plants (Soil Survey Staff, U.S.D.A., 1960). Environmental factors such as geology, climate, topography, living organisms and time, influence the development of the soil body.

Both sedentary and alluvial soils are subject to physical and chemical weathering and soluble materials are removed by leaching. The weathered mantle thus formed above the bedrock becomes the parent material of the soil body and is again subjected to weathering and erosion to produce a soil showing certain features within the profile in the form of horizons. Movement of the clay down the profile results in a zone of eluviation and lower down a zone of illuviation, where an argillic horizon may be formed (example Rengam Series, Bungor Series). Accumulation of sesquioxides of iron and alluminium (laterites), a common weathering product, often take place within a zone. Poorly drained alluvial soils of the flood plains, however, show little or no horizon differentiation. The degree and intensity of soil development is modified by topography and vegetation. A steep terrain and lack of vegetative cover would result in intense erosion. This continuous removal of top layers of the soil leaves behind a truncated soil, often exposing bedrock. Large exfoliated granite blocks (core boulders) may be seen along both sides of the Tampin - Gemas road at the 42nd milestone from Seremban. In Cairo estate, north of Seremban, where the terrain is hilly with long steep slopes, outcrops of schists are abundant within the soil profile and often come close to the surface.

The hot, humid climate of equatorial countries like West Malaysia promotes intense chemical weathering so that exposed rocks succum relatively quickly. Weathered mantle reaching to a depth of 30 feet or more is not uncommon. A vertical road cut at the 4½ milestone Labu Road shows this feature. The parent rock here is granite. The high level of precipitation also induces extensive leaching leaving it devoid of bases and soluble nutrients. Malayan soils consequently have low pH and nutrient levels. Sedentary soils in Malaya have an average pH of 4.5.

The texture of the parent material is an important factor in this breakdown by weathering. The coarse texture of parent materials derived from sandstones and granite would allow greater percolation; thus the depth of weathering and penetration by leaching fluids would be greater. Soils developed on granitic parent material (Rengam Series) and sandstones parent material (Serdang Series) have relatively deep sola. On the other hand, percolation in parent materials with fine or very fine texture like those developed from argillaceous rocks would be somewhat impeded. The depth to which weathering and leaching takes place is thus limited. A greater degree of mottling is thus found in the sola of soils developed on argillaceous rocks.

In the absence of any marked climatic variation in West Malaysia, the nature of the parent material and the age of landscape are important soil forming factors. The texture of the soil is influenced greatly by the texture of the parent material. Soils developed on argillaceous parent material have heavy textures. The chemical and mineralogical composition of the bedrock and parent material are also

..15/

expressed in varying degrees. Basic igneous rock like the small pocket of andesite that out crops near Juasseh estate in Kuala Pilah weathers to a dark red soil, relatively high in iron content.

Time is important in allowing the soil to develop its distinctive profile characteristics. Some of the differences in the morphology of the soils are due to the time factor. Profile development on landscapes of varying ages differ because of differences in the duration of the soil forming processes. Soils on this recent coastal and riverine alluvial plains have weakly developed soil profiles compared to the soils on the subrecent terrace, which is a surface rejuvenated by pleistocene erosion. On the older stable surface in the upland areas, the soil profiles are generally mature. On the steeper terrain of the upland areas, soils are less well developed because of continued soil loss by erosion.

IV. SOIL SUITABILITY

Soil Suitability Classification

The soil suitability classification in this report is based on that proposed by Leamy and Panton, (1966, p. 190) and modified by Wong (1966, p. 153-156). The soil suitability classification is based on the presence of certain features and the degree of limitation of these features to agricultural development of a range of crops. The system was drawn up with particular reference to tree crops. Thus a soil on which a wide variety of crops can be grown enjoys a higher suitability rating than one on which, because of vertain factors peculiar to the soil, only a few crops can be grown. This is despire the possibility that the latter soils because of its characteristics can be very successfully cultivated with a particular crop that demands such conditions in the soil. Thus, waterlogging which in alluvial soils offers ideal conditions for wet padi cultivation is undesirable for tree crop cultivation. In the suitability classification, therefore, undrained alluvial soils are considered to be Class III soils.

The limitations are, principally, observable physical characteristics of the soil, for it is assumed that while nutrient deficiencies can be overcome by fertilizer application, physical characteristics of the soil are more enduring and less susceptible to alteration. These limitations may be grouped into categories depending on their seriousness as follows:-

..17/

A. Very Serious Limitations

1. Slopes steeper than 20°.
2. Massive, thick laterite at or very close to the surface.
3. Extreme rockiness - i.e. boulders and rock almost entirely covering the surface.
4. Land disturbed by mining.
5. Toxicity caused by abnormally high amounts of certain elements.

B. Serious Limitations

1. Acute nutrient deficiencies - including trace element as well as major element deficiencies.
2. Very poor and poor drainage.
3. Moderately steep slopes (12° - 20°).
4. Massive, thick laterite within 2 feet (about 60 cm) of the surface.
5. 2 feet (about 60 cm) or more of acid peat.
6. Strong compaction.
7. Sand texture throughout.
8. Acid sulphate conditions.
9. Saline conditions.

C. Minor Limitations

1. Susceptibility to flooding.
2. Weak structures within the top 4 feet.
3. Imperfect or moderate drainage.
4. Acid peat less than 2 feet (about 60 cm).
5. Weak or moderate compaction.

..18/

Based on the number and degree of seriousness of the limitations the soil may be classified into one of the following five suitability classes:-

Class 1

These soil have no limitations to agricultural development and are suitable for a wide range of crops.

Class 2

These soil possess few minor limitations (e.g. susceptibility to flooding and shallow peat). Despite this, the soils in this Class are suitable for a variety of crops.

Class 3

These are soils having at least one serious limitation. They are considered marginally suitable and cultivation of these soils generally require a high standard of management.

Class 4

These soils have more than one serious limitation to agricultural development. A very high standard of management is required for profitable cultivation on these soils.

..19/

Class 5

These are soils with at least one very serious limitation and consequently not suitable for large scale agricultural development.

The soil suitability map shows the distribution of the soil suitability classes. Where soils are mapped on an association basis, different classes of soils may be mapped together. The soil suitability of an association is then obtained by considering the predominance of one soil class over the others, or by taking the averate if the soils are distributed roughly in the same proportion. An association of Malacca (Class III) and Munchong (Class I) occurring in the same proportion may be considered to be of Class II suitability.

..20/

V. THE SOILS

The soils mapped are described under the very broad general groups of sedentary and alluvial soils. Areas of land having little or no natural soil, and areas where little detail is required have been described under miscellaneous land types.

The basic mapping unit used in this soil survey is the soil series, defined as a group of soils with similar profiles, developed under similar temperature and moisture regimes and having the same or very similar parent material. As the soil series very often occupies a relatively small area, it is more practicable when mapping on a reconnaissance scale to group the soils into an association. The first named component of the association is the more widely occurring soil. On a more detailed scale of mapping the soil association can be resolved into their component series.

No attempt is made in this report to classify the soils above the series level.

Sedentary Soils

Soils Developed on Igneous Rocks

Only two soils derived from igneous rocks occur in appreciable amounts. Both are formed on the acid igneous rock, granite. Rengam Series, however, is more widespread, and Tampin Series occurs

..21/

in association with Rengam in the Pasoh Forest Reserve, Jelebu. Two small patches of Segamat series are found in Juasseh and Kepis Forest Reserve, formed over small pockets of the intermediate igneous rock, andesite.

Rengam Series

Rengam Series is derived from granite, and is characterised by sandy clay loam to coarse sandy clay textures and a deep profile. This latter feature is often seen on road cuttings particularly in Jelebu and the Seremban - Labu road. The depth of the parent material may be more than 20 feet to the parent rock.

In Seremban District, Rengam Series occurs principally on a terrain that is level to undulating. In Labu, Kirby and Pajam estates, the soil is deep with textures ranging from sandy loam to sandy clay loam. It has reddish colours (5YR) in Kirby estate just south of the Galla Forest Reserve. In Hillside estate, 4 miles west of Seremban town, where the terrain is hilly, the texture becomes coarser and the profile is distinctly shallower. There is also much granite wash (colluvium) spread around this estate.

In the Kuala Klewang area of Jelebu, the soil is coloured red (5YR) and in the Tampin area it is pale yellow (10YR).

The top soil is commonly a dark brown (10YR 4/3), friable, sandy loam to sandy clay loam texture. Moderate development of fine subangular blocky to crumb structures are common. Up to about

25 inches the soil is friable with textures of sandy loam to sandy clay loam. While sandy clay loam is the typical texture of the Rengam top soil, variation in texture give rise to sandy loam and sandy clay in the subsoil. Structural development is moderate, medium subangular blocky structure predominating. The colour is usually brownish yellow (10YR 6/6 - 6/8).

Below about 25 inches the friable consistence changes sometimes through a transition zone to firm consistence with increase in clay content in the argillic horizon. The argillic horizon has sandy clay textures and prominent development of clay-skins around ped faces. This horizon is also deep and reddish mottles may be present. A zone of unhardened plinthite is found at depth. The soil is well drained. On steeper slopes the soil tends to be shallower, with the red colours appearing nearer to the surface.

Suitability

This soil is highly suitable for a wide range of crops. The deep profile and friable consistence allow ready penetration by the roots. The soil is free draining and hence there is no serious erosion problem on level or undulating topography. Erosion only becomes a problem on steeper terrain.

Tampin Series

The Tampin Series is found on a narrow belt in the Pasoh Forest Reserve in Jelebu District. It occurs in association with the Rengam Series in a topo - sequence, with the Tampin Series occupying the lower slopes. The soil is developed over very acid granite.

..24/

Tampin Series is described by Dumanski and Ooi (pg. 40): "The surface soil is friable, very pale brown to yellow (10YR 7/3-7/6) sandy to gravelly clay loam, with poorly developed, fine to medium, subangular blocky structures and weakly expressed clayskins. This is underlain by a pale brown to olive yellow (10YR 6/3 - 2.5Y 6/6) subsoil, which is sandy clay to gravelly clay in texture, friable in consistence and possesses weakly to moderately developed, medium, subangular blocky structures and moderately developed clayskins. The soil possesses a strongly expressed Ae/Bt horizon sequence, is commonly weakly mottled at depths greater than 40 inches, and exhibits a distinct increase of clay with depth. It is well rooted, sometimes micaceous, and distinctly gritty throughout".

Suitability

Tampin Series is generally considered as a Class III soil because the subsoil becomes compact with depth and therefore hinders root penetration.

Soil Developed on Sedimentary Rocks

A great variety of soils are formed on sedimentary rocks, particularly over shales and sandstones. This is due principally to the fact that profile morphology is affected markedly by variations in the lithology of the underlying rocks and by differences in topography.

Durian Series

Durian Series is derived from argillaceous sedimentary rocks. It is found on rolling and undulating terrain over shales, phyllites and interbedded shales and sandstones.

..24/

It has a wide distribution, occuring in association with other shale derived soils. On the hilly terrain of the Jelei - Gemas Forest Reserve, it occurs with Malacca Series and Munchong Series. It is also found over large areas in eastern Negeri Sembilan in association with Batu Anam and Malacca Series.

The soil is characterised by pale colours, silty clay textures and firm consistence in the subsoil which is also moderately compacted. The top soil is a thin, dark brown layer of friable consistence and granular structures. This is followed by a pale yellow eluvial horizon of about 12 inches. Textures are usually silty clay but may vary from clay loam to clay. The eluvial horizon has a friable, or friable to firm argillic horizon with moderately developed and usually coarse subangular blocky structures. Clayskins are continuous to patchy.

Below this may be found a band of fragmental or nodular laterite usually about 18 inches thick. This is followed by a strongly mottled reddish yellow to yellowish red horizon and unhardened plinthite.

Quartz grits is ubiquitious and quartz pebbles frequently occur within the profile, mostly remnants of quartz veins.

Suitability

The Durian Series has been placed in Class III mainly because the compact subsoil impedes root penetration. The soil is also not free draining.

Suitability

The compact subsoil and the poor internal drainage within the soil hinders rooting and aeration. It is thus considered to be marginally suitable (Class III), but rubber has been successfully grown on these soils (Dumanski and Ooi, Page 42).

Serdang Series

Serdang Series is formed on arenaceous sedimentary rocks like quartzite, sandstones, conglomerates and sandy shales or on interbedded arenaceous and argillaceous sediments. This soil occurs mainly on undulating to rolling terrain, grading on hilly terrain to the shallow soils of Kedah Series. It also occurs with Munchong Series where argillaceous material is interbedded and also with Bungor Series in which the parent material is a mixed arenaceous and argillaceous sediments. In the western portion of Seremban District, Serdang Series occurs in association with Munchong and Tavy Series. Near and around Kuala Pilah however it occurs together with Bungor and Kedah Series. The soil is usually more than 4 feet deep.

Below a thin top soil is a friable yellowish brown to brownish yellow (10YR 5/4 - 5/6) sandy clay loam (usually more than 4 feet deep). Structural development is weak to moderate with fine medium subangular blocky structures. Development of clayskins is patchy. This is underlain by a textural B horizon of yellowish brown to reddish yellow (10YR 5/6 - 7.5YR 6/8) friable sandy clay loam to sandy clay with moderate development of subangular blocky structures and discontinuous clayskins. Below this is the parent material, with firm consistence and occasionally containing non-hardened plinthite.

Suitability

The depth of the soil and it's porous and friable nature allows good drainage, aeration and root penetration. It is thus a Class 1 soil, and suitable for a wide range of crops. On rolling to hilly terrain, the soil is susceptible to erosion when left bare.

Kedah Series

Kedah Series is the shallow associate of Serdang Series. Developed on sandstone they are found on hilly terrain and ridges, commonly occuring in association with Serdang Series which are found in the lower and gentler slopes. A thin topsoil overlies a subsoil which seldom exceeds 20 inches in thickness. Textures are frequently sandy loams, and the soil has a friable consistence and weak to moderately developed medium subangular blocky structures. Textures may get coarser with depth often becoming gravelly before reaching the parent material at about 20 inches.

Suitability

Both terrain and shallow depth of soil limit the agriculture potential so that Kedah Series is a Class III soil. On very steep terrain (more than 20^{o} slope) it can be considered as Class five.

Bungor Series

Bungor Series is developed over rocks with an arenaceous texture. It is found over sandy shale, sandstones, interbedded sandstone and shales on undulating to hilly terrain.

..28/

As may be expected it can occur in association with a variety of soils. In Negeri Sembilan it occurs in association with Munchong and Batu Lapan Series around Kuala Pilah and also with Durian, Malacca and Marang near Bahau.

The thin top soil of about three inches has loam to sandy loam texture, friable consistence and granular structures. This is followed by a brownish yellow (10YR 6/6) to strong brown (7.5YR 5/8) eluvial horizon with sandy clay loam textures, friable consistence and moderately developed subangular blocky structures. Clay-skins are patchy to discontinuous. The eluvial horizon overlies in most cases a textural B horizon. This horizon has a firm or friable to firm consistence, sandy clay or sandy clay loam textures. Colour may be slightly stronger but the feature that characterises the soil is the light blotchy mottling pattern present in this horizon and also in the eluvial horizon above. There is moderate development of subangular blocky structure. The soil may be lateritic at depth. The laterite if present is usually a band not more than 20 inches thick. Quartz grits and gravels are common, the latter occuring either as stone lines or as isolated gravel in the soil. The consistence becomes firmer with depth.

Suitability

The top three feet of soil is friable and sufficiently porous to allow free rooting and good aeration. Barring terrain limitation, the soil is quite suitable for a range of tree crops including oil palm.

..29/

Munchong Series

Munchong Series is derived from ferruginous shale and schist and occurs over a variety of slopes.

It is normally associated with Serdang Series as shale is often interbedded with sandstone. Munchong Series is also found in association with Malacca Series, Bungor Series and with Seremban and Batu Lapan Series in steeper terrain, in various areas in Negeri Sembilan.

The thin humic top soil is underlain by a friable strong brown to brownish yellow (7.5YR 5/6 - 10YR 5/6) soils with textures of sandy clay loam or silty clay loam. There is moderate development of medium sized subangular blocky structures and discontinuous clayskins on ped faces and lining pores. Below this horizon the consistency become firmer and colours become stronger; strong brown colours (7.5YR 5/6) are quite common and the soil exhibits moderate to well developed fine subangular blocky structures and discontinuous clayskins.

The soil is deep and porous (usually more than 4 feet deep). Occassionally it may be lateritic, the laterite being in small quantities and in the form of nodules or fragments.

Strong brown colours are a distinctive feature of Munchong Series. A reddish variant (yellowish red - 5YR 5/6 - 5/8) can be seen in Senawang estate just south of Seremban and in the Jelei-Gemas Forest Reserve (extension), which can be correlated with the Prang Series mapped in Selangor.

Suitability

A friable and deep soil like the Munchong Series does not have any limitation to cultivation of tree crops on level to undulating terrain. On cleared, hilly terrain, erosion through gullying and slumping may be a problem. Munchong is a Class 1 soil on level to undulating terrain.

Malacca Series

Malacca Series is a soil developed (usually) on ferruginous shales, schists and phyllites. It commonly occurs on undulating to hilly terrain, usually in association with Tavy Series found on the lower slopes of hills and Munchong Series as in the Port Dickson District. Here it occupies a large area on a broken terrain made up of low hills, about 100 feet high with a dendritic network of inland swamps and sluggish streams. The form of the laterite is variable. They may be massive laterite (fossil laterite?) which often stand up as low hills or just boulders strewn on the slopes. Frequently the laterite is fragmental, either loosely or closely packed.

Other series commonly associated with Malacca Series are Batu Anam or Durian Series, the latter two occupying the slopes. In the Jelei Gemas Forest Reserve, Malacca occurs sporadically with Munchong and Durian on a terrain that is undulating to hilly. Well rounded laterite (buckshot or ironstone gravel) outcrops just south of Middleton estate, Rompin. About 5 miles down the Rompin - Tampin road, there is a laterite quarry which has a wall more than 8 feet high made up of closely packed nodular and fragmental laterite.

Malacca Series also occurs as a broad belt in the eastern border of the Palong Forest Reserve and in the area east of Rompin.

The surface horizon is less than one foot in depth, friable yellowish brown to strong brown (10YR 6/8 - 7.5YR 5/6) sandy clay loam with moderate to weakly developed medium and fine subangular blocky structures. Below this is the petric horizon consisting of nodular, fragmental or massive laterite with a soil matrix. The matrix colour varies from strong brown (7.5YR 5/6), yellowish red (5YR 5/8) or reddish yellow (5YR 6/8) and has texture of sandy clay loam to clay. It is friable with discontinuous clayskins and moderately developed medium subangular blocky structures. The degree of compaction of the laterite varies somewhat and the lateritic horizon extends to more than 3 feet in depth, below which is the highly variegated non-hardened plinthite.

Suitability

The compact lateritic zone is a hindrance to root penetration. This is a serious limitation so that Malacca Series is usually placed in Class III. When there is hardly any topsoil and massive boulders of laterite outcrop on the surface, it is placed in Class V. However there are instances where the lateritic zone is quite loose and rubber is known to grow quite well on these soils.

Tavy Series

They are formed over ferruginous argillaceous parent material and occur in association with Malacca, Munchong, Batu Anam and Durian. Quite often their relationship is a catenary one, the Tavy occupying the lower slopes. They are usually found on topography which is rolling to hilly.

Tavy occurs with Malacca and Munchong in the Port Dickson district and with Durian and Malacca in the Ayer Kuning area in Tampin. It occurs with Serdang and Munchong in the eastern portion of Seremban district.

The surface horizon is a friable, yellowish brown to reddish yellow (10YR 5/4 - 7.5YR 7/6), sandy clay loam with weak to moderately developed subangular blocky structures. This horizon extends to a depth of two feet or more before coming onto the lateritic horizon. This horizon is usually less than 36 inches thick and consists of nodular or fragmental laterite or even laterised shale in a matrix of yellowish red to reddish yellow (5YR 5/8 - 5YR 6/8) gritty clay. This is underlain by variegated unhardened plinthite.

Suitability

The lateritic subsoil may limit the depth of rooting so that this soil has been placed in Class III. However, if the lateritic horizon occurs below 3 feet or more crops like oil palm with fibrous roots may be grown successfully.

Efforts must be made to prevent loss of surface soil by erosion by the use of cover crops.

Marang Series

It occurs extensively in eastern Negeri Sembilan in the Bahau and Palong Forest Reserve. It is commonly associated with Batu Anam and Bungor soils in rolling topography (slopes 6^{o}-12^{o}), and with Malacca and Tavy in steeper slopes. It is described by Dumanski and Ooi (page 44).

"The surface soil is a friable, light yellowish brown to pale yellow (10YR 6/4 - 2.5Y 7/4) sandy to fine sandy clay loam, which possesses weakly developed, fine to medium, subangular blocky structures very pale brown to yellow (10YR 7/8 - 2.5Y 7/6) sandy to fine sandy clay subsoil, which is weakly mottled and exhibits moderately well developed, fine to medium, subangular blocky structure and moderately developed clayskins. To this point the soil is porous, moderately well rooted, slightly mottled, and exhibits a well expressed Ae/Bt horizon sequence. Beneath this, at depths varying from 2 - 5 feet, there is commonly a very sharp unconformity, the soil changing to a firm highly mottled, but still well structured clay which is light grey to pale yellow (2.5Y 7/9 - 7/8) in colour. Some tiny nodules of hard and soft laterites are common in this horizon and rooting is very poor. A thin, angular quartz stoneline is often present at the boundary of the unconformity, and small fragments of quartz are common throughout the soil".

Suitability

The soil is of Class III suitability because of the shallowness of the soils and firm consistency of the subsoil.

Seremban Series

Seremban Series is formed over schists and phyllites on a hilly terrain. It occurs commonly with Munchong and is present over a wide area in Seremban district.

The top-soils overlie a reddish yellow (7.5YR 7/8) subsoil of friable to firm consistence. Structural development is moderate and textures are sandy clay to sandy clay loam. Laterised schist and phyllite fragments invariably occur within the profile often accompanied by quartz pebbles.

Suitability

The profile often tends to be shallow because the steepness of the terrain allows rapid removal of topsoil by erosion and, as rock fragments commonly occur within the profile, the soil can only be considered to be marginally suitable (Class III).

Batu Lapan Series

This soil is formed over shale and has been mapped with Bungor and Munchong in the Kepis area of Kuala Pilah. The soil profile is generally shallow and silty textures are characteristic.

The top soil is a yellowish brown (10YR 6/4) silty loam overlying a strong brown (7.5YR 5/6) silty or clay loam. The consistency tends to be firm and structural development is moderate. The parent material is usually encountered at about 30 inches and this is crumbly, soft, shale fragments or laterised shale. Terrain is undulating to rolling.

Suitability

The shallow profile and hilly terrain renders it a Class III soil. Erosion by slumping is a common feature in these soils.

..35/

Alluvial Soils

The alluvial soils can be differentiated on the basis of their topography and profile morphology into soils on the intermediate terrace and soils on the low level terrace and flood plain.

a) Soils on the intermediate terrace

These are soils located above the present flood plains of the rivers, on a terrain that is level to gently undulating.

(i) Holyrood Series

Holyrood Series is developed over sub-recent alluvium. They occur on a level to gently undulating terrain of a weakly dissected river terrace.

They are brownish yellow to yellow or pale brown, loose to friable sandy loam or sandy clay loam. It occurs over a small area, in association with Lunas and Akob Series, near Kuala Pilah.

The topsoil is a very friable grey brown, loamy sand or sandy loam with granular and subangular blocky structures. Below is an horizon sometimes more than 12 inches thick, very friable with sandy loam textures and brownish yellow (10YR 6/6) colour. It has weakly developed subangular blocky structures. There is gradual increase of clay down the profile. A weakly expressed B may be found at about 18 inches. The horizon is very friable, brownish yellow or pale brown in colour with weak subangular blocky structures Faint mottles may be present usually reddish yellow and ligh. grey. The mottles increases down the profile.

Suitability

The soil is strongly leached and the loose texture of the soil allows rapid internal drainage. This would result in heavy loss of fertiliser and also drying up of the soil when there is insufficient rain. Holyrood Series is thus marginally suitable (Class III).

(ii) Lunas Series

Lunas Series is another alluvial soil developed over subrecent alluvium. It is found in low lying areas of the Holyrood terraces and is very pale coloured compared to the Holyrood.

Below the dark brown thin topsoil, is a friable, weakly structured pale brown to yellow sandy loam. At about fifteen inches is the light grey weakly expressed 'B' horizon. This horizon is also friable, with weakly developed subangular blocky structures. Texture may be sandy clay loam or sandy clay. The soil is frequently waterlogged.

Suitability

The soil is very much like the Holyrood. Drainage is impeded, Lunas is only marginally suitable (Class III).

b) Soils on the low level terrace and flood plain

These are hydromorphic soils, poorly drained and with little or no horizon differentiation.

..37/

(i) Briah Series

Briah Series is developed on recent riverine alluvium or mixed marine and riverine alluvium in coastal areas. Water table is usually encountered within three feet from the surface.

Colours are generally light grey. Textures of clay or silt loams are common and the soil is quite strongly mottled.

The top 6 inches is a dark brown, friable, silty clay loam or clay loam with weakly developed fine subangular blocky structures. The subsoil is light grey (5Y 7/2) to grey (6Y 5/1). Texture is usually silty clay. The structure changes to moderate or well developed coarse prisms. Consistence becomes plastic and sticky with depth. Mottles are common ranging in colours from yellowish brown (10YR 5/8), reddish yellow (7.5YR 7/6) and strong brown (7.5YR 5/6). Below the water table the soil becomes sticky, plastic and structureless.

Suitability

Briah may be subject to seasonal flooding. When drained it can be used successfully for a variety of tree crops: otherwise it is ideally suited for padi cultivation. It is of Class II suitability.

(ii) Akob Series

Akob Series is an alluvial soil occurring in association with Holyrood and Lunas and with Local Alluvium near Kuala Pilah. It occurs in depressional areas behind levees and is utilised for cultivation of padi.

A pale brown (10YR 8/3) topsoil overlies a pale brown to white (10YR 7/3 to 8/2) firm sandy clay. It is strongly mottled and has weak to moderately developed subangular blocky structures.

Suitability

The soils are subject to seasonal flooding and are thus of Class II suitability. They are, however, excellent for padi cultivation.

(iii) Linau Series

This soil is developed over recent marine alluvium behind the active shore line free from tidal inundation. Under natural conditions it is a fresh water swamp soil. The surface soil is usually a dark greyish brown (10YR 3/3) organic clay with decaying vegetation. The subsoil at about 18 inches is structreless having a strong sulphurous odour. Within this horizon there are large amounts of decomposed and semi-decomposed plant remains. This horizon is underlain by bluish grey clay with sulphurous odour.

Suitability

When drained the soil may be utilised for shallow rooting crops. However on drainage and consequent oxidation these soils are known to become very acidic and deposits of sulphur are commonly observed in the soil. This toxic state is a serious limitation and, thus, Linau is a Class IV soil.

(iv) Kranji Series

Kranji Series is developed on recent marine and estuarine clays along the coast. They are saline gley soils, and being subject to tidal influence are actively accumulating. They support a mangrove and Nipah (Nipa fruiticans) vegetation.

There is little profile differentiation in these soils. Colours are usually bluish grey and textures clay or silty clay with a sticky and plastic consistence.

Suitability

The high salinity of these soils is a serious limitation. Besides, on drainage,highly acidic conditions may develop. Consequently,Kranji Series is a Class IV soil.

(v) Mangrove Swamp Association

These occur over a small area in association with Kranji soil along Sungei Sepang. There is a wide textural range in these soils varying from sand to clay and which are often interstratified. Otherwise they are similar to Kranji Series.

..40/

Suitability

Like the Kranji, because of their poor drainage status and high salinity, they are Class IV soils.

(vi) Organic Clays and Muck

This is an organic soil complex having a high percentage of organic matter. They have a loss of ignition between 20 per cent and 65 per cent. They occur in association with Briah Series in Port Dickson.

There is very little profile development. They are dark grey, sticky, and structureless with plant remains in varying stages of decomposition. These soils are frequently waterlogged.

Suitability

Organic Clays and Mucks are of Class IV suitability. The poor drainage condition is a serious limitation and the organic horizon is acidic.

Miscellaneous Land Units

These are land units used in the mapping of soil groups in land with low agricultural potential. Although there is no scientific basis for grouping these soils into these land units, they are a convenient group because of the ease with which they can be demarcated. Besides, on the schematic reconnaissance scale of survey no further detail is required.

(i) Steepland

Land with average slopes of more than 20^{o} are considered as steepland. This is the steepland boundary proposed in the 'Soil Survey Manual for Malayan Conditions (Leamy & Panton p. 16)'.

In most cases the 250' contour level was found to conform to the steepland boundary. The soils on the steepland have shallow profiles and are easily eroded, so that allowing it to remain under forest would seem to be the best land use policy.

(ii) Disturbed Land

Land disturbed by mining activity and by development of township, rural or urban are designated as disturbed land. They have very little agricultural potential.

(iii) Local Alluvium

These are recent alluvial deposits of small streams and rivers, which are present all over the countryside. Textures are very variable depending on the rock type being eroded and there is very little profile development as fresh material is constantly added.

(iv) Riverine Alluvium

This is a mixed alluvium in the flood plains of larger rivers, and lying adjacent to and intergrading into the local alluvium. They may be considered to be sub-recent alluvium on

..42/

a terrace where very little dissection has taken place. The soils show some degree of profile development.

These soils can be utilized for a variety of crops. Padi is the main crop cultivated on these soils.

(v) Inland Swamp Association

As the term implies these are poorly drained soils almost permanently under water. These may grade into organic clays, muck and peat. With proper drainage control they may be utilized for padi cultivation.

..43/

VI. POTENTIAL FOR AGRICULTURAL DEVELOPMENT

In this Chapter the present land use in Negeri Sembilan is summarized and the Potential for Agricultural Development in the State is briefly discussed.

1. Present Land Use in Negeri Sembilan

A detailed account of the present land use statistics may be obtained from the Present Land Use Survey, Negeri Sembilan, 1968 (Donaldson and Siew, 1968) and only the more salient points are mentioned here. Of the total 1,646,122 acres of land in Negeri Sembilan about 34.8 percent is under various forms of agriculture. About 86 percent of agriculturally

../44/

used land is under rubber. Negeri Sembilan boasts the second highest rubber yields (lbs. per acre) in the country.* The average yield is 1,014 lbs per acre, the National Average being 898 lbs per acre (Rubber Statistics Handbook, 1966). Rubber is followed by padi which takes up about 5.5 percent and the remaining agricultural land is shared between oil palm, coconut and annual crops like tapioca, maize, sugar cane, bananas etc. Oil palm only accounts for about 0.9 percent of agricultural land. It is expected that oil palm acreages will increase substantially when it replaces old rubber holdings.

As Negeri Sembilan does not possess large areas of alluvial flats, either coastal or riverine, padi cultivation is mainly confined to valley floors and small alluvial plains. About 31,320 acres of land is under padi cultivation and 45 percent of the State's padi is grown in the district of Kuala Pilah.

As estimated 1,500 acres of land is under coconut, of which about 80 per cent is grown along the coast in Port Dickson district. It is certainly not a thriving concern and Donaldson and Siew (1968 pg. 8) noted that "with rapid development of 'Tourist Urbanization' combined with seaward encroachment of more profitable rubber, the coastal strips of coconut are quickly disappearing".

---

* Next to Malacca.

2. Potential for Agricultural Development

Agricultural development is far more extensive (about 61 per cent of the land) in the more populous and accessible western half of Negeri Sembilan, comprising the districts of Rembau, Seremban and Port Dickson. It is also pertinent to note that 64 per cent of Class 1 soils and 47 per cent of Class II soils in the state are located here. Only about 24 per cent of the land in the eastern half is under agricultural use, so that in terms of available land there is more scope for agricultural development in the districts of Jelebu, Kuala Pilah and Tampin.

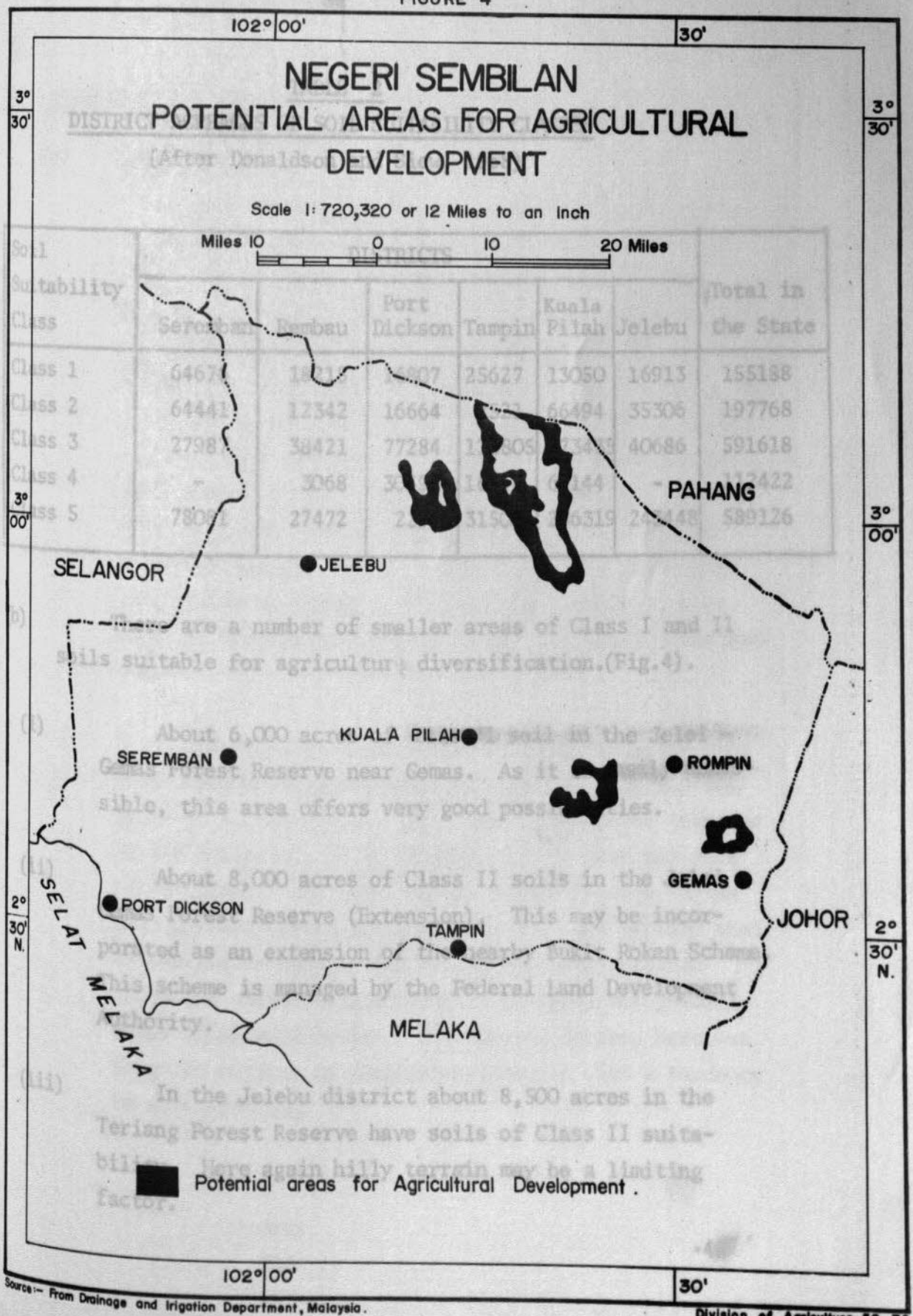
The amount and distribution of soil suitability classes in Negeri Sembilan are shown in table 2.

3. Undeveloped Forested Land with Agricultural Potential

(a) In the Pasoh Forest Reserve there are about 25,000 acres of Class II soils which can be utilised for immediate agricultural use (Fig. 4). They take the form of a narrow belt and extend northwards into Pahang. The soils are granite derived, Rengam - Tampin association. They are deep and friable and have little or no limitation to tree crop cultivation. Although terrain is for the main part rolling to hilly, it is partly undulating in places, particularly in the South. As the soils extends over a larger area in Pahang, this area is suitable for a large land development scheme.

..46/

FIGURE 4



Source:– From Drainage and Irrigation Department, Malaysia.

Division of Agriculture 56-70

TABLE 2

DISTRICT ACREAGES OF SOIL SUITABILITY CLASSES

(After Donaldson and Siew, 1968)

Soil Suitability Class	DISTRICTS						Total in the State
	Seremban	Rembau	Port Dickson	Tampin	Kuala Pilah	Jelebu	
Class 1	64676	18215	16807	25627	13050	16913	155188
Class 2	64441	12342	16664	2521	66494	35306	197768
Class 3	27987	38421	77284	133805	273435	40686	591618
Class 4	-	3068	30598	16594	62144	-	112422
Class 5	78081	27472	2298	31508	206319	243448	589126

(b) There are a number of smaller areas of Class I and II soils suitable for agricultur diversification.(Fig.4).

(i) About 6,000 acres of Class 1 soil in the Jelei - Gemas Forest Reserve near Gemas. As it is easily accessible, this area offers very good possibilities.

(ii) About 8,000 acres of Class II soils in the Jelei - Gemas Forest Reserve (Extension). This may be incorporated as an extension of the nearby Bukit Rokan Scheme. This scheme is managed by the Federal Land Development Authority.

(iii) In the Jelebu district about 8,500 acres in the Teriang Forest Reserve have soils of Class II suitability. Here again hilly terrain may be a limiting factor.

4. Agricultural Potential of Class III Soils

(i) Sedentary Soils

Areas with Class III soils are considered to be moderately suitable for agricultural diversification. Much of these areas in Negeri Sembilan are Forest Reserves, and it may be in the best interests to leave them under forest. However, ignoring the land capability factor and considering the prospects of agriculture 'per se' these areas although not having the best soils can and have been successfully developed for agriculture, particularly rubber. Dumanski and Ooi (pg.52) observe that "although they are not suitable for agricultural diversification, they are still capable of producing high yields of rubber". The deciding factor in most cases is the availability of a high standard of management.

The soils in these areas are derived mostly from argillaceous rocks and the main limitation is its tendency to be lateritic. While the occurance of laterite is not universal, it is variable in its form and mode of occurance. In Jelei - Gemas Forest Reserve Durian and Munchong Series are also present, on a terrain that is rolling to hilly. The soils have been accorded Class III suitability because of the apparent predominance of Malacca Series. The Malacca Series, here was found to consist of fragmental laterite with a tendency to close packing.

The Palong and South Gemas Forest Reserve have a more favourable terrain of undulating land and low hills, but here again the soils are either extensively lateritic or have subsoils of firm consistency (e.g. Durian and Batu Anam).

(ii) Alluvial Soils

Although the bulk of Class III soils are sedentary soils, most of the alluvial soils in Negeri Sembilan fall within this class. The long,narrow and sinuous strips of local and riverine alluvium and inland swamps are present throughout the State and add up to an appreciable acreage. But, waterlogging and susceptibility to flooding limit these soils to padi cultivation. With proper drainage and water control these soils would be suitable for intensive cultivation of padi.

ACKNOWLEDGEMENTS

The authors were assisted in the field by Junior Agricultural Assistant Encik Abdul Malek bin Gadoh.

Thanks are due to the State Agriculture Officer, Encik Ahmad bin Baba and the Staff of the Department of Agriculture in Seremban. The authors also extend their grateful thanks to their colleagues both in the field and in the laboratory for their valuable suggestions and services.

Finally the authors wish to thank S. Pushpadevi for typing the report.

REFERENCES

DONALDSON & SIEW KAM YEW (1968) "The Present Land Use of Negeri Sembilan". Present Land Use Report No. 2, Research Branch, Division of Agriculture, Malaysia.

DUMANSKI J. & OOI CHENG HOCK (1966). "Reconnaissance Soil Survey of the Temerloh - Gemas Region, Malaya". Malayan Soil Survey Report 5/1966.

IVES, D.W. (1967). "Schematic Reconnaissance Soil Survey of South East Pahang". Malayan Soil Survey Report No. 1967 (in print).

LAW WEI MIN & LEAMY M.L.(1966). "Factors Involved in the Genesis of Some Shale Derived Soils in Malaya". Proc. 2nd Malaysian Soils Conference. Res. Branch. Division of Agriculture, Malaya pg. 79 - 85.

LEAMY M.L. & PANTON W.P.(1966). "Soil Survey Manual For Malayan Conditions". Ministry of Agriculture & Cooperatives, Malaysia, Division of Agriculture, Bulletin No: 199 pg. 226.

PARAMANANTHAN S. (1968). "Schematic Reconnaissance Soil Survey of Malacca". Malayan Soil Survey Report No: 3/1967.

RUBBER STATISTICS HANDBOOK (1966). Department of Statistics.

SMALLWOOD, H.A. (1966). "Schematic Reconnaissance Soil Survey of the Segamat - Gemas, Tangkak Region, North Johore". Malayan Soil Survey Report No: 2/1966.

SOIL SURVEY STAFF (1960). "Soil Classifications. A comprehensive System". 7th Approximation. Soil Conservation Service, US. Dept. Agric. 265 p.

TREWARTHA, G. (1954). "An Introduction to Climate" McGraw Hill Series in Geography, Toronto, Canada.

WILLBOURNE, E.S. (1922). "An Account of the Geology and Mining Industries of South Selangor and Negeri Sembilan". Geological Department Federated Malay States.

..53/

WONG, I.F.T. (1966). "Soil Suitability Classification for Dryland Crops in Malaysia". Proc. 2nd Malaysian Soils Conference, Research Branch, Division of Agriculture, Malaya pg. 153 - 156.

WONG, I.F.T. (1966). "Reconnaissance Soil Survey of Selangor". Malayan Soil Survey Report No: 6/1966.

Wyatt-Smith, J. (1964). "A Preliminary vegetation map of Malaya with description of the vegetation types". J. Trop. Geog. Vol. 18.

../54

ANALYSIS OF BATU ANAM SERIES PROFILE

HORIZON	Percentages				On Original Sample		pH	Percentages			Exchangeable Cations m.e/100g.				Saturation %	Easily Soluble
	Clay	Silt	Fine Sand	Coarse Sand	Gravel %	Stones %		Carbon	Nitrogen	C.E.C. m.e/100g.	K	Ca	Na	Mg		P (ppm)
Ah	47	36	16	6	-	-	3.4	1.24	0.10	10.46	0.20	0.38	0.04	0.64	12	57
Ae	53	34	12	5	-	-	3.5	0.24	0.04	7.43	0.14	0.11	0.07	0.35	9	50
Bt	57	32	10	4	-	-	3.4	0.17	0.04	7.60	0.14	0.11	0.09	0.20	7	41
C	61	30	9	4	-	-	3.2	0.12	0.02	7.93	0.06	0.22	0.02	0.12	5	29

APPENDIX 1

Profile Description and Chemical Analysis of Major Soil Series

(Horizon Nomenclature after Leamy and Panton, 1966)

Batu Anam Series

Location : South Gemas Forest Reserve. Map Sheet 105. Grid Position: 575124.

Topography : About 4^{o} slope in undulating terrain.

Vegetation : Primary jungle.

Parent Rock : Shale.

Profile:

Ah: 0-2"; light brownish grey (10YR 6/2) clay; friable; well developed granular structures; abundant roots, channels and pores; quartz grits; boundary distinct.

Ae: 2-14"; very pale brown (10YR 7/3) clay; firm; weakly developed coarse blocky structures breaking down to medium angular blocky structures; patchy clayskins; few roots, channels and pores; boundary distinct.

Bt: 14-28"; very pale brown (10YR 8/3) clay; very firm; weak coarse structure; patchy clayskins; few roots, channels and pores; many medium prominent reddish yellow (7.5YR 7/6) mottles; boundary distinct.

C : 28-46" and light grey (10YR 7/1) clay; very firm; massive and structureless; no roots, channels and pores; abundant medium prominent red mottles (2.5YR 5/8). One inch thick laterite band at 28".

ANALYSIS OF DURIAN SERIES PROFILE

HORIZON	Percentages				On Original Sample		pH	Percentages			Exchangeable Cations m.e/100g.				Saturation %	Easily Soluble
	Clay	Silt	Fine Sand	Coarse Sand	Gravel %	Stone %		Carbon	Nitrogen	C.E.C. m.e/100g.	K	Ca	Na	Mg		P (ppm)
Ah	36	29	21	18	-	-	3.4	1.23	0.13	10.80	0.34	0.19	0.06	0.78	13	49
Ae	42	29	19	14	-	-	3.4	0.35	0.07	8.61	0.24	0.11	0.02	0.38	9	44
Bt	58	23	13	11	0.46	-	3.5	0.18	0.07	10.13	0.20	0.14	0.04	0.20	6	42
BC	55	18	15	14	6.6	2.7	3.3	0.12	0.06	9.79	0.09	0.14	0.04	0.20	5	37

Durian Series

Location : South Gemas Forest Reserve. Map Sheet 105.
Grid Reference : 576117.

Topography : About 5^{o} slope on undulating terrain.

Vegetation : Primary jungle.

Parent Rock : Shale.

Profile:

Ah: 0-1"; light yellowish brown (10YR 6/4) clay loam; friable; moderately developed granular structure; many roots, channels and pores; boundary distinct.

Ae: 1-12"; yellow (10YR 7/6) clay; friable; weakly developed medium subangular blocky structures; few roots, channels, many pores; patchy clayskins; quartz grits present; boundary distinct.

Bt: 12-18"; reddish yellow (7.5YR 6/8) clay; firm; weakly developed coarse to medium angular blocky structures; few roots, channels and pores; patchy clayskins; quartz grits present; boundary diffuse.

BC: 18"+; very pale brown (10YR 7/3) clay; firm; weakly developed coarse blocky structures; no roots, patchy to discontinuous clayskins; quartz grits present; strongly mottled to variegated; mainly light red (2.5YR 6/8) mottles.

ANALYSIS OF BUNGOR SERIES PROFILE

HORIZON	Percentages				On Original Sample		pH	Percentages			Exchangeable Cations m.e/100g.				Saturation %	Easily Soluble
	Clay	Silt	Fine Sand	Coarse Sand	Gravel %	Stones %		Carbon	Nitrogen	C.E.C. m.e/100g.	K	Ca	Na	Mg		P (ppm)
Ah	37	14	41	9	-	-	3.6	1.82	0.25	12.32	0.35	0.54	0.07	0.96	16	77
Ae	43	14	42	10	-	-	3.4	0.44	0.09	9.96	0.16	0.08	0.09	0.32	7	40
Bt	55	10	33	8	-	-	3.6	0.26	0.07	11.31	0.06	0.03	0.02	0.23	3	38
Btj	60	10	28	6	-	-	3.7	0.21	0.04	11.14	0.06	0.05	0.04	0.29	4	40

Bungor Series

Location : Kepis Forest Reserve. Map Sheet 104.
Grid Reference: 221279.

Topography : About 18° on hilly terrain.

Vegetation : Primary jungle.

Parent Rock : Sandy shale.

Profile:

Ah: 0-3"; light yellowish brown (10YR 6/4) sandy clay, friable; well developed granular structure; many roots, casts, channels and pores; quartz grits present; boundary distinct.

Ae: 3-20" sandy clay brownish yellow (10YR 6/6) friable, moderately to strongly developed medium subangular blocky structures; many pores, roots, casts and channels; patchy to discontinuous clayskins; quartz grits present; faint yellowish mottles; boundary diffuse.

Bt_1: 20-44"; strong brown (7.5YR 5/8) clay; friable to firm; moderate to strongly developed medium subangular blocky structures; many roots and pores; discontinuous to continuous clayskins; quartz grits; yellow (10YR 7/8) mottles common; boundary diffuse.

Bt_2: 44"+; strong brown (7.5YR 5/8) clay; firm; weak to moderately developed subangular blocky structures; few roots; patchy clayskins; quartz grits; yellow mottles (10YR 7/8) common.

ANALYSIS OF MUNCHONG SERIES PROFILE

HORIZON	Percentages				On Original Sample		pH	Percentages			Exchangeable Cations m.e/100g.				Saturation %	Easily Soluble
	Clay	Silt	Fine Sand	Coarse Sand	Gravel %	Stones %		Carbon	Nitrogen	C.E.C. m.e/100g.	K	Ca	Na	Mg		P (ppm)
Ah	74	19	9	3	-	-	3.2	2.39	0.14	15.87	0.24	0.78	0.06	0.78	12	84
Aej	80	9	9	4	-	-	3.6	0.8	0.05	9.45	0.18	0.03	0.09	0.43	8	54
Btj	83	14	6	2	-	-	3.8	0.50	0.03	8.65	0.09	0.03	0.07	0.41	7	61
Bt	84	9	5	2	-	-	3.8	0.43	0.03	7.93	0.03	0.03	0.04	0.52	8	55

Munchong Series

Location : Jelei - Gemas Forest Reserve. Map Sheet 104. Grid Reference: 315219.

Topography : About 7^{o} slope in rolling terrain.

Vegetation : Primary jungle.

Parent Rock : Shale.

Profile:

Ah: 0-2"; dark yellowish brown (10YR 4/4) clay; very friable; moderate to strongly developed medium to fine subangular blocky structures; abundant roots and pores; boundary distinct.

Aej: 2-9"; strong brown (7.5YR 5/6) clay with few grits; very friable; moderate to strongly developed medium subangular blocky structures; abundant roots and pores; discontinuous to continuous clayskins, boundary diffuse.

Btj: 9-21"; yellowish red (5YR 5/6) clay with few grits; friable; moderate to strongly developed medium subangular blocky structures; few roots and casts, many pores; discontinuous clayskins; boundary diffuse.

Bt : 21-45"+; yellowish red (5YR 5/8) clay; friable to firm; weak to moderately developed fine subangular blocky structures; few roots; patchy clayskins.

ANALYSIS OF RENGAM SERIES PROFILE

HORIZON	Percentages				On Original Sample		pH	Percentages		Exchangeable Cations m.e/100g.					Saturation %	Easily Soluble
	Clay	Silt	Fine Sand	Coarse Sand	Gravel %	Stones%		Carbon	Nitrogen	C.E.C. m.e/100g.	K	Ca	Na	Mg		P (ppm)
Aeh	53	2	16	34	-	-	3.7	1.42	0.14	10.13	0.16	0.19	0.07	0.49	9	70
Ae	51	18	18	16	4.0	-	3.2	1.11	0.09	9.28	0.20	0.19	0.04	0.41	9	50
Bt	64	4	10	26	-	-	3.8	0.27	0.04	7.25	0.03	0.08	0.04	0.23	5	46

Rengam Series

Location : Seremban - Labu road. Map Sheet 102.
Grid Reference: 844477.

Topography : About 9° slope on rolling terrain.

Vegetation : Secondary growth - belukar and old rubber.

Parent Rock : Granite.

Profile:

Aeh: 0-3"; dark brown (10YR 4/3) coarse sandy clay; friable; moderately developed fine subangular blocky structures; many roots; coarse channels and pores; quartz grit; boundary distinct.

Ae: 3-24"; reddish yellow (7.5YR 6/6) clay; friable; weak to moderately developed subangular blocky structures; many roots; few casts; many pores; patchy to discontinuous clayskins; quartz grits; boundary diffuse.

Bt: 24-48"; brownish yellow (10YR 6/6) clay; friable to firm; weakly developed medium subangular blocky structures; few roots; pores; patchy clayskins; quartz grits.

ANALYSIS OF BRIAH SERIES PROFILE

HORIZON	Percentages				On Original Sample		pH	Percentages			Exchangeable Cations m.e/100g.				Saturation %	Easily Soluble
	Clay	Silt	Fine Sand	Coarse Sand	Gravel %	Stones %		Carbon	Nitrogen	C.E.C. m.e/100g.	K	Ca	Na	Mg		P (ppm)
Ah	49	40	6	Trace	-	-	3.2	2.47	0.16	18.73	0.38	0.19	0.16	0.98	9	73
ABg	62	34	5	Trace	-	-	3.3	1.30	0.09	18.57	0.38	0.35	0.85	0.46	11	66
BCg	63	40	2	Trace	-	-	3.2	2.00	0.07	24.31	0.60	1.03	1.92	3.71	30	47

Briah Series

Location : Chuah, Port Dickson. Map Sheet 102.
Grid Reference: 723310.

Topography : Level.

Vegetation : Secondary growth (belukar).

Drainage : Water table at 18 inches.

Parent Material : Mixed riverine and marine alluvium.

Profile:

Ah: 0-7"; dark grey (10YR 4/1) clay loam; friable; moderately developed fine to medium subangular blocky structures; many roots; pores; boundary distinct.

ABg: 7-18"; light brownish grey (2.5YR 6/2) silty clay; friable to firm; moderately developed coarse subangular blocky structures; many roots; pores; abundant prominent reddish yellow (7.5YR 6/8 and 5YR 6/8) mottles; many roots; boundary distinct.

BCg: 18"+; dark brown (10YR 3/3) silty clay; sticky and firm; weak to moderately developed coarse angular blocky structures; few roots; few yellow (10YR 7/8) mottles.

ANALYSIS OF MARANG SERIES PROFILE

HORIZON	Percentages				On Original Sample		pH	Percentages			Exchangeable Cations m.e/100g.				Saturation %	Easily Soluble
	Clay	Silt	Fine Sand	Coarse Sand	Gravel %	Stones %		Carbon	Nitrogen	C.E.C. m.e/100g.	K	Ca	Na	Mg		P (ppm)
Ah	24	15	43	19	-	-	4.6	1.28	0.08	7.4		-	-	-	10	19
Ae	32	18	37	16	-	-	4.9	0.39	0.03	5.6	-	-	-	-	6	13
Bt	44	15	30	14	-	-	4.8	0.21	0.02	7.1	-	-	-	-	5	9
Btgb	54	15	23	10	4.1	-	4.9	0.14	0.01	8.3	-	-	-	-	5	7

Marang Series*

Location : Along main forest track going east from Bahau - Ayer Hitam Road, Map Sheet 36/3.

Grid Reference: 645689.

Topography : 3^{o} slope in undulating terrain.

Vegetation : Poor quality primary jungle.

Parent Rock : Shale and Sandstones.

Profile:

Ah: 0-2"; yellowish brown (10YR 5/4) sandy loam; friable; fine; weakly developed granular to subangular blocky structure; abundant pores; much quartz grit; well rooted; boundary diffuse.

Ae: 2-11"; very pale brown (10YR 7/4) sandy clay loam; friable; fine, moderately well developed subangular; blocky structure; abundant pores; much quartz grit; weakly mottled; well rooted; boundary diffuse.

Bt: 11-24"; yellow (10YR 7/5) sandy clay; friable; fine moderately to strongly developed subangular blocky structure; discontinuous clayskins; abundant pores; much angular quartz grit; weakly mottled; well rooted; boundary distinct.

Btgb: 24"+; light grey (2.5YR 7/0) clay with many, medium, prominent, very pale brown (10YR 7/4) and strong brown (7.5YR 5/6) mottles; firm; coarse, strongly developed prismatic to subangular blocky structure; almost continuous clayskins; few pores; much angular quartz grit; poor to moderate rooting.

* - Taken from Temerloh - Gemas report, Pg. 60.

* ANALYSIS OF TAMPIN SERIES PROFILE

HORIZON	Percentages				On Original Sample		pH	Percentages			Exchangeable Cations m.e/100g.				Saturation %	Easily Soluble
	Clay	Silt	Fine Sand	Coarse Sand	Gravel %	Stones %		Carbon	Nitrogen	C.E.C. m.e/100g.	K	Ca	Na	Mg		P (ppm)
Ah	23	9	32	4	5.5	-	5.0	1.24	0.10	7.8	B.D	N.D	N.D	N.D	15	20
Ae	28	13	25	36	5.7	-	5.1	0.35	0.03	5.6	-	-	-	-	9	14
Bt	42	9	21	31	10.1	-	5.0	0.22	0.22	6.1	-	-	-	-	7	13
Btgj	49	9	17	28	8.1	-	5.0	0.17	0.17	6.6	-	-	-	-	6	11
Cu	48	10	20	24	2.2	-	5.0	0.15	0.15	7.0	-	-	-	-	6	11

* Average from three profiles.

Tampin Series*

Location : Main road north Ayer Hitam Junction. Map Sheet 3G/2.

Grid Reference: 463737.

Topography : 2^{o} slope in rolling country.

Vegetation : Distrubed primary jungle.

Parent Rock : Acid Granite.

Profile:

Ah: 0-3"; dark brown (10YR 4/3) gravelly loam; friable; fine weakly developed subangular blocky to crumb structure; many pores; much quartz grit; very well rooted; boundary distinct.

Ae: 2-18"; very pale brown (10YR 7.5/3) gravelly clay loam to gravelly clay with few mottles; friable; fine, weakly developed subangular blocky structure; patchy to discontinuous clayskins; abundant pores; much quartz grit; many roots; boundary indistinct.

Btj: 18-36"; very pale brown (10YR 7/4) gravelly clay matrix with very diffuse mottles; friable; medium, weakly developed subangular blocky structure; discontinuous clayskins; abundant pores; much sub-rounded quartz grit; moderately well rooted; boundary distinct.

Bti: 36"+; pink (7.5YR 7/4) gravelly clay matrix few, medium faint, pinkish white (7.5YR 8/2) mottles; friable; medium weakly developed subangular blocky structure; discontinuous to almost continuous clayskins; many pores; much sub-rounded quartz grit; poorly rooted.

* Taken from Temerloh - Gemas report, Page 65.

APPENDIX 2

Laboratory Analysis

The Bouycoucos hydrometer with tetron as a dispersant was used in the mechanical analysis of the soil samples.

pH was determined with a glass electrode.

Carbon was analysed by the Walkley - Black Method while nitrogen was determined by the Micro-Kjeldahl Method, the Catalyst being a mixture of selenium, copper sulphate and potassium sulphate.

Cation exchange capacity values were obtained by leaching 0.1N barium chloride and titrating with N/50 versenate. Percentage base saturation was calculated as a function of the total cations present in the leachate.

Easily soluble phosphorous was obtained by leaching with a solution of 2N Sodium Chloride and 0.2N hydrochloric acid and extraction with 0.1N Sodium hydroxide.