SOUTH EAST JOHORE PROJECT

WORKING PAPERS.

SOIL SUITABILITY CLASSIFICATION

LAND USE POTENTIAL.

Soil Series Suitability for Crop Groups

Yong Peng Series

On dacite and rhyodacite. Yellowish brown to reddish yellow; sandy clay loam to clay; moderately to well developed fine and medium subangular blocky structures; firm to very firm consistency; deep soil (Over 40 inches).

This series is generally compacted and coarse structured from a depth of 10 to 18 inches, a lateritic layer if present, only occurs below 40 inches.

Slope range	Crop Group Selection
3 - 6°	~~(4)~~, ~~5~~, (6), 7, ~~9~~, 10
7 - 12°	~~5~~, (6), 7, ~~9~~, 10
13 - 20°	~~9~~, 10
21 - 25°	forest and bamboo 11
Over 25°	forest reserve 12

The compactness and generally heavy textures precludes this soil from a wide range of crops, resulting in a crop group selection which is practically same as that for Yong Peng Series, moderately deep phase.

Yong Peng Series, coarse phase

The profile of this phase of the Yong Peng Series soils is similar to the Yong Peng Series described above, the difference being that quartz grit occurs within a depth of 24 inches.

This soil has a similar agricultural potential as the Yong Peng Series.

...3/-

Yong Peng Series, Moderately deep phase

The series description is the same as for the Yong Peng Series above, but due to the occurrence of lateritic stones and gravel, this phase is a moderately deep soil (20 to 40 inches).

This series is generally compacted and coarse structured from a depth of 10 to 18 inches, the lateritic layer which commonly occurs commencing at a depth of about 24 inches and varying in thickness from two inches to a foot 12 inches.

Slope range	Crop Group Selection
3 - 6°	(4), 5, (6), 7, (9), 10
7 - 12°	5, (6), 7, (9), 10
13 - 20°	(10)
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve , 12

The compactness, shallowness and generally heavy textures precludes this soil from a wide range of crops, and it is also marginal for groups 4, 6, 9 and 10 especially from a managerial point of view. Its shallowness may create problems with terracing, especially on slopes between 13 and 20° therefore group 9 has been excluded for this slope range.

Kulai Series

On rhyolitic tuffs or rhyolites. Pale yellowish brown, strong brown at depth; loam to silty clay; subsoil firm, compacted, with weak angular blocky structure.

...4/-

Slope range	Crop Group Selection
3 - 6°	~~4~~(4), ~~5~~5, (6), ~~7~~7, ~~9~~(9), 10
7 - 12°	~~5~~5, (6), ~~7~~7, ~~9~~(9), 10
13 - 20°	~~9~~, (10)
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Rooting of the natural vegetation is shallow due to compactness of the soil between 20 and 40 inches. Hence the soil is regarded as shallow, and is only suitable for a narrow range of crops. Groups 4, 6, and 9 are marginally suitable. On slopes between 13 and 20° the soil is often shallow, less than 20 inches, therefore, group 9 is excluded on this slope range.

Jerangau Series

On biotite - hornblende granite and granodiorite. Strong brown; fine sandy clay to clay; well developed fine and medium subangular blocky structures; friable; deep soil (depth over 40 inches).

Slope range	Crop Group Selection
3 - 6°	~~2~~2, 3, 4; ~~5~~5, 6, ~~7~~7; ~~8~~8, 9, 10
7 - 12°	~~5~~5, 6, ~~7~~7; ~~8~~8, 9, 10
13 - 20°	~~9~~9, 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Physically a soil with negligible limitations to crop growth, only slope limiting crop selection.

...5/-

Rengam Series

On granite. Yellowish brown to reddish yellow; sandy clay; weakly to moderately developed fine and medium subangular blocky structures; friable; deep to very deep soil (depth over 40 inches);

Slope range	Crop Group Selection
3 - 6°	~~1~~(2), 3, 4, ~~5~~ 5(6), 7, ~~8~~(8), 9, 10
7 - 12°	~~5~~ 5(6), 7, ~~8~~(8), 9, 10
13 - 20°	~~8~~ 9, 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Terracing to be discussed in general in managerial Chapter. (K.L. 26/10-70). ✓

Limitation mainly on slope; however the groups 2, 6 and 8 are considered marginal due to unfavourable physical soil conditions.

(Note: Unfavourable due to weak to moderate developed structures and increasing firmness at around 20"; for group 2 texture too heavy) 20/1-71. ✓

Rengam Series, coarse sandy clay phase

On granite. Brownish yellow to reddish yellow; coarse sandy clay to gravelly clay; weakly to moderately developed medium and coarse subangular blocky structures; friable becoming firm with depth; deep to very deep soil (depth over 40 inches).

No impenetrable layers occur but a high percentage (of the soil volume) of gravel and grit restricts rooting to the first 20 inches of the profile, therefore available water would be relatively low.

RQM coarse: gravel & grit starts from a depth above 50 cms. 20/1-71.

...6/-

...7/-

Slope range	Crop Group Selection
3 - 6°	~~(4)~~; ~~5~~, 7, (9); ~~10~~
7 - 12°	~~5~~, 7, (9); ~~10~~
13 - 20°	~~10~~
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

The coarse nature of this soil is the reason for exclusion of all crop groups with high soil requirements, with group 4 and 9 as marginal. Other limitations are on slope only. Group 9 has been excluded for the slope range 13 to 20° as terracing would create extra managerial difficulties due to the occurrance of grit and gravel at 20 inches depth.

Rengam Series, fine sandy clay phase

On fine-grained granite. Yellowish brown to strong brown, fine sandy clay to clay; moderately developed fine and medium subangular blocky structures; friable, becoming firm and compacted with depth; deep to very deep soil (depth over 40 inches).

No true impenetrable layers occur but the compactness of the soil restricts rooting of natural vegetation to the top 20 inches of the profile.

Slope range	Crop Group Selection
3 - 6°	~~(2)~~, (3), 4, ~~5~~, (6), 7; ~~(8)~~, 9, 10
7 - 12°	~~5~~, (6), 7; ~~(8)~~, 9, 10
13 - 20°	~~9~~, 9, 10
20 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

...7/-

Crop groups 2, 3, 6 and 8 are marginal due to unfavourable physical soil conditions. Further limitations are on slope.

Masai Series

On fine-grained granite and granodiorite. Effective soil depth is 10 to 20 inches due to the occurrence of a laterite layer up to 3 feet deep. This layer, however, is gravelly and bouldery, not massive, and is penetrable by primary roots. Laterite stones and boulders commonly cover the soil surface.

Slope range	Crop Group Selection
3 - 6°	
7 - 12°	
13 - 20°	
21 - 25°	forest, 11
Over 25°	forest reserve, 12

Limitations to crop selection are effective soil depth and slope. The occurrance of lateritic stones and boulders restricts soils cultivation. On slopes between 13 and 20° terracing becomes impossible due to soil depth, therefore group 10 is marginally suitable.

Prang Series

On basic shist or hornfels. Yellowish red; friable silty clay to day; well developed fine and medium subangular blocky structures with weak horizonation. Laterite may be present at depth, a deep soil (depth over 40 inches).

...8/-

Slope range	Crop Group Selection
3 - 6°	~~4~~(2), 3, ~~4~~, ~~5~~, 6, ~~7~~, ~~8~~, 9, 10
7 - 12°	~~5~~, 6, ~~7~~, ~~8~~, 9, 10
13 - 20°	~~8~~, 9, 10
21 - 25°	forest 11
Over 25°	forest reserve 12

Limitations to crop selections is on slope only.

Prang Series, ~~shallow~~ lateritic phase

This soil is similar to the Prang Series described above but a compacted, nodular lateritic band occurs at 24 inches depth; friable; a shallow soil (10 to 20 inches deep).

Slope range	Crop Group Selection
3 - 6°	~~4~~, ~~5~~, ~~7~~, ~~8~~(9), 10
7 - 12°	~~5~~, ~~7~~, ~~8~~(9), 10
13 - 20°	~~8~~ (10)
21 - 25°	forest 11
Over 25°	forest reserve, 12

The ~~shallow~~ lateritic phase of this series has been downgraded considerably, the laterite band precluding it from many crops. Group 9 and 10 are marginally suitable for this reason.

...9/-

Slope Phase

0 - 8°
7 - 12°
13 - 20°
21 - 25°
Over 25°

Crop Group Selection

4(2), 5, 6, 7, 8, 9, 10

Forest reserve 12

Forest 11

Forest reserve, 12

Limitations to crop selections is on slope only.

Terrain Series, Subsoil Phase

This soil is similar to the Irong Series described above but a compacted, modular, lateritic band occurs at 24 inches depth; friable, clayey soil (20 to 30 inches deep).

Crop Groups Selection

4(2), 5, 6, 7, 8, 9, 10

5 - 6°
7 - 12°
13 - 20°
21 - 25°
Over 25°

4 (10)

Forest 11

Forest reserve, 12

The Subsoil phase of this series has been downgraded considerably, the lateritic band precluding it from many crops. Group 9 and 10 are marginally suitable for this reason.

.../9

Seremban Series

On quartz - mica schists intermixed with phyllites and vein quartz. Mainly found on ~~rolling (terrain with slopes above 12°~~ undulating to hilly terrain. Greyish brown to yellowish brown friable to firm fine sandy clay loam overlying reddish yellow to yellowish red firm fine sandy clay. Structures are moderate medium subangular blocky. Quartz gravels and angular pebbles together with laterized pieces of parent material commonly occur between 20 and 40 inches.

Slope range	Crop Group Selection
3 - 6°	~~2~~, (3), (4), ~~5~~, 7, ~~8~~ 10
7 - 12°	~~5~~, 7, ~~8~~ 10
13 - 20°	~~8~~ 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

A moderately deep soil. The laterized parent material is not massive, but available moisture could be too low for certain crops. Due to its shallowness, the groups 3 and 4 are ~~only~~ marginally suitable, group 9 very marginal to unsuitable since laterite often occurs above 20 inches depth.

Batang Merbau Series

On schists. A friable yellowish brown, silty clay loam overlying a firm clay loam to silty clay with weak subangular blocky structures; mica is often present in the profile. Normally a moderately deep soil (20 to 40 inches).

...10/-

Slope range	Crop Group Selection
3 - 6°	~~(2)~~, (3), (4), ~~(5)~~, (6), 7, ~~(8)~~, 9, 10
7 - 12°	~~(5)~~, (6), 7, ~~(8)~~, 9, 10
13 - 20°	~~9~~, 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Note: unfavourable because of firm and heavy texture, and weak structures, so soil aggregates unstable. (20/1-71)

A soil suitable for a wide range of crops, it is marginal for groups 2, 3, 4, 6 and 8 due to unfavourable physical soil conditions.

Serdang Series

On sandstones, quartzites or conglomerates. Textures are generally coarse sandy loam to sandy clay loam or sandy clay depending on parent material. Colours vary between strong brown, yellowish brown or brownish yellow; weak to moderate fine and medium subangular blocky structures; profile friable throughout. Depth over 40 inches.

Slope range	Crop Group Selection
3 - 6°	~~(2)~~, 3, 4, ~~(5)~~, (6), 7, ~~(8)~~, 9, 10
7 - 12°	~~(5)~~, (6), 7, ~~(8)~~, 9, 10
13 - 20°	~~9~~, 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

A deep, friable and commonly sandy soil, with insufficient water holding capacity for many crops when the sand fraction is coarse. Groups 2, 6 and 8 are marginal due to the low water holding capacity. There are no other physical limitations except slope.

...11/-

Serdang Series, sandy clay phase

This soil is similar to the Serdang Series described above, the fine sand fraction however is much higher. Textures vary between fine sandy clay loam to sandy clay.

Slope range	Crop Group Selection
3 - 6°	~~2~~, 3, 4, ~~5~~, 6, 7, ~~8~~, 9, 10
7 - 12°	~~5~~, 6, 7, ~~8~~, 9, 10
13 - 20°	~~5~~, (6) ~~8~~ 9, 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

This phase of the Serdang Series has a higher available moisture capacity and is therefore suitable for a wide range of crops.

Serdang Series, moderately deep phase

The description is the same as for the Serdang Series above. Soil depth is between 20 and 40 inches, due to the occurrence of partly weathered parent material.

Slope range	Crop Group Suitability
3 - 6°	~~1~~(2), 3, 4, ~~5~~, (6), 7, ~~8~~ 10
7 - 12°	~~5~~, (6), 7, ~~8~~ 10
13 - 20°	forest and bamboo, 11
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

...12/-

Bordeaux Series, sandy clay phase

This soil is similar to the Bordeaux Series described above, the fine and fraction however is much higher. Textures vary between fine sandy clay loam to sandy clay.

Slope range	Cross Section Selection	
0 - 5%	(2), 3, 4, (5), 7, 9, 10	
2 - 12%	(2), (5), 7, 9, 10	
12 - 20%	(5), 7, 9, 10	
21 - 25%	forest and bamboo, 11	
Over 25%	forest reserve, 12	

This phase of the Bordeaux Series has a higher available moisture capacity and is therefore suitable for a wide range of crops.

Bordeaux Series, moderately deep phase

The description is the same as for the Bordeaux Series above. Soil depth is between 20 and 40 inches, due to the occurrence of partly weathered parent material.

Slope range	Cross Section Suitability	
0 - 5%	(2), 3, 4, (5), 7, 9, 10	
2 - 12%	(2), (5), 7, 9, 10	
12 - 20%	(5), 7, 9, 10	
21 - 25%	forest and bamboo, 11	
Over 25%	forest reserve, 12	

...12/-

Crop Group selection is limited by depth of soil and available moisture capacity. Groups 2 and 6 are marginal.

Serdang Series, shallow phase

The description is the same as for the Serdang Series, but soil depth is less than 20 inches.

Slope range	Crop Group Selection
3 - 6°	5, (6)
7 - 12°	5, (6)
13 - 20°	forest , 11
21 - 25°	forest reserve , 12
Over 25°	forest reserve, 12

Soil depth is the overriding limiting factor for crop group selection.

Kedah Series

On quartzite and conglomerate ridges. Sandy loam to sandy clay; strong brown; weak to moderate structures. Laterite concretions and laterised shale pieces may be present when interbedded shales occur in the parent material. The series only occurs on slopes steeper than 20°.

This soil series is only suitable for forest (group 12) and other reserves.

...13/-

Bungor Series

On shale and sandstone. Brownish yellow to yellowish brown; fine sandy clay loam to fine sandy clay; moderately to well developed fine and medium subangular blocky structures; continuous clayskins; friable; deep to very deep (depth over 40 inches).

Slope range	Crop Group Selection
3 - 6°	(2), 3, 4, 5, (6), 7, 8, 9, 10
7 - 12°	5, (6), 7, 8, 9, 10
13 - 20°	9, 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Groups 2 and 6 are termed marginal due to physical soil characteristics such as texture.

Bungor Series, moderately deep phase

The description of this phase of the Bungor Series is the same as that for Bungor Series mentioned above. Laterite or laterized parent material occurs between 20 and 40 inches.

Slope range	Crop Group Selection
3 - 6°	(2), 3, 4, 5, (6), 7, (9), 10
7 - 12°	5, (6), 7, (9), 10
13 - 20°	10.
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

...14/-

Crop limitations only due to depth of the soil, otherwise the crop group selection is the same as for the Bungor Series described above.

Kuala Brang Series

On shales or shales interbedded with quartzites. Yellowish brown to brownish yellow fine sandy clay loam; weak to moderate subangular blocky structures; consistency friable becoming firm with depth; shallow to moderately deep soil. (Less than 40 inches).

The parent material consisting of shale and vein quartz is reached within 3 feet depending on slope. On steep terrain this soil is very shallow.

Slope range	Crop Group Selection
3 - 6°	(2) (3) (4), 5, 7, (9), 10
7 - 12°	5, 7, (9), 10
13 - 20°	forest and bamboo, 11
21 - 25°	forest reserve, 12
Over 25°	forest reserve, 12

This soil is moderately deep on easy terrain, but shallow to very shallow on steeper terrain. Due to its variable depth this series is suitable for a narrow range of crops.

Marang Series

On shales, interbedded with sandy lenses and vein quartz or siltstones. Generally occupying upper slopes and associated with Apek Series. Pale yellow to light grey, friable fine sandy loam, overlying a yellow

...15/-

Crop limitations only due to depth of the soil, otherwise the crop group selection is the same as for the Bungor Series described above.

Alagla Shrubby Series

On alagles or shallow interbedded with quartzites. Yellowish brown to brownish yellow fine sandy clay loam; weak to moderate subangular blocky structure; consistency friable becoming firm with depth; shallow to moderately deep soil. (less than 40 inches).

The parent material consisting of slate and vein quartz is reached within 3 feet depending on slope. Deep to very deep terrain this soil is very shallow.

Crop Group Selection

Slope range	
3 - 6°	(1), (2), (3), (4), 5, 6, 7, 8, 9, 10
7 - 12°	5, 6, 7, 8, 9, 10
13 - 20°	forest and bamboo, 11
21 - 25°	forest reserve, 12
Over 25°	forest reserve, 12

This soil is moderately deep on easy terrain, but shallow to very shallow on steeper terrain. Due to its variable depth this series is suitable for a narrow range of crops.

Pastura Series

On slopes, interbedded with sandy lenses and vein quartz or siltstone, commonly occurring upper slopes and associated with Apak Series.

Pale ~~brown~~ Yellow to light grey, friable fine sandy loam, overlying a yellow ~~de~~

~~brownish yellow~~, firm and compacted fine sandy clay loam subsoil, which is mottled. The parent material is light grey with reddish mottles and is sticky. Soil depth is very variable and ranges from shallow to moderately deep and deep.

Slope range	Crop Group Selection
3 - 6°	~~4~~(4); ~~5~~, 7; ~~10~~
7 - 12°	~~5~~, 7; ~~10~~
13 - 20°	forest and bamboo, 11
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

This series is generally a shallow soil with a compact and often coarse-textured subsoil suitable for only a narrow range of crops. Group 4 is marginal due to the variable soil depth

Marang Series, deep phase

The description is the same as for Marang Series mentioned above; but the compacted subsoil occurs below 40 inches.

Slope range	Crop Group Selection
3 - 6°	~~2~~, 3, 4; ~~5~~, 6, 7; ~~9~~, 10
7 - 12°	~~5~~, 6, 7; ~~9~~, 10
13 - 20°	~~9~~, 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

This phase of the Marang Series is suitable for a wide range of crops, although structures are weak and therefore soil aggregates may be very unstable.

Permeable yellow, firm and compacted fine sandy clay loam subsoil, which is mottled. The parent material is light grey with reddish mottles and is sticky. Soil depth is very variable and range from shallow to moderately deep and deep.

Slope range	Crop Selection
3 - 6°	K(4), FG, T, RTO
7 - 12°	FG, T, RTO
13 - 20°	Forest and bamboo, II
21 - 25°	Forest and bamboo, II
Over 25°	Forest reserve, IE

This series is generally a shallow soil with a compact and often coarse-textured subsoil suitable for only a narrow range of crops. Group 4 is marginal due to the variable soil depth

Durian series, deep phase

The description is the same as for Durian Series mentioned above; but the composited subsoil occurs below 40 inches.

Slope range	Crop Selection
3 - 8°	K, S, FG, G, T, RTO, TO
9 - 12°	G, T, RTO, TO
13 - 20°	FG, TO
21 - 25°	Forest and bamboo, II
Over 25°	Forest reserve, IE

This phase of the Durian Series is suitable for a wide range of crops, although structures are weak and therefore soil aggregates may be very unstable.

Kamathi series

On carbonaceous shales and silt stones, generally only occurring on upper slopes of hilly to steep terrain. Greyish brown uniform clay loam to clay; firm in consistency and moderate medium subangular blocky structure. Soil depth seldom exceeds 38 inches.

Slope range Reference

3 - 6%	45, 75, 210
7 - 12%	75, 210
13 - 20%	Forest and bamboo, 11
21 - 25%	Forest and bamboo, 11
Over 25%	Forest reserve, 12

A moderately deep and heavy textured soil, often stony, with a low available water capacity, and hence unsuitable for many crops. Its often shallow nature on steeper slopes restricts terracing therefore crop IO has been excluded from slopes between 13 and 20°.

Distribution series

On Shale. Brownish yellow; silty clay to clay; moderate to well developed coarse angular blocky structure; firm and compact; moderately deep soil. A band of laterite 6-9 inches thick ~~is~~ as a depth of 20 to 40 inches.

A moderately deep soil due to compactness of the heavy clay horizon in the subsoil.

Slope range	Crop Group Selection
3 - 6°	~~4~~(3), 4, ~~5~~, (6), 7, ~~8~~(9), 10
7 - 12°	~~5~~, (6), 7, ~~8~~(9), 10
13 - 20°	~~8~~ 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Durian Series, deep phase

The description is as for Durian Series, but soil depth is over 40 inches.

This phase of the Durian Series Soils has the same crop suitability as the modal profile described above. This is due to the compactness at shallow depth.

Munchong Series

Pohoi Series

On carbonaceous shales. Brown or olive brown clay loam to fine sandy clay, with moderate medium blocky structures, becoming coarser with depth; consistency is friable but becomes firmer with depth. Laterite and shale fragments may be present (depth over 40 inches).

Slope range	Crop Group Selection
3 - 6°	2, 3, 4, 5, 6, 7, 8, 9, 10
7 - 12°	5, 6, 7, 8, 9, 10
13 - 20°	9, 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

Physically a soil with few limitations, suitable for a wide range of crops. Limitations mainly on slope.

Malacca Series

On shale. The top 10 to 20 inches is a strong brown, firm, sandy clay to clay with moderately developed medium subangular blocky structures. This overlies at a depth of less than 20 inches a thick, massive, compacted laterite band. The soil surface is characteristically covered with lateritic stones and boulders.

Slope range	Crop Group Selection
3 - 6°	5, (10)
7 - 12°	forest, 11
13 - 20°	forest, 11
21 - 25°	forest reserve, 12
Over 25°	forest reserve, 12

The shallow, compacted laterite precludes this soil from most crops. Group 10 is marginal due to depth of soil. Soil depth is also insufficient for terracing on steeper slopes.

Tavy Series

On argillaceous sediments (shales). The top 12 to 18 inches is friable, sandy clay loam, yellowish or strong brown with weak to moderate subangular blocky structures. This overlies a laterite band of less than 24 inches thick, consisting of well rounded nodules changing to angular and subangular fragments, embedded in a yellowish red to red fine sandy clay or silty clay matrix, with moderate medium subangular blocky structures. The laterite band overlies a variegated parent material of massive clay.

Slope range	Crop Group Selection
3 - 6°	~~2~~, (3), (4), ~~5~~, 7, ~~(9)~~, 10
7 - 12°	~~5~~, 7, ~~(9)~~, 10
13 - 20°	~~(10)~~
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

A shallow soil less than 20 inches deep, unsuitable for many high demanding perennial crops and marginal for some semi-perennial crops. Groups 3, 4 and 9 are marginal, while group 9 has been excluded on steeper slopes.

Harimau Series

On older alluvium. Yellow to yellowish brown; sandy clay loam to coarse sandy clay; weakly to moderately developed fine and medium subangular blocky structures; friable; moderately deep to very deep.

Slope range	Crop Group Selection
3 - 6°	(2), 3, 4, (5), (6), 7, (8), 9, 10
7 - 12°	(5), (6), 7, (8), 9, 10
13 - 20°	9, 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

The physical characteristics and nutritional levels are very similar to those of the Rengam Series soils.

Harimau Series, moderately deep phase

The description is the same as for Harimau Series above, but the depth is between 20 and 40 inches. In Johor Tengah the older alluvium derived soil occurs as a thin capping lying on older land surfaces, which commonly consist of shale. ~~There is~~ A gritty, gravelly or stony horizon occurs at the shale surface, and this horizon generally obstructs rooting.

Slope range	Crop Group Selection
3 - 6°	(2), 3, 4, (5) (6), 7, (9), 10
7 - 12°	(5) (6), 7, (9), 10
13 - 20°	(9), 10
21 - 25°	forest and bamboo, 11
Over 25°	forest reserve, 12

The coarse nature of this Series restricts rooting and available moisture, thus excluding a number of crops with high requirements. Groups 2, 6 and 9 are ~~only~~ marginally suitable for these reasons.

...21/-

Tampoi Series

Ulu Tiram Series

On older alluvium. The profile consists of about 24 inches of yellowish brown, friable sandy loam to sandy clay loam with weak structures, overlying a firm, compact, coarse sandy loam or gravelly loam. The depth is 20 to 40 inches.

Slope range	Crop Group Selection
0 - 2°	4, 5, 7, (10)
3 - 6°	4, 5, 7, (10)
7 - 12°	5, 7, (10)
13 - 20°	(10)

The coarse and compact nature of this series precludes it from a wide range of crops. Group 10 is marginal. The depth and texture of this soil is very variable, and in some cases group 3 can be grown, whereas in others, where the texture is coarse throughout, even groups 4, 5 and 10 would be unsuitable.

Slope range	Crop Group Selection
0 - 2°	~~4~~(2), 3, 4; ~~5~~, (6), 7; ~~(10)~~
3 - 6°	A(2), 3, 4; ~~5~~, (6), 7; ~~(10)~~
7 - 12°	~~5~~, (6), 7; ~~(10)~~

The low very sandy texture makes it, without proper management, a poor medium for crop growth. For this reason the groups 2, 6 and 10 are classed as marginal, this series is however suitable for sugarcane.

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20

Tampoi Series

On older alluvium. This soil is associated with the Harimau Series and occupies the lower and more moist positions. It is a red sandy clay to clay, with coarse blocky structures and a firm consistency (depth 40 inches).

Slope range	Crop Group Selection
0 - 2°	4, 5, (6), 7; 9, 10
3 - 6°	4, 5, (6), 7; 9, 10
7 - 12°	5, (6), 7; 9, 10
13 - 20°	9, 10

A soil which has certain characteristics similar to the Harimau Series, but its texture is heavier and drainage poorer. Groups 6, and 9 are marginal for these reasons. However on steeper slopes above 7° drainage is not a restricting factor hence groups 9 and 10 are termed suitable.

Holyrood Series

On sub-recent alluvium. Very friable, yellowish brown weakly developed sandy loam to sandy clay loam.

Slope range	Crop Group Selection
0 - 2°	4(2), 3, 4; 5, (6), 7; 9(10)
3 - 6°	A(2), 3, 4; 5, (6), 7; 9(10)
7 - 12°	5, (6), 7; 9(10)

The low very sandy texture makes it, without proper management, a poor medium for crop growth. For this reason the groups 2, 6 and 10 are classed as marginal, this series is however suitable for sugar cane.

...22/-

Lunas Series

On sub-recent alluvium. This soil is associated with the Holyrood Series and occurs in depressions where the water table is high. It is a pale grey sandy loam to sandy clay loam with weak structures.

Slope range	Crop Group Selection
0 - 2°	(3), (4), 5, (7)
3 - 6°	(3), (4), 5, (7)
7 - 12°	5, (7)

The very sandy texture and poor drainage makes this series a poor medium for crop growth, unless carefully managed. For these reasons, groups 8, 9 and 10 are classed as marginal; but is suitable for sugarcane.

Local Alluvium

On recent alluvium. A poorly drained soil with variable textures, but commonly heavy; varying degrees of gleying occur. Liable to frequent and serious flooding.

Slope range	Crop Group Selection
0 - 2°	(1), 5

Only group 5 (grass), is suitable and then only for certain species of grass). Due to drainage requirements and flooding hazards group 1, is classed as marginal.

With soil improvements and flood protection the following crop groups could be successfully grown on the following slope range 0-2° : A1, 2, 3, 4; B5, 6, 7; C8, 9, 10, provided the soil texture is not too coarse for the required crop.

...23/-

Riverine Alluvium

On recent alluvium. Texture is variable, and the soil is well to moderately well drained. Weak profile development occurs on the better drained members. Liable to occasional flooding.

Slope range	Crop Group Selection
0 - 2°	~~1~~, (2), 3, 4, ~~5~~, (6), 7, ~~9~~(9), 10
3 - 6°	~~1~~ (2), 3, 4, ~~5~~, (6), 7, ~~8~~(8), 9, 10

With soil improvements, such as drainage, irrigation and flood-protection the crop group selection could be as follows:

0 - 2	~~1~~, 2, 3, 4, ~~5~~, (6), 7, ~~9~~(8), 9, 10
3 - 6	~~1~~, 2, 3, 4, ~~5~~, 6, 7, ~~8~~, 9, 10

Kranji Series

On marine alluvium, and located as narrow fringes along the coast and estuaries. The profile consists of a thin top of friable, dark greyish brown organic clay with weak structures, overlying a permanently water-logged greenish-grey sticky and structureless clay, with sulphurous smell and plant remains at depth. The salt content in this soil can be high enough to preclude crop growth.

Without protection against marine intrusion this soil is unsuitable for agricultural development. It is marginally suitable for controlled forest exploitation and suitable as forest reserve.

This soil is only suitable for a very narrow range of crops and imposes many problems on reclamation and drainage. In group 10, only coconut would thrive on this series. Also only some grass species would be suitable.

Riverine Alluvium

On recent alluvium. Texture is variable, and the soil is well to moderately well drained. Weak profile development occurs on the better drained members. Liable to occasional flooding.

Slope range — Group description

0 - 2° — (2), 3, 4, 5, (6), 7, 9, (9), 10

2 - 8° — (2), 3, 4, 5, (6), 7, 8, (8), 9, 10

With soil improvements, such as drainage and flood-protection the crop growth selection could be as follows:

0 - 2° — 2, 3, 4, 5, (6), 7, 8, (8), 9, 10

2 - 8° — 2, 3, 4, 5, 6, 7, 8, 9, 10

Marsh Series

On marine alluvium, and located as narrow fringes along the coast and estuaries. The profile consists of a thin top of friable, dark greyish brown organic clay with weak structure, overlying a permanently water-logged greenish-grey sticky and structureless clay, with sulphurous small and plant remains at depth. The salt content in this soil can be high enough to preclude crop growth.

Without protection against marine intrusion this soil is unsuitable for agricultural development. It is marginally suitable for controlled forest exploitation and suitable as forest reserve.

This soil is only suitable for a very narrow range of crops and improves many problems on reclamation and drainage. In group 10, only coco-nut would thrive on this series. Also only some grass species would be suitable.

~~Rudua/Rusila Association~~

Rudua Series

On old beach ridges, which run parallel to the present beach. The top soil is loose sand stained with humus, overlying a light grey to white horizon and in turn overlying a slightly compacted and cemented iron-humus horizon. A soil very low in nutrients and imposing special problems to crop growth.

Rusila Series

This series occurs in association with the Rudua Series and occupies the lower slopes and depressions of the old beach. The dark grey topsoil of loose sand overlies a light grey sand or loamy sand, in turn overlying an iron-stained horizon generally above the water table, which commonly is very high. Peat of varying depth occurs in the lowest and waterlogged sites.

The Rudua and Rusila Series ~~Both series~~, have very low agricultural potential, due to sandy textures and very low available moisture, in addition to the high water table and peaty nature of the Rusilla Series.

Slope range	Crop Group Selection
0 - 2°	5, (7), 10a, 10f
3 - 6°	5, (7), 10a, 10f

...25/-

Organic Clays and Mucks

Muck

These are organic soils with a loss on ignition of between 35 and 65 per cent. These soils occur as transition zones between peats and the surrounding mineral soils. The depth of the organic soils overlying mineral alluvial material exceeds 6 inches.

Organic Clay

Soils having an organic surface horizon exceeding 6 inches and with a loss on ignition between 20 and 35 percent. These soils are similar in appearance to muck, and also overly mineral alluvial material.

Muck and Organic Clay Soils have been mapped as an association. Depending whether the underlying material is sand or clay the crop group selection is the same as for Local Alluvium.

Slope range	Crop Group Selection
0 - 2°	4(1), 5
After drainage:	
0 - 2°	2, 3, 4; 5, 6, 7; 4(8), 9, 10

Peat

Peat consists largely of decomposed plant material, with loss on ignition of above 65 percent. The peat on the east coast of the Penggerang

...26/-

area is very acid and generally poorly humified. The underlying material is generally sand although areas with heavier textures occur. There are three depth phases : shallow (10 to 20 inches of peat), moderately deep (20 to 40 inches of peat) and deep (over 40 inches of peat).

Peat, shallow phase

Slope range	Crop Group Selection
0 - 2°	forest reserve, 12

Peat, moderately deep phase

Slope range	Crop Group Selection
0 - 2°	forest reserve, 12

Peat, deep phase

Slope range	Crop Group Selection
0 - 2°	forest reserve, 12

The agricultural potential is very low due to sand, which underlies the peat over a majority of the project area, also the humification is very poor and acidity very high. In comparison with the peats on the West coast, the East coast peats are of a much poorer quality.

ILAY/RS/20/10/70

scid and generally poorly humified. The underlying material
and although areas with heavier textures occur. There are
phases : shallow (20 to 20 inches of peat), moderately deep
ches of peat) and deep (over 40 inches of peat).

w phase

rosp Group Selection

forest reserve, 12

tely deep phase

rosp Group Selection

forest reserve, 12

phase

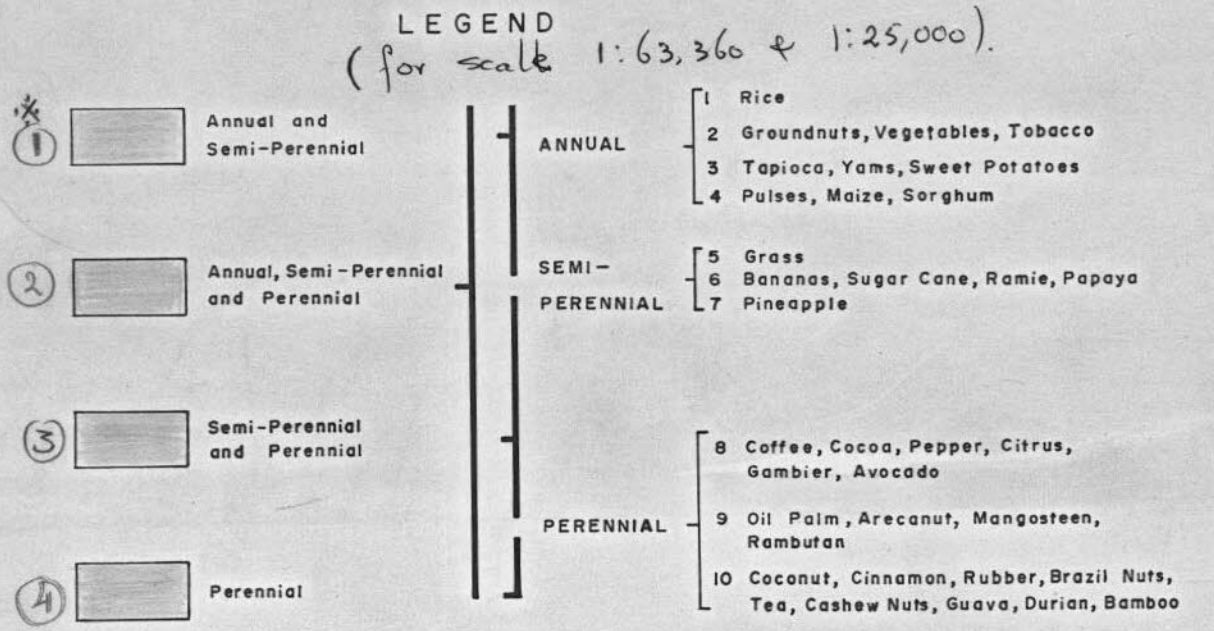
Crop Group Selection

forest reserve, 12

ent a major potential is very low due to sand, which underlies
most soils of the project area. Only the immediate south part
soil profile very [illegible] the complexities with the peats
[illegible] Eastern Coast [illegible] part of a coastal swamp

LAND USE POTENTIAL.

LEGEND (for scale 1:63,360 & 1:25,000).



(2) Unit code for generalised map at 1:250,000.

Figure 4

JOHOR TENGAH
DRAFT
LAND USE POTENTIAL
SCALE 1:250,000

LEGEND

1. Annual & Semi-Perennial.
2. Annual Semi-Perennial & Perennial.
3. Semi-Perennial & Perennial.
4. Perennial.
5. Forest. (incl. controlled forests + forests reserves)
6. Developed land. (including existing estates & disturbed mining land)

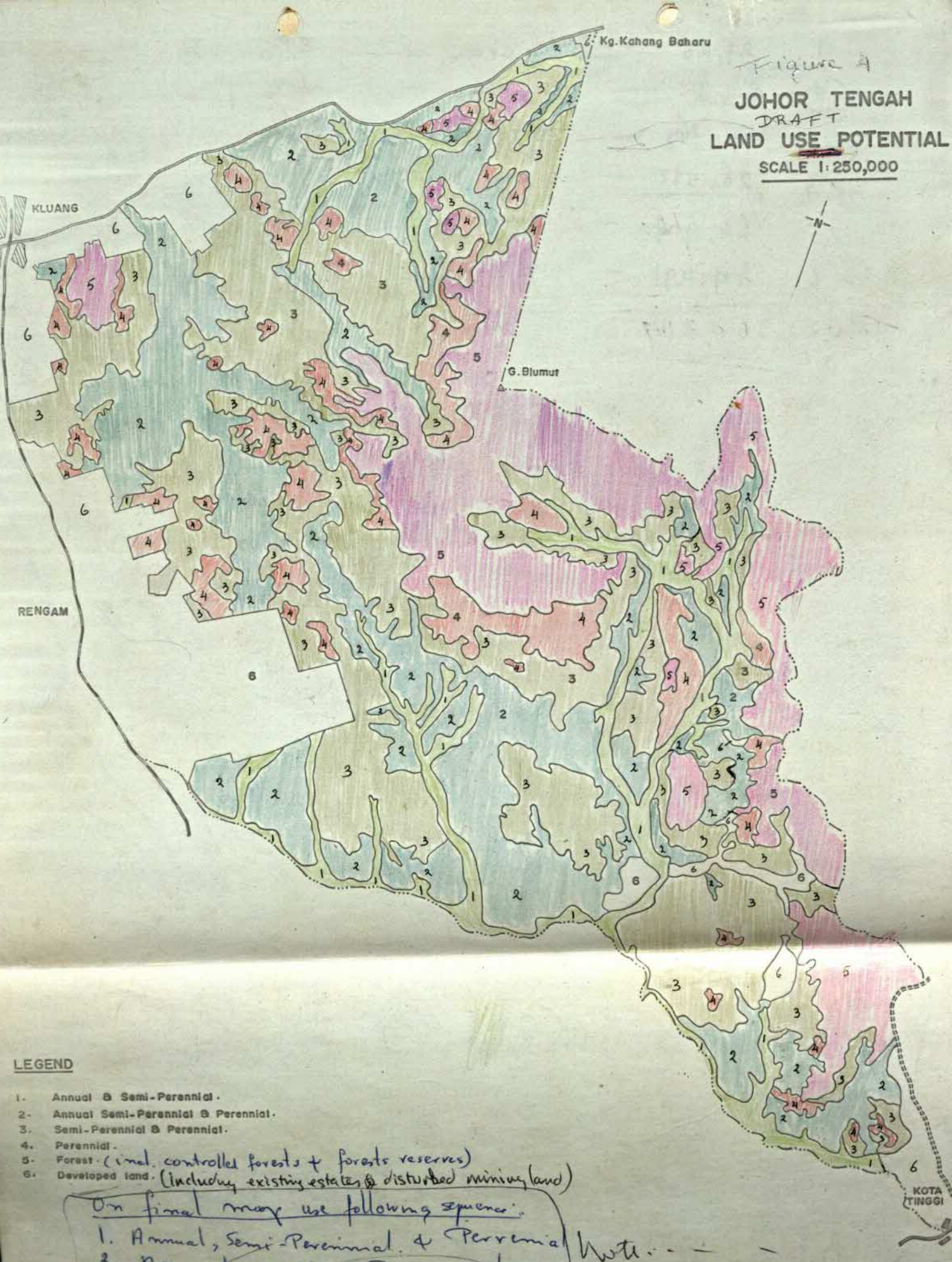
On final may use following sequence:
1. Annual, Semi-Perennial & Perennial
2. Annual + Semi Perennial
3. Semi-Perennial + Perennial
4. etc. see above.

Note: — — —

P.T.O

Figure 4

JOHOR TENGAH
DRAFT
LAND USE POTENTIAL
SCALE 1:250,000



LEGEND

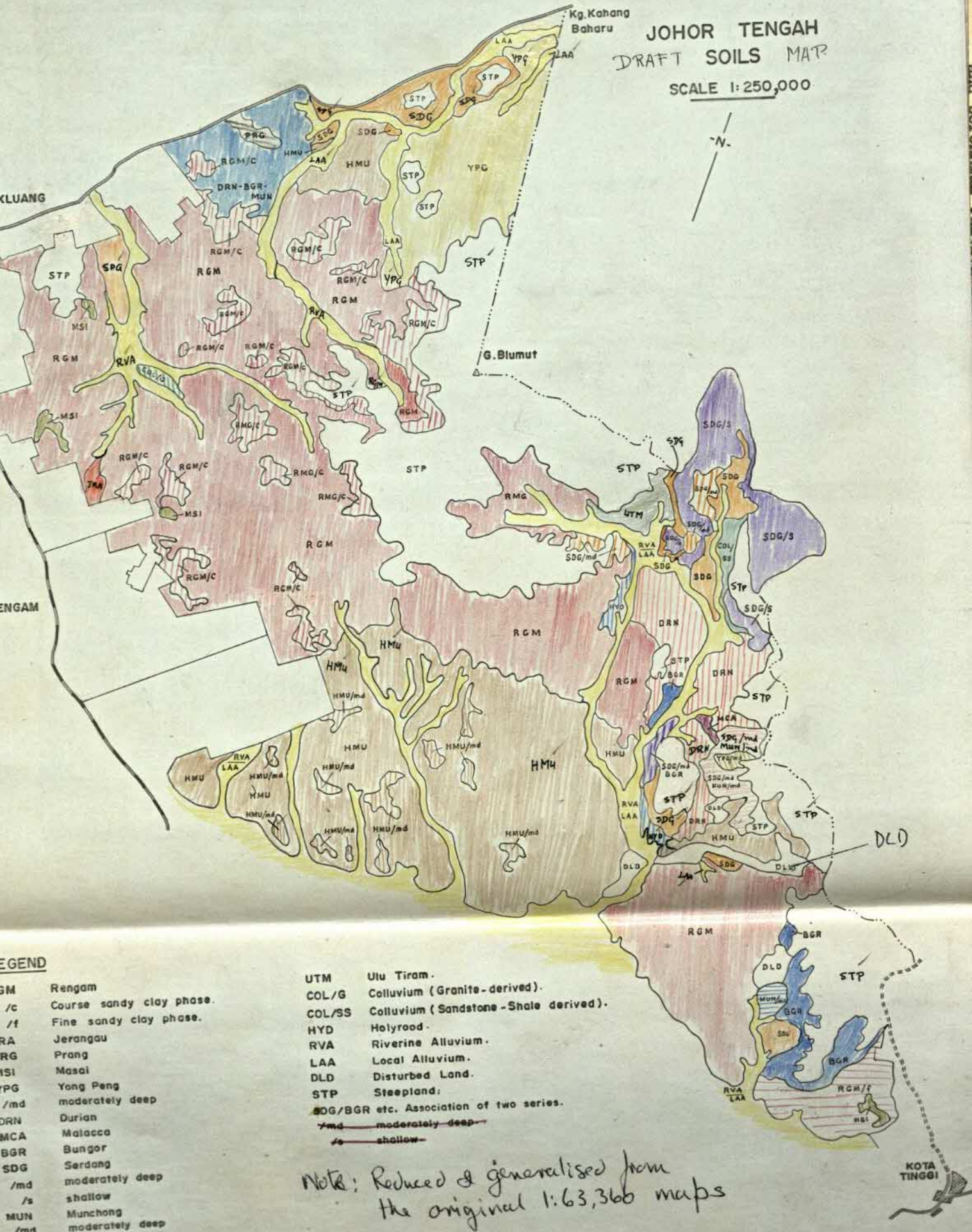
1. Annual & Semi-Perennial.
2. Annual Semi-Perennial & Perennial.
3. Semi-Perennial & Perennial.
4. Perennial.
5. Forest. (incl. controlled forests & forests reserves)
6. Developed land. (including existing estates & disturbed mining land)

On final may use following sequence:
1. Annual, Semi-Perennial & Perennial
2. Annual + Semi Perennial
3. Semi-Perennial + Perennial
4 etc see above.

Note. . . — —

P.T.O

JOHOR TENGAH
DRAFT SOILS MAP
SCALE 1:250,000



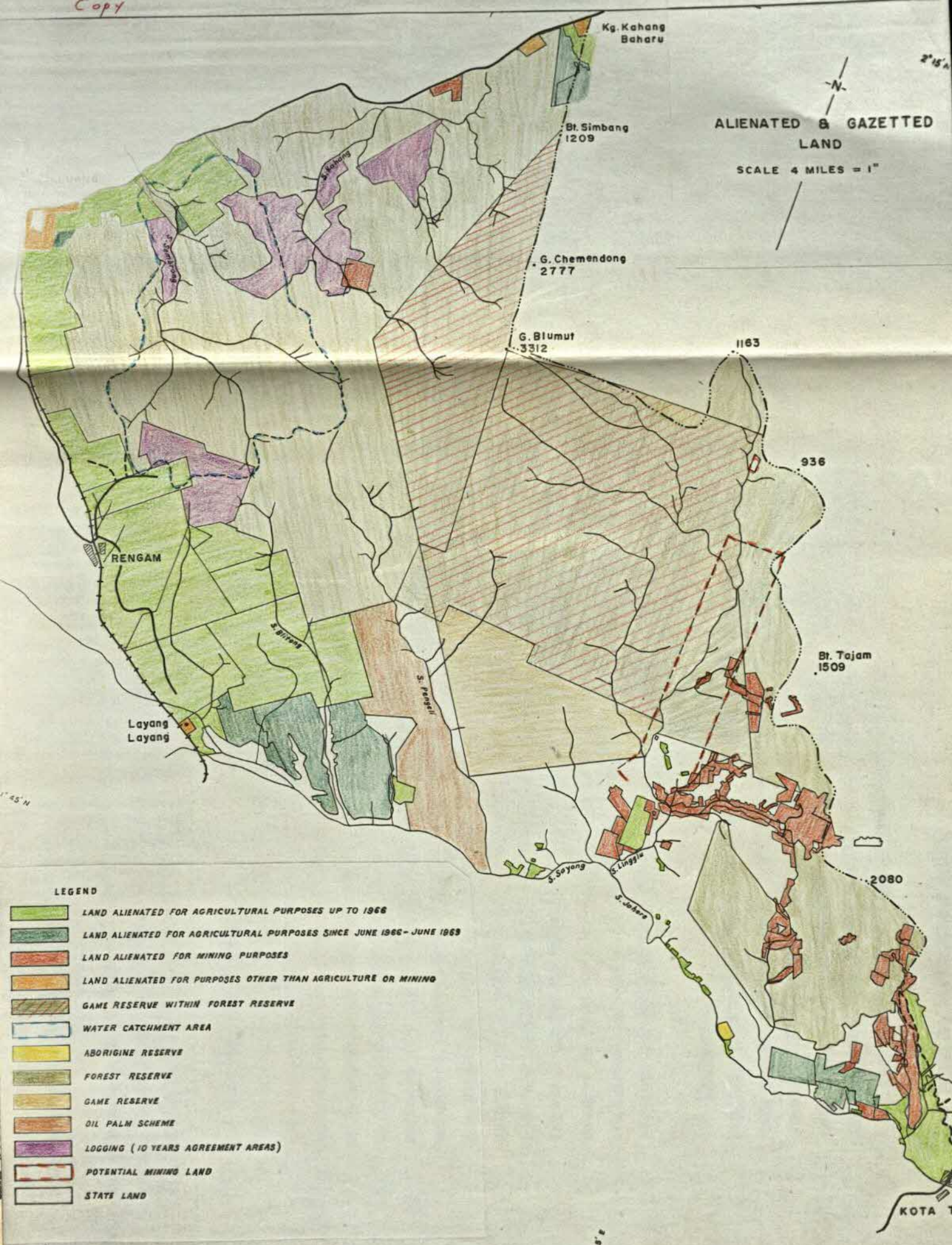
LEGEND

RGM	Rengam
/c	Course sandy clay phase.
/f	Fine sandy clay phase.
RVA	Jerangau
PRG	Prang
MSI	Masai
YPG	Yong Peng
/md	moderately deep
DRN	Durian
MCA	Malacca
BGR	Bungor
SDG	Serdang
/md	moderately deep
/s	shallow
MUN	Munchong
/md	moderately deep
HMU	Harimau
/md	moderately deep

UTM	Ulu Tiram.
COL/G	Colluvium (Granite-derived).
COL/SS	Colluvium (Sandstone-Shale derived).
HYD	Holyrood.
RVA	Riverine Alluvium.
LAA	Local Alluvium.
DLD	Disturbed Land.
STP	Steepland.
SDG/BGR etc.	Association of two series.
~~/md~~	~~moderately deep~~
~~/s~~	~~shallow~~

Note: Reduced & generalised from the original 1:63,366 maps

Copy


Kg. Kahang Baharu
Bt. Simbang 1209
S. Kahang
S. Simbang
G. Chemendong 2777
G. Blumut 3312
1163
936
RENGAM
S. Blitong
S. Pengil
Bt. Tajam 1509
Layang Layang
S. Sayang
S. Linggiu
S. Jeberu
2080
KOTA
N
ALIENATED & GAZETTED LAND
SCALE 4 MILES = 1"
LEGEND
LAND ALIENATED FOR AGRICULTURAL PURPOSES UP TO 1966
LAND ALIENATED FOR AGRICULTURAL PURPOSES SINCE JUNE 1966 - JUNE 1969
LAND ALIENATED FOR MINING PURPOSES
LAND ALIENATED FOR PURPOSES OTHER THAN AGRICULTURE OR MINING
GAME RESERVE WITHIN FOREST RESERVE
WATER CATCHMENT AREA
ABORIGINE RESERVE
FOREST RESERVE
GAME RESERVE
OIL PALM SCHEME
LOGGING (10 YEARS AGREEMENT AREAS)
POTENTIAL MINING LAND
STATE LAND

SOIL SUITABILITY CLASSIFICATION

Proposals & consideration for S.E.J.P.

1. In this project, consideration will have to be given to suitability of soils for arable or annual cultivation. To allow for this some tightening of the limits will be neccessary. To effect this, the original class I of the Malaysian soil suitability classification has been divided into three classes. Classes I and II indicate soils suitable for both annual and perennial cultivation, Class III then becomes the best class for perennial cultivation only. The succeeding classes follow the principles laid down in the Malaysian soil suitability classification.

2. The parameters laid down for the various classes are offered for discussion. The kind of limitations considered are the same as in the Malaysian classification. The actual parameters are somewhat modified.

(a) Gradient and texture

The limits chosen are similar to those of the Malaysian classification as far as slope angle is concerned. The initial limits have been tightened to allow for arable cultivation. 25° has been set as a possible upper limit for agricultural use. It may be desireable to incorporate a further division of, say, 25° - 35° as upper limit suitable for productive forest management and > 35° to be left as watershed protection, wild-life reserve, etc. Obviously these practices are feasible also within the better class soils, but alternative use for agriculture and/or Forestry is a socio-economic question and does not need to be considered in this classification. The textural limits in relation to gradient have been raised slightly because so many sedentary soils have textures of SCL or finer. Some consideration should, perhaps, be given to the relationship between erosion and infiltration rates.

(b) Drainage

Drainage limitations have been slightly altered. For the present, very poorly and excessively drained have been considered of equal status as limitations. However, in many cases a very poorly drained soil may be more susceptible to improvement than an excessively drained one. The latter may often be a more series continuing hazard than the former. Some distinction may have to be made.

(c) Depth to impenetrable layer.

Fixed and arbitrary depths have been chosen for the various classes. Some modification has been allowed where the impenetrable layer is 6" or less in thickness. A further modification has been made on the basis of texture for very shallow soils.

(d) Salinity

A saline horizon has been considered to be a horizon with an E.C. of equal to, or greater than 4 mmhos. Depth factor is the same as for depth to an impenetrable layer.

(e) Acid Sulphate layer

Depths are the same as for salinity. Some definition of an acid sulphate layer will be necessary e.g. on content of total sulphur.

(f) Depth of organic horizon

Should an upper limit be chosen on the premise that deep swamp jungle peats are of little or no agricultural value? Parameters quoted are based on an estimation of the remaining depth after drainage. This to some extent will be a continuing limitation. Depth before drainage is transient only. The nature of the peat will also be important. Some distinction should be made between well humified peats and raw poorly humified peat, especially since the latter are usually woody. No distinction has been made at present.

(g) Rockiness

The limits are largely as in the Malaysian classification.

(h) Nutrient unbalance

Distinction has been made between nutrient deficiencies which can be corrected simply by addition and those where either toxicity occurs which is difficult to remove or there is an unbalance e.g. severe phosphate fixation which is very difficult to overcome. This is inherent in the definition given in the Malaysian classification.

Nov. 1969.

SOIL SUITABILITY CLASSIFICATION FOR AGRICULTURE.

KIND OF LIMITATION	CLASS I	CLASS II	CLASS III	CLASS IV	CLASS V	CLASS VI	CLASS VII
gradient and texture	0 - 2°	2-6° ≯ SCL 2-4° < SCL	6-12° ≯ SCL 4-6° < SCL	12-20° ≯ SCL 6-12° < SCL	20-25° ≯ SCL 12-20° < SCL	20-25° ≯ SCL 12-20° < SCL	>25° ≯ SCL >20° < SCL
drainage	well drained	moderately well drained	Imperfectly or very well drained	poorly drained	very poorly drained or excessively drained	no limitation	no limitation
texture and structure	≯ SCL friable and well structured	≯ SCL friable and moderately structured	≯ 15% clay slight compaction moderate structure	≯ 15% clay moderate compaction weak or coarse structure	LS or finer compact weak structure	LS or finer compact weak structure	no limitation
salinity	E.C. < 4 mmhos within 60"	E.C. < 4 mmhos within 40"	E.C. < 4 mmhos within 40"	E.C. < 4 mmhos within 24"	E.C. < 4 mmhos within 12"	E.C. < 24 mmhos within 12"	no limitation
acid sulphate layer	% S < within 60"	% S < within 40"	% S < within 40"	% S < within 24"	% S < within 12"	% S < within 12"	no limitation
depth to impenetrable layer	> 60"	> 40" or layer < 3" thick if within this depth	> 40" or layer < 6" thick if within this depth	> 24"	> 12" or > 18" if < 15% clay	> 12" or > 18" if < 15% clay	< 12" of any texture
Depth of overlying organic horizon	organic layer < 6"	organic layer < 6"	organic layer < 12" after shrinkage	organic layer < 12" after shrinkage	organic layer < 24" after shrinkage	organic layer < 24" after shrinkage	organic layer > 24" after shrinkage
Stoniness	no or few stones	< 10% of surface	< 25% of surface	< 50% of surface	< 75% of surface	< 75% of surface	> 75 % of surface
nutrient imbalance	slight ; easily ameliorated	moderate : easily ameliorated	moderate : easily ameliorated	severe : easily ameliorated	severe : difficult to ameliorate	severe : difficult to ameliorate	no limitation
						MORE THAN ONE OF ABOVE	

Reen for discussion

CRITERIA FOR LAND EVALUATION.

These criteria are suggested as a basis for land ~~classification~~ EVALUation. The criteria are intended to be easily understood, to have specific parameters and cover only features relevant for consideration.

The list set out below is provisional and it is hoped that discussion will add to its practicality and further define the parameters. Normal management practices are assumed to be carried out where required.

Gradient. 0 - 6° .....suitable for all crops.
6° - 12° .....crops other than annual crops.
12° - 25° .....mot semi-perenial crops e.g. cane, bananas.
25° - 35° .....suitable for tea or forestry only.
> 35° .....leave undisturbed.

Drainage.

Excessively drained .....will dry out to depths of x ft. in y days in absence of further rain.

Very well drained .....will dry out to depth of x - ft. in y-days in absence of further rain.

Well drained .....not liable to cause stress from water-logging nor drought.

Moderately well drained...will remain well wet to depth of x ft. for y days in absence of further rain.

Imperfectly drained .....permanently waterlogged below 20", remains waterlogged in top 20" for x days without further rain.

Poorly drained ..... permanently waterlogged below ? then as above.

Very poorly drained .....permanently waterlogged to surface.

Depth of Soil to impenetrable layer by roots.

6 ft. ..... suitable for all crops.
5 - 6 ft.
4 - 5 ft.
3 - 4 ft.
2 - 3 ft.
1 - 2 ft.
0 - 1 ft.

.....2/

Scale of Soil Workability. See closer on last sheet.

This is to measure the comparative ability of a soil to withstand mechanical cultivation on a regular basis. This would include:-

a) ease of cultivation
b) stability of peds
c) organic matter status
d) stoniness.

This information would not be obtained from profile descriptions but from observation of soil series under cultivation, where possible.

Depth of Acid Sulphate layer.

> 84 inches .....suitable for all crops.
60 - 84 inches
36 - 60 inches
24 - 36 inches
12 - 24 inches
0 - 12 inches ..... unsuitable for all crops.

Salinity.

E.C. Scale mm/hos.

Depth	0 - 2	2 - 4	4 - 8	8 - 16	16
0 - 12					
12 - 24					
24 - 36					
36 - 60					
60 - 84					
> 84					

Scale of lime requirement.

Tons/acre/annum to maintain neutrality.

Depth of Peat Layers.

0 - 12 inches
12 - 24 inches
24 - 48 inches
48 - 84 inches
> 84 inches.

.....3/

Amendment to Criteria for Land Evaluation.

Salinity.

(A) Depth to Saline Layer.

> 84 .....Suitable for all crops.
60 - 84
36 - 60
24 - 36
12 - 24
0 - 12 ..... Unsuitable for all crops.

(B) Salinity content measured as E.C. mm/hos.

0 - 2)
> 2 - 4) Low
> 4 - 8)
> 8 - 16) Moderate
> 16 ——high

Scale of lime requirement.

Tons/acre/annum to raise ph. by any given number of units or half units.

Scale for major nutrient requirements.

Total nutrients by depth phases.
Available nutrients expressed as ~~tons~~ lbs/acre foot.

J.V.H.
R.A.H.

Crop Grouped According to Soil Workability Requirements.

All crops including annual crops .....Group I
Semi-perenial crops e.g. BANANAS, CANE, RAMIE .....Group II
Perenial crops rooting > 4 feet .....Group III
Perenial crops rooting < 4 feet .....Group IV

LIMITATIONS TO CROP GROWTH

SYMBOL	LIMITATION TYPE	VERY SERIOUS	SERIOUS	MODERATE	MINOR
G, g, g	GRADIENT AND TEXTURE	>20° or 25° slopes with light textured soils or >35° slopes with heavy textured soils	12°–20° or 25° slopes with light textured soils or 20° or 25°–35° slopes with heavy textured soils	6°–12° slopes with light textured soils or 12°–20° or 25° slopes with heavy textured soils	2°–6° slopes with light textured soils or 2°–12° slopes with heavy textured soils
d	DRAINAGE	—	Very poorly to poorly drained	Imperfectly drained or Excessively drained	Somewhat excessively drained
c	DEPTH TO STRONGLY COMPACTED LAYER	Less than 10 inches (25 cm.)	10 to 20 inches (25–50 cm.)	20 to 40 inches (50–100 cm.)	40 to 50 inches (100–125 cm.)
s	SALINITY	—	Strongly saline	Moderately saline	Weakly saline
a	ACID SULPHATE LAYER	0 to 10 inches from the surface	10 to 20 inches from the surface	20 to 40 inches from the surface	40 to 50 inches from the surface
o	ORGANIC HORIZON	—	(Waterlogged) any thickness	(Drained) >4 feet thick at the surface	(Drained) 2 to 4 feet thick at the surface
r	ROCKINESS	Extreme (> 75% of soil volume)	Moderately extreme (50–75% of soil volume)	Moderate (25–50% of soil volume)	Slight (10–25% of soil volume)
n	NUTRIENT IMBALANCE	Toxicity caused by extremely high contents of certain elements	—	Acute nutrient deficiencies	Moderate nutrient deficiencies
h	HUMAN	Disturbed land	—	—	—

LEGEND ——→ 100

80.

Class 1 - Soils with no limitations or only minor limitations to crop growth.

1G
1c

Class 2 - Soils with one or more moderate limitations to crop growth.

2G
2g
2nd
2er
2gc
2Gr
2gn
2gnd

Class 3 - Soils with at least one serious limitations to crop growth.

3G
3g
3c
3d
3cr
3gc

Class 4 - Soils with more than one serious limitations to crop growth.

4gcr

Class 5 - Soils with at least one very serious limitations to crop growth.

5Gr
5g

Soil Suitability for Oil Palms in

CLASS 1 - Soils with no limitations or only minor limitations to crop growth.

1G Light-textured soils on slopes between 0° & 6° gradient not exceeding

1g Heavy textured soils on slopes not exceeding 12°

CLASS 2 Soils with one or more moderate limitations to crop growth.

2G Light textured soils on slopes between 6- 12° not exceeding 12°

2g Heavy " " " " between 12- 20° or 25°

2nd Soils with acute nutrient deficiencies and excessively drained

2cr Soils with compact layer at 20-60 inches from the surface and 25-50% rockiness of soil volume

2ge Heavy-textured soils on slopes between 12- 20° or 25° not exceeding 20-25° and 25-50% rockiness of soil volume. compact layer at 20-60" from the surface.

2Gr. Light textured soils on slopes between 6- 12° not exceeding 12° and 25-50% rockiness of soil volume.

2gn Light-textured soils on slopes between 6- 12° not exceeding 12° and with acute nutrient deficiencies

2Gnd. Light textured soils on slopes between 6- 12° not exceeding 12°; excessively drained and heavy acute nutrient deficiencies.

CLASS 3 Soils with at least one serious limitations to crop growth.

3G Light-textured soils on slopes between 12- 20° or 25° not exceeding 20° or 25°.

3g. Heavy textured soils on slopes between 20-25- 35° not exceeding 35°

3c Soils with compact layer at 10-20" from surface.

3d. Soils Very poorly to poorly drained soils

3cr. Soils with compact layer at 10-20" from surface and having 25-50% rockiness of soil volume.

Soil Suitability for Oil Palms in West Malaysia

by

(Dr. NG SIEW KEE)
Department of Agriculture, Kuala Lumpur.

Introduction

The acreage under oil palms in West Malaysia has approximately doubled in the last five years (Table 1) and it is envisaged that by 1972, the total acreage will exceed half a million. This expansion has taken place on cultivated as well as forest land with a ratio of about two to one. Although the rate of expansion is impressive, the present oil palm acreage constitutes but only seven per cent of our monolithic rubber estate and under five per cent of total land under cultivation. There is thus considerable scope to accelerate the pace of crop diversification so often advocated. Perhaps, current rubber prices will give greater impetus to oil palm development in the next decade.

Table 1

Oil Palm Acreage in West Malaysia

Year	Acreage			oil production (tons)
	Total	ex-forest land	in production	
1962	153,400	2,230	114,150	106,500
1963	175,500	7,890	121,450	123,650
1964	186,700	16,200	128,100	120,100
1965	207,950	24,660	144,300	146,350
1966	256,200	45,000	157,600	166,450
1967	300,000 ?	60,000	-	-

Ideally, such development should be planned so that the oil palm is cultivated in the more favourable climatic and soil conditions of this country in order to secure large yields and effect sound crop diversification. In this manner, the growing oil palm industry can further consolidate its already viable position and strengthen its competitiveness in the world oil market. It is, therefore, heartening to note that the expansion over the past five years has in fact taken place largely on the better soil and climatic conditions of this country. This guided development, so to speak, is important because the potential for oil palm plantings on both cultivated and virgin land is apparently large and in both cases, soil conditions can influence yields significantly. The development of the oil palm industry cannot be isolated from overall agricultural development and has to be viewed in the light of the objectives of sound utilization of the nation's soil resources for diversified agriculture.

What then is the development potential for oil palms in West Malaysia in terms of the extent and quality of land resources? To determine this, it is necessary to consider the climatic and pedological requirements of the oil palm and the nature of soil resources in West Malaysia. The prime objective of making this appraisal is to draw up a guide line for development.

Climate

Oil palms are principally cultivated in the tropical belt and although not much is known about the relationship between oil palm yields and climate, lower yields are generally obtained in a truly monsoonal climate as in Nigeria than in a more equatorial climate as Malaysia. Observations within Malaya indicate that an annual rainfall of 70 inches or more which is fairly well distributed is adequate. A pronounced dry season of three months or more is less favourable. Thus, most parts of West Malaysia with the possible exception of parts of northern Perlis/Kedah and the Tasek Bera region, are climatically suitable for oil palms.

Soil Conditions

The characteristics of a soil affecting its suitability for oil palm development are physical and chemical but of these, the physical features are more important as they are more

.../2

durable and less amenable to change by management. Broadly speaking, soils intended for oil palm cultivation should be on flat or gentle terrain, deep and friable to allow firm anchorage and healthy root development, and posses good retentive powers for moisture and plant nutrients. Thus, the physical properties pertain to slope, soil depth, texture, structure and consistence, presence of impenetrable or compacted horizons and permeability of profile. The major chemical features are soil reaction (pH) and general nutrient status of the soil although this is less critical today. Within each characteristic, there are differences of grading which affect plant growth more or less favourably. Thus, the potential of a soil is determined by the particular combination of grades of these properties.

In establishing and using such criteria, emphasis is given to their measureability and general validity. The first presents little difficulty. However, field experiments to verify the validity of soil criteria for oil palms are pratically non-existent; so it is necessary to rely heavily on evidence from observations made on various oil palm holdings. This admittedly, decreases the objectivity of one's interpretation but it is unlikely any superior method can be deviced at this juncture.

The major soil properties and their grading used are presented in Table 2.

Table 2

Major Soil Properties Used For Assessing Soil Suitability For Oil Palms

Property	Grade		
	Favourable	Marginal	Unfavourable
1. Terrain	< 12°	12-20°	> 20°
2. Effective soil depth in relation to impenetrable subsoil layer or permanent water table	> 30"	15-30"	< 15"
3. Texture	loam or heavier	sandy loam	loamy sand or sand
4. Structure and consistence	strongly developed, friable to moderately firm	moderately developed and firm	weak or massive and extremely firm
5. Laterite	nil	fragmental 6-12" thick	fragmental 12" thick or massive
6. pH	4.0-6.0	3.2-4.0	< 3.2
7. Peat layer (thickness)	0-2'	2-5'	> 5'
8. Permeability	moderate	rapid or slow	very rapid or very slow

Only three grades of each major soil property are warranted by present data and the grading depicts the increasing demands on capital inputs and managerial skills as soil conditions become more adverse. The slope grading may be thought rather conservative in some quarters but this view has to be counter-balanced by the needs of soil and water conservation on a national basis and it is not tenable to encourage large scale deforestation of steepland when so much more suitable land is available.

The suitability of a soil is determined by the particular combination of major properties it possesses and to differentiate soils, the criteria shown in Table 3 are used. Using such standards for delineation and information on the nature of soil resources in West Malaysia, a suitability classification designed to project the potentials of common soils for oil palm development is deviced. (Table 4).

It is appreciated that the suitability of a soil can be seriously influenced by economic forces, especially price levels of palm oil and cost of production. Consequently, the boundaries

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between the classes are not rigid and there are also gradations within each class. However, an adverse decline in prices of palm oil in the future will certainly hit hardest those estates on marginal or unsuitable soils while those on better soils should buffer adequately against such unfavourable effects.

Table 3

Criteria of Suitability Classification

Classification		Criteria
(a)	Highly suitable	Soils possessing all scheduled properties within favourable grade.
(b)	Moderately suitable	Soils possessing not more than two properties in marginal grade.
(c)	Marginal	Either three or more properties under marginal grade plus one property in unfavourable grade.
(d)	Unsuitable	Two or more properties under unfavourable grade.

Table 4

Common Malayan Soil Series Classified According To Their Suitability For Oil Palm Planting

Soils		Highly suitable	Moderately suitable	Marginal	Unsuitable
(a)	Derived from igneous parent materials	Kuantan Segamat Kampong Kolam Katong Jerangau Rengam	Jempol Kulai Tampin Kala	Bukit Lunchu	
(b)	Derived from sedimentary parent materials	Prang Munchong	Batang Merbau Bungor Serdang Tavy	Seremban Durian Pohoi Batu Anam Kemuning	Kedah Kuala Brang Malacca Gajah Mati Apek Marang
(c)	Derived from older and sub-recent alluvium	Harimau Tampoi Sitiawan	Ulu Tiram Kawang Sogomana	Lunas Manik Holyrood	
(d)	Derived from recent alluvium	Telemong Briah Kangkong Selangor	Akob	Telok	Linau Kranji Rudua Rusila
(e)	Organic soils		Organic clays and peat over clay up to 2' deep.	2-5' peat	5' peat.

Yield data

The preceding soil suitability classification is based essentially on pedological factors considered significant for the growth of the oil palm. Therefore, its general validity can only be upheld by yield data of palms cultivated on soils of variable quality. Table 5 shows a sample of data obtained mainly from a number of oil palm estates and although this soil - yield relationship study is by no means exhaustive, it offers adequate evidence which is in fair accord with the suitability appraisal.

Potential Acreage

It is evident that a majority of common soil types in West Malaysia are suitable for oil palm cultivation and the potential acreage of such soils is large as presented in Table 6. This

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Table 5

Yields Of Oil Palm Plantings On Different Soils (Tons/Acre)

Soil Series	Suitability	Material Planting	F.F.B.
Selangor	H.S.	DxD (post-war) DxT	9-12
Kangkong	"	" "	8-11
Briah	"	DxT "	8-10
Munchong	"	DxD "	7-9
Rengam/Jerangau	"	DxD "	8-10
Bungor	M.S.	DxD "	6-8
Serdang	M.S.	DxD "	6-7
Organic clays	M.S.	DxD "	6-8
Durian	M.	DxD (pre-war)	4-5
Batu Anam	M.	DxD (post-war)	4-5
Telok	M.	DxT "	4-6
Holyrood	M.	DxD "	4-6
Peat (2-5')	M.	DxD "	3-5
Malacca	U.	DxD (pre-war)	3-4
Linau	U.	DxD "	2-4

H.S. = Highly Suitable
M.S. = Moderately Suitable
M. = Marginal
U. = Unsuitable

Table 6

Soil Potential For Oil Palms In West Malaysia (In Thousand Acres)

	Suitability		
State	Suitable	Marginal	Unsuitable
Perlis	-	59	25
Kedah	295	91	345
Penang	109	20	11
Kelantan	227	213	74
Trengganu	405	19	714
Perak	893	382	130
Selangor	742	87	466
Negri Sembilan	336	626	15
Malacca	206	113	21
Pahang	2,820	1,320	1,040
Johore	2,060	888	958
TOTAL	8,093	3,818	3,799

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potential occurs in both cultivated and forested land. In the former category, the potential lies on land mainly under rubber or coconuts in the coastal flats of Johore, Selangor and Perak, and on the undulating to rolling rubber country largely in the same states mentioned as well as Negeri Sembilan. The potential oil palm acreage now under forests lies principally in Pahang and Johore and to a smaller extent in Trengganu. It is on these suitable soils that our future oil palm expansion should be channelled so that maximum economic returns can be achieved. As this land potential is large, is there really any need to develop oil palms in less favourable areas?

The marginal soils will exert greater pressures on capital and management and the returns are most likely to be lower. While some of the marginal soils may be considered satisfactory for oil palm development, on the whole, a proper decision can hardly be arrived at without a thorough cost-benefit analysis of oil palm vis-a-vis rubber cultivation. Such an analysis is far beyond our responsibility and rightly lies in the domain of each prospective oil palm grower. As a government agency, our present stand from a national viewpoint is to discourage development of oil palms on marginal soils on a extensive scale when better opportunities abound.

The unsuitable soils comprise the poorest lands in West Malaysia which present formidable physical or nutritional problems in oil palm cultivation. They have a very limited potential for diversified cropping and no serious consideration should be given to oil palm development on such soils.

Future

As oil palm research advances, which it will, and produces superior planting materials capable of larger yields of oil per acre, it may be envisaged that some marginal soils could be confidently developed with oil palms. However, this is still far in the offing and much depends on price levels. For the foreseeable future and in pursuance of a more diversified Malaysian agriculture, it is hoped that the expansion of the oil palm industry will continue in such a fashion as to make the most of capital, management skills, soil resources and knowledge. An indiscriminate replacement of rubber or coconuts with oil palm without due regard to soil and climatic conditions offers no panacea to present and future agricultural problems of Malaysia for all this will do is to place all the new eggs in one new basket.

Acknowledgment

We wish to express our thanks to all the Managers of the oil palm estates studied, which are too numerous to mention individually, for their willing co-operation extended to us.

NSK/mj.

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SOIL SUITABILITY CLASSIFICATION

LAND USE POTENTIAL.

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SOIL SUITABILITY CLASSIFICATION

LAND USE POTENTIAL

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OPTIMUM CONDITIONS FOR GROWTH OF VARIOUS TYPES OF CROPS IN WEST MALAYSIA

The economic crops in West Malaysia can be divided into four groups according to broad similarities in the anatomy of the plant. These are:-

a) Tree crops - deep rooting
b) Shrubs - moderately deep rooting
c) Herbs and grasses (including padi) - shallow rooting
d) Root crops - shallow to moderately deep rooting.

2. Each of these groups of crop requires a different set of conditions for optimum growth to give maximum yields. All crops are grown on soils and each crop will only thrive within a certain range of physical and chemical conditions in the soils. Some crops are more tolerant of adverse conditions while others are less tolerant. In establishing the suitabilities of the soils for these crops this tolerance range must be known.

3. The following information will give the main range of tolerance for each of these crops grown in West Malaysia, and have been compiled for your guidance. Some information may not have been included and the authors will be grateful for such additional information.

4. TREE CROPS

Rubber - is intolerant to waterlogging and massive structures in the soil, but is known to grow reasonably well in loosely to moderately compacted nodular lateritic soils. Shallow soils less than 2 feet thick are to be avoided. For optimum growth the soil reaction should be on the acid side of neutral. Although rubber is known to be able to grow in alkaline soils, the yield is also known to be low. This has been attributed to high Mg, so that the soils derived from limestones are to be avoided. Only extended periods of drought are deterimental.

depth 24"

Oil Palm - is found in regions with a fairly well distributed rainfall of more than 70 inches a year in the tropics. A pronounced dry spell of more than 3 months is less favourable.

30"

The rooting zone extends down to about 30 inches. Reaction - pH 4 to 6 or 7, with deficiency symptoms showing outside this range. Soils with loam or heavier textures and well drained profiles are preferred.

Coconut - prefers light, deep, permeable alluvial soils which can provide unimpeded root development. The alluvial sandy soils along the coast where the ebb and flow plus water from the hinterland provides good growth, as is also along rivers and at foot of slopes.

Coconuts can tolerate a wide pH range, being found on strongly alkaline as well as strongly acid peats (though peats do not provide good anchorage). They cannot tolerate stagnant water; therefore swampy and marshy soils must be drained before coconuts can be cultivated.

Sea water is not harmful to the coconut palm which can also flourish on soils without any salt, i.e.

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it is a typical halophyte. Rolling land is not favourable for coconut cultivation as moisture stress is common for this crop under such situations.

Areca Nut - susceptible to drought. Rolling land is to be avoided.

Cacao - cannot endure dry soil. Thrives on uniform rainfall and a wide range of soil conditions from heavy clays to loams on hills and alluvial flats. Reaction range varies from pH 4 - 7.4 in upper soil layers to pH 4 - 8.3 in subsoil layers.

Papaya - thrives on light pervious soils rich in humus. Intolerant to waterlogging with 48 hours of immersion being fatal.

Langsat - very tolerant of soil conditions; growth is more vigorous and rapid in deep and well drained sandy loams.

Avocardo Pears - Deep, fertile, well drained sandy loam of alluvial origin with neutral or slightly acid reaction is preferable. Heavy clays, susceptible to waterlogging, are unfavourable.

Nutmeg - is a surface feeder preferring light sandy soils.

Kapok thrives in light, well drained loams. Laterite and heavy clays are to be avoided.

Mango - thrives on well drained soils with loam to clay textures. Light sandy or heavy clay soils are to be avoided. It is intolerant to waterlogging and in wet conditions will not flower or fruit properly.

5. SHRUBS

Coffee - grows well on soils with pH of 4.2 to 5.1. Thrives in deep, well drained soils, if not too sandy or clayey.

Liberica - tolerates coastal clays, acidity and excess moisture.

Robusta - sensitive to acidity and excess moisture.

Tea - of high quality is only produced in a cool climate. Grows well if soil reaction is pH 5 - 6 and soil is well drained, deep friable with sandy loam to heavy clay texture.

Citrus Oranges and tangerines.

The best oranges and tangerines are grown at high altitudes (900 - 1,200 m or 3,000 - 4,000 ft.) where temperatures are 68°F - 86°F. Grapefruits, pomeloes and limes thrive better in lowlands of the

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tropics. Lemons are not particularly well adapted to humid lowlands. All citrus cannot tolerate drought, (not less than 2" per month) and also cannot stand waterlogging.

They cannot withstand concentrations of 500 - 700 p.p.m. or more of soluble salts.

Important areas of citrus are on deep, well drained sands, sandy loams, loams, clay loams or silt loams; preference for loose sands or sandy loam with good physical features. Heavy clays are to be avoided because of impeded drainage and insufficient aeration. All citrus have superficial root systems, therefore the water table should be below 18 inches (0.45 m.) pH 4 - 9.

Cashew - will do well up to 1,000 m (3,000 ft.) on soils which other crops may not thrive on.

6. HERBS & GRASSES (INCLUDING PADI)

Banana - requires a deep friable and well drained sandy loam rich in humus (usually of alluvial origin). Will also do well on other soils if loose, well-aerated and drained. Roots are soft and fleshy and the top 30 cm. of soil is important. Clay or light sandy and gravelly soils should be avoided. Hilly sites which are liable to erosion are unsuitable. pH 4.5 - 8.0, optimum at 6 - 6.6.

Abaca (Manila Hemp) - is a member of the Musaceae family but the emphasis is on the production of fibre and not fruits. Intolerant of poor drainage or high acidity. It will thrive in deep, permeable and well drained sandy loams.

Sisal Hemp - needs a fertile, open, light sandy soil. Fairly high rainfall, evenly distributed throughout the whole year is ideal.

Sugar cane - is known to be grown on a very wide range of soils ranging from heavy clays to light sands, but clay loams are preferred, while the lighter soils have better drainage. Reaction ranging from pH 4 - 7 are suitable. Slopes should not exceed 6° as otherwise erosion hazards may be increased while harvesting difficulties may be increased.

Maize - a) Climate

thrives in a climate with temperature at 86 - 90°F. Rainfall is not important as maize has been found in regions with 10 to 200 inches annual rainfall. But the rainfall distribution affects yield. Water required for germination is considerable - the minimum requirement being at least 19 - 25% of water capacity of soil while the maximum is 60%. In contrast to germination the young maize plant requires only very little water, but the plants must be well established.

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Maximum water supply is again required after flowering.

b) Soils

Well drained and well aerated loams rich in humus are preferred. Light sandy soils must have the water and nutrient requirements. Peat can be used for maize cultivation after high acidity and trace elements deficiencies have been corrected. Heavy clays are to be avoided because of poor drainage and aeration.

Optimum pH is 5.5 - 8. Free aluminium ions are injurious and since these are not found in peat maize can be cultivated on peats with lower pH readings than clays.

Sorghum - yields well on fertile, well drained sandy loams. Will tolerate rather high pH as well as moderate amounts of alkali, although optimum pH is neutral or slightly acid.

Rice - pH 5 - 6, requires only 20 - 25 cm. of soils. Will not tolerate saline and acid sulphate conditions. 20 - 25 cm

Groundnuts - will wilt on wet soils; loose fertile well drained soils preferred requires high Ca and pH of 7 or more.

Can be grown in most sandy alluvial soils in Malaya.

Tobacco - Neutral to slightly acid reaction on well aerated and drained soils. Waterlogging and excessive dryness are equally injurious So is saline and acid sulphate conditions.

Pineapple - very sensitive to waterlogging. Only extremely heavy clays to be avoided because of poor drainage. Medium to heavy loams rich in humus, slightly acid in reaction and rich in nutrients, pH 5.5 - 6.2. Soils with higher pH unsuitable because of calcium chlorosis.

Well drained peat is extensively grown with pineapple in West Malaysia.

7. ROOT CROPS

Tapioca - can be grown in altitudes up to 2,000 m (6,000 ft.) with an annual temperature of 20°C. High relative humidity is beneficial to growth. Does well on permeable soils with high nutrients but also successful on both lighter and heavier soils must be firable). Cannot tolerate waterlogging.

Sweet potatoe - light soils with high humus and permeable subsoil are best. Also thrives very well on sandy soils with adequate fertilisers. Too much organic manure will promote leaf growth and not tuber formation

Yam - of the numerous species and varieties of yam (Dioscoreaceae) only the water yam D. alata L.

is found in Malaysia (Keladi), which is not affected by poor drainage. Others require fertile, permeable loams or loamy sands with high humus contents. Heavy soils or those permanently waterlogged are unsuitable.

3. The vegetables have not been dealt with here as the range is very wide. Generally vegetable cultivation is labour intensive and most soils with about 12 inches friable topsoil should be adequate, loams or clay loams are preferable while heavy clays unless well structured should be avoided.

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A SOIL SUITABILITY CLASSIFICATION FOR MALAYSIA

by

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JANUARY 1970

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WEST MALAYSIA

CONTENTS

INTRODUCTION

In Malaysia, soil surveys have been carried out as part of a national resource inventory programme. The soil maps produced as an end result of the soil surveys depict the areal distribution of various soils. These maps, however, do not indicate to the land use planner or the potential user of soils the suitability of the soils for crop growth.

The user of the soil maps has to refer to the soil reports which contain a description of each soil unit depicted on the maps. But the soil units are described in technical terms which are familiar only to those who have had special training in soil science.

With only a little more effort it is possible for the soil surveyor responsible for the production of a soil map to draw up another map showing a re-grouping of the soil units illustrated on the first map according to crop growth limitations present in the soils. This extra effort will result in the production of a soil suitability map. The legend of this map would indicate classes of soils according to their suitability for crop growth. The most suitable class of soils would have none or only few very minor limitations to crop growth while the least suitable class would include all soils that have the most severe limitations to crop growth. Such a map can easily be used by a land use planner or any other soil map user as it does not entail the necessity of having specialized training in soil science.

With a soil suitability map at hand the land use planner can select the best areas for crop cultivation. Where less suitable soils need to be utilized for crop cultivation the crop growth limitations can be looked into so that proper measures can be taken to ameliorate the soils for crop cultivation on a sustained yield basis.

PREFACE

This Pan-Malaysian Soil Suitability Classification was originally intended to be an improvement on the 1966 classification (Wong) which had limited application as it covered only dryland crops and placed emphasis on rubber and oil palm. It was also intended to cover West Malaysia only. But following the suggestion of Mr. J.P. Andriesse, Senior Soil Surveyor of the Department of Agriculture, Sarawak, and author of "The Classification and Evaluation of Land in Sarawak", the West Malaysian classification has been extended to include soil conditions in East Malaysia as well.

After the revision, the draft Malaysian Soil Suitability Classification was circulated for comments. As this national classification would be the standard referred to in all subsequent government reports dealing with the suitability of soils for agricultural development, it was thought worthwhile to invite as many suggestions as possible for improvement in the draft from soil scientists and other agriculturists working in the country. It was with this purpose in mind that a seminar was organized by the Technical Sub-Committee on Land Capability Classification of the Economic Planning Unit of the Prime Minister's Department. The suggestions for improvement of the draft scheme brought up at the seminar have, wherever possible, been incorporated into the classification which has now been drawn up.

ACKNOWLEDGEMENTS

The soil suitability classification for Malaysia cannot be considered the product of a single person. It is the result of the contribution of a great number of soil scientists and agriculturists. The author is mainly responsible for compiling the accumulated knowledge on the crop growth limitations present in the soils of the country as observed by soil scientists and agriculturists. As such the author is grateful to the many contributors for their valuable comments and suggestions for improvement of the draft, in particular Messrs. J.P. Andriesse (Senior Soil Surveyor, Department of Agriculture, Sarawak), W.P. Panton (Director, Regional Planning Division, Economic Planning Unit, Prime Minister's Department), K. Kanapathy (Senior Chemist, Department of Agriculture, Kuala Lumpur), Law Wei Min (Acting Senior Soil Scientist, Department of Agriculture, Kuala Lumpur), Dr. Ng Siew Kee (previously Senior Scientist, Department of Agriculture, Kuala Lumpur) and the participants at the seminar on soil suitability classification for Malaysia.

In setting up a soil suitability classification the underlying principles and criteria adopted need to be clearly defined so that given the same set of data different individuals will arrive at the same classification of the objects in question which, in this case, are soils.

The general principles adopted for the Malaysian Soil Suitability Classification are that

(1) the criteria used for the assessment of a soil should be the properties currently possessed by that soil;

(2) the seriousnes of a limitation should be a function of the severity with which crop growth is inhibited; and

(3) the suitability of a soil for crop growth is better when a wider range of crops can be cultivated on it than on another soil.

In this way a soil is classified according to the crop growth limiting factors currently found in it. How the limiting factors can be corrected, at what expense and in what interval of time, are all questions which are outside the scope of this classification. What this classification will do, however, is to highlight the limiting factor (or factors) in a soil and to indicate the seriousness of the limitation to crop growth on a sustained yield basis.

COMPARISON WITH OTHER CLASSIFICATION SYSTEMS

The Soil Suitability Classification for Malaysia is similar in approach to the Land Capability Classification set up by Klingebiel and Montgomery (1961), Haantjens (1963) and Andriesse (1966); the soils are classified according to the severity of soil factors which limit crop growth. It is different from the Land Capability Classification of the Technical Sub-Committee of the Economic Planning Unit, Prime Minister's Department, West Malaysia (Panton, 1966), which is a classification of land according to its natural resources potentials, that is, mineral, agricultural and forestry potentials.

The soil suitability classification for Malaysia is further similar to those of the U.S.D.A. (Klingebiel and Montgomery, 1961), C.S.I.R.O. (Haantjens 1963, 1967) and Sarawak (Andriesse, 1966) in having subclasses based on the kinds of limitations to crop growth.

Moreover, like the systems of Haantjens and Andriesse but unlike that of Klingebiel and Montgomery, the Malaysian system takes into consideration perennial (tree) crops and padi cultivation besides arable farming as forms of land use.

Climate has not been considered as a limiting factor because the high temperatures and generally high rainfall encourage more than limit crop growth.

Suitability classes are subdivided into subclasses. There are no further subdivisions into units as is the case in the American system. This is because of a lack of data on management practices, crop performance and yields and also because the soil mapping units are based mainly on reconnaissance and semi-detail surveys.

Contrary to the other three systems, there are only 5 suitability classes in the Malaysian classification; class I soils are the most suitable for crop growth on a sustained yield basis and the suitability decreases to class V in which the soils are least suitable for long term crop cultivation.

Very poorly drained soils cannot be considered completely unsuitable for agriculture especially for padi cultivation. Thus, in contrast to the other three systems, in the Malaysian classification, waterlogged soils are considered suitable for agriculture though the choice of crops is very limited.

ASSUMPTIONS AND EXPLANATIONS

1. The Soil Suitability Classification for Malaysia is a special purpose classification geared solely to crop growth.

rather crop selection!

2. A moderate level of management is assumed, that is, one which will conserve a soil while the latter is being utilized for crop cultivation.

3. Only those crop growth limiting factors which are currently present in a soil are considered.

4. The suitability classification may be changed by major reclamation projects (e.g. drainage and irrigation) which permanently alter the limitations to crop growth. The classification will then be based on the remaining limitations which have not been removed.

5. The system is based mainly on physical limitations since these are generally more permanent and difficult to rectify; where applicable, however, severely limiting chemical properties are also taken into consideration.

6. Accessibility and proximity to markets, do not influence the grading. This also applies to the skill or resources of individual operators who can put in a level of management higher than that of those who are capable of only a moderate level of management.

7. The interpretations attempt to express current knowledge and as new experience is acquired new interpretations may be necessary e.g. the limits of the parameters may need to be changed according to new knowledge on crop behaviour.

8. The system is not a soil suitability classification for specific crops e.g. rubber, oil palm or padi. Interpretations of soil maps for such purposes may require different groupings of the soil mapping units according to the specific needs of each crop.

9. Agronomic data and other observations of crops performances are used as the bases for classifying the soils in suitability subclasses and classes. Where there is a lack of data on crop response to soils, the placing of such soils in the respective subclasses and classes is based on the interpretation of soil properties according to general principles about use and management developed for similar soils elsewhere.

FACTORS LIMITING CROP GROWTH

In defining the suitability classes and subclasses, only general statements of conditions can be given. In practice, however, more specific parameters are needed to guide the allocation of mapping units to the various suitability subclasses and classes. For this purpose, in Malaysia, the factors limiting crop growth have been separated into four groups, namely:-

a. Very serious limitations.

b. Serious limitations.

c. Moderate limitations.

d. Minor limitations.

The seriousness of a limitation is determined by the extent to which it will inhibit crop growth. Accordingly, a very serious limitation will not only retard but may even totally inhibit crop growth. A serious limitation, however, is not detrimental to all crops; while some of the more sensitive crops may not survive such conditions, others may even thrive in them e.g. padi and sago under wet conditions.

Moderate limitations affect a limited range of crops which may be very sensitive to some soil conditions. For most crops these limitations can be surmounted by proper management.

Minor limitations are those which can affect a very selected number of crops; the effect is more in terms of yields than of crop survival.

The parameters given below are based on current knowledge of crop response to soils; with more empirical data on crop performances they may need redefining.

a. Very serious limitations

1. Gradient and Texture (G); steep slopes (above 20° or 25° with light textured soils) SC, SCL, L, SiL, Si, LS, S
or
(g); (above 35° with heavy textured soils). C, CL, SiC, SiCL

2. Depth to strongly compacted layer (c); less than 10 inches (25cm).

3. Acid sulphate layer (a); 0 to 10 inches from the surface. (25cms)

4. Rockiness (r); extreme (more than 75% of soil volume).

5. Nutrient imbalance (n); toxicity caused by extremely high contents of certain elements.

6. Human (h); disturbed land.

b. Serious limitations

1. Gradient and Texture (G); moderately steep slopes (12° to 20° or 25° with light textured soils)
or
(g); (20° or 25° to 35° with heavy textured soils).

2. Drainage (d); very poorly to poorly drained.

3. Depth to strongly compacted layer (c); 10 to 20 inches (25-50cm).

4. Salinity (s); strongly saline.

5. Acid sulphate layer (a); 10 to 20 inches from the surface. (25-50cms)

6. Organic horizon (o); any thickness if waterlogged.

7. Rockiness (r); moderately extreme (50 to 75% of soil volume).

Heavy Text soils: C, CL, SiC, SiCL.

Light " " : SC, SCL, L, SiL, Si, LS, S.

c. Moderate limitations

1. Gradient and Texture (G); Strongly inclined slopes (6° to 12° with light textured soils).
or
(g); (12° to 20° or 25° with heavy textured soils).

2. Drainage (d); imperfectly or excessively drained.

3. Depth to strongly compacted layer (c); 20 to 40 inches(50-100cm).

4. Salinity (s); moderately saline.

5. Acid sulphate layer (a); 20 to 40 inches from the surface.

6. Organic horizon (o); more than 4 feet thick at the surface(drained).

7. Rockiness (r); moderate (25 to 50% of soil volume).

8. Nutrient imbalance (n); acute nutrient deficiencies.

d. Minor limitations

1. Gradient and Texture (G); gently inclined slopes (2° to 6° with light textured soils).
or
(g); (2° to 12° with heavy textured soils).

2. Drainage (d); somewhat excessively drained.

3. Depth to strongly compacted layer (c); 40 to 50 inches(100-125cm).

4. Salinity (s); weakly saline.

5. Acid sulphate layer (a); 40 to 50 inches from the surface.

6. Organic horizon (o); 2 to 4 feet thick at the surface (drained).

7. Rockiness (r); slight (10 to 25% of soil volume).

8. Nutrient imbalance (n); moderate nutrient deficiencies.

For easy comparison the above parameters have also been tabulated as indicated in TABLE I.

TABLE I. LIMITATIONS TO CROP GROWTH

4 (2 or more of (1.3) SELECTION (SEJP)

SYMBOL	TYPE	5 VERY SERIOUS	3 SERIOUS	2 MODERATE	1 MINOR
G AND g	GRADIENT AND TEXTURE	20 - 25° > 20° or 25° slopes with light textured soils SC, SCL, L, SiL, Si, LS, S or > 25° > 35° slopes with heavy textured soils C, CL, SiC, SiCL	12°–20° or 25° slopes with light textured soils or 20° or 25° or 35° slopes with heavy textured soil	6°- 12° slopes with light textured soils or 12°–20° or 25° slopes with heavy textured soils	2°–6° slopes with light textured soils or 2°–12° slopes with heavy textured soils
d	DRAINAGE	—	Very poorly to poorly drained	Imperfectly drained or Excessively drained	Somewhat excessively drained
c	DEPTH TO STRONGLY COMPACTED LAYER	Less than 10 inches (25 cm.)	10 to 20 inches (25–50 cm.)	20 to 40 inches (50–100 cm.)	40 to 50 inches (100–125 cm.)
s	SALINITY	—	Strongly saline	Moderately saline	Weakly saline
a	ACID SULPHATE LAYER	0 to 10 inches from the surface	10 to 20 inches from the surface	20 to 40 inches from the surface	40 to 50 inches from the surface
o	ORGANIC HORIZON	—	(Water logged) any thickness	(Drained) > 4 feet thick at the surface	(Drained) 2 to 4 feet thick at the surface
r	ROCKINESS	Extreme (> 75% of soil volume)	Moderately extreme (50–75% of soil volume)	Moderate (25–50% of soil volume)	Slight (10–25% of soil volume)
n	NUTRIENT IMBALANCE	Toxicity caused by extremely high contents of certain elements	—	Acute nutrient deficiencies	Moderate nutrient deficiencies
h	HUMAN	Disturbed land	—	—	—

SOIL SUITABILITY CLASSES

Class I. Soils with no limitation or one or more minor limitations to crop growth

The soils in Class I are suitable for the widest range of crops. They can be profitably cultivated under a moderate level of management. These soils occur on flat to rolling terrain (0° - 12°). They have good water-holding and nutrient-retaining capacities and are well suited to continuous cropping on a sustained yield basis.

The most versatile soils in this class are those found in flat areas where they can be utilized for a very wide range of dryland crops or irrigated for padi cultivation; these are deep, well structured soils with a very high clay content.

Class II. Soils with one or more moderate limitation to crop growth

These soils are suitable for a narrower range of crops than Class I soils. A moderate level of management is necessary to obtain economic returns from crops grown on them. Management practices may include erosion control measures, minor drainage and irrigation works, or improvements in the air and water relations. 6 - 20°

Class III. Soils with one serious limitation to crop growth

As these soils possess one serious limitation besides possibly one or more moderate limitations, they are restricted to a narrow range of crops. Even so, a high standard of management is necessary to develop or conserve them for long term crop cultivation. Necessary management practices may include erosion control measures, an intensive fertilizer programme and/or drainage and irrigation works involving moderate expense. 12 - 20°

Class IV. Soils with more than one serious limitation to crop growth

In having more than one serious limitation these soils are limited to a very narrow range of crops, often only to specific crops. Even though the choice of crops is very narrow, the level of management for these soils has to be increased if their continuing productivity is to be maintained. Major conservation or amelioration measures are necessary before these soils can be cultivated on a long term basis.

12 - 20°

ie deep peats

Class V. Soils with at least one very serious limitation to crop growth

The soils included within this class, in their present condition, are the least suitable for crop growth. Where they are not built over for urban development or excavated for mining and quarrying purposes they are best allowed to continue under primary or regenerating forest.

SOIL SUITABILITY SUBCLASSES

Soil suitability subclasses are subdivisions within suitability classes. They are formed on the basis of the kinds of limitation affecting crop growth. Their formation and inclusion in soil suitability maps will give potential users of such maps a better guide regarding the management practices which may be needed for long term cultivation of land.

As there are altogether nine different types of limitations to crop growth in Malaysia, subdivision of suitability classes into subclasses is based on these nine limitations. They are listed below with respective letter symbols which will indicate on soil suitability maps the kinds of limitation possessed by different mapping units. The ninth (disturbed land) although not a limitation in the sense of the other eight, is included because all land that is presently being mined or is under urban development is not available for agriculture and therefore cannot be considered for crop growth in the present scheme.

Only the most severe limitation or limitations will be shown on the soil suitability map. For instance, a mapping unit which is very poorly drained and has acute nutrient deficiencies will be indicated as a Class IIId soil. The symbol 'n' for acute nutrient deficiencies, which are only moderate limitations, will only be shown when the drainage of the soil has been improved; the suitability class may then be IIdn, that is, the soil is imperfectly drained and has acute nutrient deficiencies.

G or g = gradient & texture
d = drainage
c = depth to strongly compacted layer
s = salinity
a = acid sulphate layer
o = organic horizon
r = rockiness
n = nutrient imbalance
h = disturbed land

Gradient and Texture

These two soil properties have been considered together because the severity of erosion by water in this country where heavy thunderstorms are common is not only influenced by gradient but also by the texture of the soil.

In this classification a light textured soil is defined as any soil with a subsoil texture of sandy clay or lighter while a heavy textured soil is any soil with subsoil textures heavier than sandy clay. The light textured soils, as indicated in Fig.1, would thus include all soils with clay contents less than 27% and also soils with sand contents exceeding 45%. These are the sandy clays, sandy clay loams, sandy loams, loamy sands, sands, loams, silt loams and silts. B1

Light textured soils have been observed to be usually more susceptible to erosion than the heavy textured soils. While broad bench terracing and cover cropping may be an essential conservation requirement for crop cultivation on a light textured soil, narrower contour terraces would often suffice, on similar gradients, for soils with heavy textures. This is why the slope limits for the heavy textured soils can be raised above those for the light textured soils.

As light textured soils are more susceptible to erosion their gradient limits are indicated by a capital "G", while slope limits for heavy textured soils are shown with a small "g".

The slope parameters for this classification are based on observations made in the field and on measurements made on contoured maps by soil surveyors in Malaysia. In East Malaysia and, to a lesser extent, West Malaysia gradients of 35° mark the upper limit of very steep slopes. The next break of slope occurs at 25° in East Malaysia and 20° in West Malaysia. The hilly terrain slopes are between 25° or 20° and 12°; in rolling terrain 12° to 6° slopes are common while in indulating terrain the slopes range between 6° and 2°. On the plains slopes are commonly between 2° and 0°.

Slope Class	Slope Range (°)	Map colours
C1	0 - 2	blue
C2	3 - 6	green
C3	7 - 12	yellow
C4	13 - 20	orange
C5	21 - 25	brown
C6	> 25	red

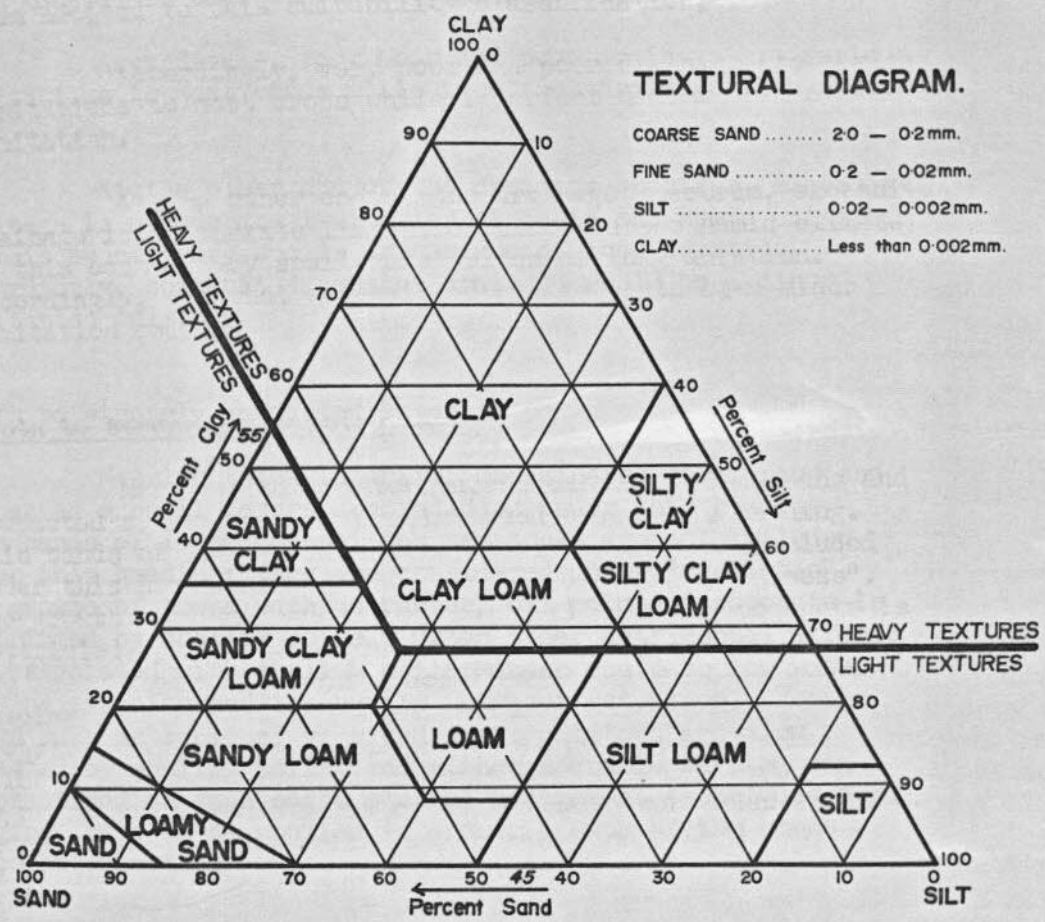

Figure 1: Triangular texture diagram showing sand and clay limits for light and heavy textured soils.

Drainage

The drainage status of a soil does not affect all plants in the same way. While wetland crops such as padi and sago palm thrive under very wet conditions all dryland crops may not survive these conditions. As most crops are inhibited in growth with increasing soil wetness or dryness the drainage classes of the U.S.D.A. Soil Survey Manual have been adopted in this suitability classification.

Accordingly, very poor and poor drainage are serious limitations to most crops while imperfect drainage is a moderate limitation.

At the other end of the drainage spectrum, excessive drainage is a moderate limitation since in the humid climate of this country dry spells are seldom of long duration. Accordingly, somewhat excessive drainage would be a minor limitation only.

Depth to strongly compacted layer

Massive thick laterite, unweathered rock, pans and compacted subsoil layers are included under this heading. Thin bands of loose concretions or stones are not included under this heading; they are considered under "rockiness". The growth of trees such as rubber, oil palm and coconuts is restricted by shallow soils. Often other detrimental effects are associated with shallow soils; these could be low water-holding capacity and inadequate nutrient retention. Root crops such as tapioca, yams and sweet potatoes are also affected by shallow soils, and although arable farming can be practiced on such soils special management techniques e.g. ridging, have to be applied if proper growth of the crops is to be expected.

Salinity

Salinity is associated with heavy textured marine alluvium inundated by sea water. A salinity classification which has been found to be satisfactory by the U.S. Salinity Laboratory (1954) for appraising soil salinity in relation to plant growth has been adopted for Malaysian conditions and is indicated below.

Salinity Scale

Conductivity of saturation extract of soil (millimhos/cm at 25°C				
0	2	4	8	16
Non saline	Very slightly saline	Moderately saline	Strongly saline	Very strongly saline
Salinity effects mostly negligible	Yields of very sensitive crops may be restricted	Yields of many crops restricted	Only tolerant crops yield satisfactorily	Only a few very tolerant crops yield satisfactorily

Results of a soil investigation in the proposed Sungai Sarawak Padi Scheme Area (Andriesse and Sim, 1968) indicate that salinity is not uniform throughout any one area. In general, however, the type of natural vegetation can be taken as an indication of the frequency of tidal flooding of a soil; mangrove, characterized by Rhizophora species occupy sites daily subject to two tidal floods. The soils in such sites would be strongly to very strongly saline. Where the mangrove vegetation consists of species of Avicennia and Sonneratia flooding by saline water is less frequent; the soils in such sites can be expected to have conductivity readings of up to 8 millimhos/cm. at 25°C, which would be within the moderately saline range. Often moderately saline sites can be identified by the presence of a mixture of mangrove and nipah palm (Nipa fruticans). On sites where the nipah palm is predominant flooding by saline water is even less frequent so that the soils are very slightly saline. Where the nibong palm (Oncosperma filamentosa) is predominant flooding by saline water is of very occasional occurrence so that the soils are usually non saline.

L.I.P. figures ECe

<4 millimhos – all crops thrive

4-8 – " – – only tolerant crops thrive.

8-15 – " – – no crop do well

>15 – " – – no crop survives.

Acid Sulphate layer

A considerable acreage of marine alluvial soils in Malaysia are highly acid due to the presence of excessive amounts of oxidisable sulphur compounds. These sulphur compounds are produced by the microbiological reduction of sulphur derived from sea water. When the soil is drained oxidation of the sulphur compounds to sulphate takes place. Hydrolysis of the sulphate in water produces an acid conditon in the soil. Drainage of a sulphide-containing soil usually results in severe deterioration of the condition of the soil so that very many years of continued aeration and leaching must elapse before the soil can become suitable for cultivation.

The acid sulphate condition of a soil can be determined in the laboratory. Two measurements are made, the pH of the air dried soil in a water culture and the water soluble sulphur content as sulphate. Soils with pH readings of 3.5 or lower and sulphate concentrations of more than 0.1% inhibit the growth of cultivated crops.

As the acid sulphate condition of a soil is influenced by the permanent ground water table, this condition occurs in affected soils as a definite layer within the soil. Depths to which the highly acid and strongly sulphurous layer occurs are taken to be similar to those for strongly compacted layers, i.e. 0 to 10 inches, 10 to 20 inches, 20 to 40 inches and 40 to 50 inches.

Organic horizon

Organic or bog soils in Malaysia are associated with bottom lands which are usually waterlogged. They vary in organic matter content from true peats to organic clays and mucks. A true peat consists of incompletely decomposed organic debris and when ignited at 800°C to a constant weight, the loss in weight is more than 65%. Muck is organic material which has decayed to such an extent that plant remains are well broken down; on ignition its loss in weight is between 35% and 65%. Organic clay is predominantly clay but in which there is a substantial proportion of decayed organic matter; its loss in weight on ignition is between 25% and 35%. High acidity is frequently associated with such soils.

Peats are poor anchoring mediums for trees and this is clearly indicated by coconut and oil palms growing with their trunks leaning close to the land surface. Because of their high porosity the permeability of peats is very rapid. Very frequently, in deep peats, large logs occur which impede tillage operations. The maintenance of a correct water table level is critical in the proper utilization of peats - over-draining produces very rapid initial shrinkage followed by irreversible drying and oxidation of the organic matter at the surface while lack of draining results in waterlogging and inhibition of root development which in trees can result in poor anchorage and consequent leaning. With proper draining, however, the cultivation of shallow-rooting crops is a feasible proposition and it has been shown that pineapple cultivation is very successful under such conditions. Mucks and organic clays, because they have higher mineral matter content, more thoroughly decomposed organic matter and are shallower, do not limit the cultivation of tree crops except where the drainage is poor or where the underlying clay is strongly sulphurous.

In their natural condition even shallow peats possess a serious limitation to crop growth, namely, very poor drainage. When drained, however, progressive shrinkage occurs in them so that the cultivation of permanent tree crops is limited. While a peat thickness of 2 to 4 feet may be a minor limitation, thicknesses of more than 4 feet are a moderate limitation particularly to permanent tree crops.

Rockiness

This limitation includes rocks, stones and concretions of varying sizes ranging from large boulders to stones occurring as loosely dispersed particles within the soil and/or on its surface. Thus bands of stones, gravels and iron concretions occurring as non-indurated bands or spread throughout the profile are included under this heading.

Instead of considering only the surface area of land occupied by rocks, stones or conretions, the whole volume of a soil down to four feet depth is taken into account so that soils which do not have rocky surfaces but are internally filled with stones and concretions can also be considered under this heading. While rocks on the surface can reduce the effective area for crop cultivation, those within the soil not only have the same effect but can also impede proper root ramification besides reducing the effective soil volume for moisture and nutrient retention. Yields of root crops such as tapioca (cassava), yams and sweet potatoes are also drastically lowered.

Nutrient Imbalance

Although the soils in Malaysia are considerably leached, nutrient deficiencies in them cannot be considered as permanent but only as a temporary limitation to crop growth on a sustained yield basis since it is possible to remedy this situation by correct fertilizer application. Nevertheless, a soil with acute nutrient deficiencies needs better management than one without such problems, so that the former cannot be raised to a status equal to that of the latter, all other conditions being equal.

On the other hand, the presence of excessive quantities of some elements such as nickel, boron and sulphur can be toxic to plants. Fertilizer application alone will not correct such excesses easily. Continuous applications of chemicals and years of continuous leaching may be necessary before the toxicity can be brought under control.

Disturbed Land

Land that has been disturbed by human activity, particularly by mining and urbanization, is least suitable for crop cultivation in its present condition. When such land has been allowed to return to its native condition it can then be considered for agricultural development; its suitability classification will then depend on the properties it has developed as a result of the change in land use.

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Land Capability Classification in West Malaysia

AN EXPLANATORY HANDBOOK

Prepared by the Natural Resource Capability Section of the Economic Planning Unit, under the direction of the Technical Sub-Committee on Land Capability Classification of the National Development Planning Committee

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FOREWORD

The wise use of natural resources is the very foundation of a nation's economic progress and prosperity, and the Malaysian Government is well aware of the contribution which science and technology can make towards the utilisation of these resources within a sound conservation context. In order that the maximum benefit can accrue it is important that the scientific and technological research and surveys should be co-ordinated and the recommendations drawn from the investigations of workers in many fields presented in a clear and unambiguous manner. Only then may the results be applied with confidence to problems of development by all sections of the community.

In the field of land use and natural resource development the need for an expert concensus on land use potentials is particularly desirable, for land can be rich in many resources, and used for many purposes, but not all of these uses may be equally desirable, and some may be extremely harmful, leading in extreme cases to complete spoilation of the land with serious consequences for future generations.

Land Capability Classification is one way of indicating the most desirable manner of utilising the land for the best economic purposes, while ensuring that certain areas of low development potential, or of particular aesthetic or scientific merit, will be conserved in their natural state for the long term benefit of the nation. The co-operation of scientists of many disciplines is involved in the Land Capability Classification Programme for West Malaysia which is described in this explanatory handbook.

Malaysia is fortunate in having considerable reserves of natural resources, principally minerals, soils, forests, and water and in planning to develop these resources she can learn from the experiences of others which was often gained through a disregard of scientific principles or through the unrestricted play of human greed. It is the intention of the Malaysian Government to prevent such misuse by wise land administration, and the Land Capability Classification Programme described in the following pages is a major step towards this objective.

(TUN ABDUL RAZAK BIN HAJI HUSSEIN)
DEPUTY PRIME MINISTER

Kuala Lumpur,
3rd January, 1967.

CONTENTS

LAND CAPABILITY CLASSIFICATION

What Land Capability Classification is about

The process of classifying land according to the use potential of the natural resources is known as Land Capability Classification. The need for such a classification, which is a type of economic land classification, has become increasingly apparent in Malaysia in recent years. It is designed to indicate the purpose for which given areas of land should be used in order to make the best use of the inherent resources.

The land capability classification is used as the legend for classification maps which are easily understandable to a wide variety of persons who are interested in making the best use of the land. Such a classification is therefore relatively simple, as it is designed to meet the needs of persons who are not necessarily well informed about technical details.

Why Land Capability Classification is needed

It is known that much valuable information about our natural resources, particularly minerals, soils, forests, and water is not made use of by non-technical personnel, either because it is unpublished and has been half forgotten in departmental archives, or else because the reports and papers which contain this information are written in specialised jargon which is unintelligible to most people. Much of this information is worth publishing in a more understandable form because of its great value in matters of land use planning and natural resource development.

Such studies, which in Malaysia should embrace a study of mineral, soil, forest, and water potential, and evaluate the development potential of the land in terms of these natural resources, are of particular value in drawing up development plans at both a local and national level, and they help to ensure that development expenditure, particularly in the rural areas, is devoted to the right purposes, and exploited in an economically beneficial manner.

The success of the Rural Development Programme during the second Malayan Five-Year Plan period and the key role played in this programme by the Red Book, is now universally acknowledged. In retrospect, it is apparent that much of this success has been occasioned by the way in which the spirit of Gotong Royong has been inculcated amongst Government staff and the people, and the degree of co-operation and co-ordination which has resulted has been highly impressive.

The very satisfactory overall rate of progress attained was partly due to the manner in which the drawing up and execution of local development plans was made the responsibility of the District Development Committees. These Committees were able to draw up their proposals with the minimum of delay, and then allowed to implement these proposals without a surfeit of possibly conflicting advice.

Unfortunately, the success of a development scheme can be severely jeopardized if the technical and scientific evidence is not properly appraised by the developers, and experience during the past years of active development has given rise to the suggestion

that a closer degree of co-operation should be attained in the technical field of natural resource evaluation so that the development committees can take advantage of unambiguous technical advice. This springs from a realization that if the technical interests involved could reach a measure of agreement with regard to the optimum use of the land containing these resources, and then prepare maps embodying a classification which reflects this optimum use, the recommendations and suggestions which would follow from such an exercise would be of immense value in matters of national planning.

The Land Capability Classification Reports, accompanied by maps, which are prepared are therefore made the joint responsibility of the technical and scientific specialists who are normally engaged in carrying out basic natural resource surveys.

How Land Capability Classification is carried out

Plans for carrying out these studies on a district basic for West Malaysia have been prepared by the Technical Sub-Committee on Land Capability Classification of the National Development Planning Committee, and a section which is known as the Natural Resource Capability Section has been set up within the Economic Planning Unit for the specific purpose of co-ordinating such studies. The programme for West Malaysia commenced in 1965, and should be completed within a period of about three years.

A high degree of co-ordination is expected from the technical departments of government which are concerned with the survey and development of Malaysian natural resources, and all these departments together with other interested organizations are represented on the Technical Sub-Committee. They include the departments of Survey, Lands, Mines, Agriculture, Forest, Geological Survey, Game, Aborigines, Veterinary, Town and Country Planning, Drainage and Irrigation, Public Works, and the National Electricity Board, Federal Land Development Authority, Rubber Research Institute, and the University of Malaya. The procedure adopted in carrying out these studies calls for the contributing departments to prepare resource maps which define the relative value of the individual resource potentials (mineral, soil, forest, water) by means of a simple classification, and copies of these maps, which are drawn up largely by reference to existing records, are stored within the Natural Resource Capability Section, where they constitute a valuable source of professional and technical information, not otherwise available for reference in one place.

A co-ordinator, who is on the Economic Planning Unit staff, is responsible for preparing Land Capability maps from these resource maps and the classification used on the capability maps differentiates between those areas known to have a high mineral development potential; a high or medium agricultural development potential; a high productive forest potential; and a relatively negligible potential for any of these purposes.

Up-to-date land alienation and gazettement maps are also prepared, and both these maps are based on the most accurate available topographic sheets supplied by the Survey Department.

Current departmental proposals, for additional water catchment, forest, game, aborigine, and grazing reserves, are also collected in

order that these proposals may be contrasted and compared with the land capability classes in the same way as is possible for the current land alienation and gazettement data.

A short explanatory report summarises the resource potentials of the area, highlights the major possibilities for future development, and suggests very broadly the manner in which development might take place within a sound conservation context designed to ensure the orderly exploitation of the natural resource potentials.

Each district is treated in a similar fashion, and district maps and reports are completed at intervals of a few weeks. By combining the maps for each district in any State, a valuable appraisal is made of the resource potentials for the State as a whole, and a similar appraisal can ultimately be made for all the States in West Malaysia.

The value of the information shown on these maps, at National, State, and District levels is incalculable, and it is hoped that these studies will be found helpful to District and State Development Committee amongst others, in providing professional advice in a readily understandable form.

It is especially important to note that these reports do not constitute plans. They should be considered as guides to sound planning, and the maximum benefit is likely to accrue if the more detailed physical planning is made the responsibility of professional officers on the State establishment.

It will be appreciated that this classification programme depends for its success on a measure of State and Federal Government co-operation, although no large burden of extra responsibilities is imposed on the State Governments, as most of the compilation work necessary for the preparation of the resource and capability maps is undertaken by Federal staff within the Federal Headquarters of the technical departments. The various Federal officers engaged in this programme, and particularly the co-ordinator in charge of the Natural Resource Capability Section within the Economic Planning Unit consult State Government officers with regard to existing development plans and seek local advice and opinion with regard to future development proposals. The officers most able to assist in this manner are the State Secretaries; State Commissioners for Lands and Mines; State Development Officers; District Officers; and the heads of State Agricultural, Survey, and Forest Departments.

The need for accurate and up-to-date alienation detail is essential for the proper execution of the land capability classification programme, and the most satisfactory sources of such detail are the State Survey Offices and the Land Offices. These State departments therefore co-operate by supplying an outline of the alienated land boundary, reduced to 1 inch to a mile, for each individual district. A base map on which this information is superimposed is supplied by the co-ordinator, and the work of the State departments involves transferring the boundaries by tracing from 1 inch to a mile originals, if these exist in the State Survey Offices or the District Operation Rooms, or reducing the information from larger scale cadastral or land alienation sheets where up-to-date 1 inch maps showing this detail are not already available.

Plans to carry out a systematic present land use survey for West Malaysia, based on a complete 1: 25,000 aerial photographic cover obtained during 1966, are also being formulated, and the results of this factual survey will later be compared with the other data which is already being collected.

The Federal departments contribute by supplying maps showing the suitability for development of the resource for which they are responsible, or of the present or proposed use pattern in which they may have interests.

Programme

The programme for West Malaysia has been drawn up to allow all of the States to be treated consecutively, and land capability classification maps and reports for individual districts are prepared at intervals of a few weeks.

The order in which the State and District maps and reports are being prepared is listed below. Sub-districts are shown in brackets, and are included in the maps and reports for the main districts:

1. PAHANG—
   1. Kuantan
   2. Bentong
   3. Temerloh
   4. Pekan (Rompin)
   5. Raub
   6. Cameron Highlands
   7. Lipis
   8. Jerantut

2. JOHORE—
   9. Mersing
   10. Kota Tinggi
   11. Johore Bharu (Kulai)
   12. Pontian (Rengit)
   13. Batu Pahat (Yong Peng)
   14. Muar (Tangkak, Lenga)
   15. Kluang
   16. Segamat

3. MALACCA—
   17. Jasin
   18. Malacca
   19. Alor Gajah

4. NEGRI SEMBILAN—
   20. Tampin (Gemas)
   21. Kuala Pilah (Bahau)
   22. Rembau
   23. Port Dickson
   24. Seremban (Mantin)
   25. Jelebu

5. SELANGOR—
   26. Kuala Langat (Sepang)
   27. Ulu Langat
   28. Kuala Lumpur (Kepong, Sungei Besi)
   29. Klang
   30. Kuala Selangor (Tanjong Karang)
   31. Sabak Bernam
   32. Ulu Selangor (Rawang)

6. PERAK—
   33. Batang Padang
   34. Lower Perak (Tanjong Malim)
   35. Dindings
   36. Kinta (Gopeng, Kampar)
   37. Kuala Kangsar (Parit, Sungei Siput)
   38. Larut and Matang (Selama)
   39. Krian
   40. Upper Perak (Kroh, Lenggong)

7. PENANG AND PROVINCE WELLESLEY—
   41. Nibong Tebal
   42. Butterworth
   43. Bukit Mertajam
   44. Penang Island
   45. Penang Northeast

8. KEDAH—
   46. Bandar Bahru
   47. Kulim
   48. Kuala Muda
   49. Baling

50. Sik
51. Yen
52. Kota Star
53. Padang Terap
54. Kubang Pasu
55. Langkawi

9. PERLIS—
56. Perlis

10. KELANTAN—
57. Ulu Kelantan
58. Tanah Merah
59. Pasir Mas
60. Tumpat
61. Kota Bahru
62. Bachok
63. Machang
64. Pasir Puteh

11. TRENGGANU—
65. Besut
66. Ulu Trengganu
67. Kuala Trengganu
68. Marang
69. Dungun
70. Kemaman.

After the programme of Land Capability Classification has been completed for all the districts in a State, the district maps and reports are consolidated for the State, and State Land Capability Classification maps and reports are prepared. When all the districts have been completed a national appreciation for West Malaysia will be made from the State maps and reports.

The possibility of carrying out similar classification studies for the East Malaysian States before the end of the First Malaysia Plan period is also being considered.

Specifications

Specifications for the purpose of the Land Capability Classification Programme for each district are as follows:

Base Maps (Survey Department Contribution)

Prepare and supply copies of the most up-to-date one inch to a mile topographical maps covering each district.

Land Alienation and Gazettement (State Survey Office and Land Office Joint Contribution)

Prepare a map showing alienated and gazetted land detail for single or contiguous areas exceeding ten acres in size, with subdivisions into ten groups as follows:

(1) Land alienated for all country (agricultural land) purposes, including approved applications, but excluding land held on T.O.Ls and also land allocated for agricultural schemes in course of development.
These areas are edged by black lines and hatched with horizontal black lines.

(2) Land alienated on mining leases and mining certificates.
These areas are edged by black lines and hatched with broken horizontal black lines.

(3) Land gazetted as Malay Reserves.
These areas are edged by yellow lines.

(4) Land gazetted as Grazing Reserves.
These areas are edged by brown lines.

(5) Land gazetted as Aborigine Reserves.
These areas are edged by red lines.

(6) Land gazetted as Forest Reserves.
These areas are edged by green lines.

(7) Land gazetted as Game Reserves.
These areas are edged by blue lines.

(8) Land alienated as town or village land, which occurs within local authority areas (Municipality, Town Council, and Local Council areas).
These areas are edged by black lines and hatched with a pattern of horizontal and vertical black lines.

(9) Land reserved for government purposes other than those shown separately above.
These areas are shaded grey.

(10) Land covered by current prospecting permits.
These areas are edged by broken red lines.

Aborigine Reserves (Aborigines Department Contribution)

Prepare a map showing the following:

(1) Land gazetted as aborigine reserves larger than ten acres.
These areas are edged by red lines.

(2) Land classified as approved aborigine reserves larger than ten acres (i.e. areas approved by the State Executive Council but not yet gazetted).
These areas are edged by broken red lines.

(3) Land classified as proposed aborigine reserves larger than ten acres [i.e. areas which in accordance with current proposals the department is anxious to see included in category (1) but which have not yet reached the stage of category (2)].
These areas are edged by dotted red lines.

Game Reserves (Game Department Contribution)

Prepare a map showing the following:

(1) Land gazetted as game reserves larger than ten acres.
These areas are edged by blue lines.

(2) Land classified as approved game reserves larger than ten acres (i.e. areas approved by the State Executive Council but not yet gazetted).
These areas are edged by broken blue lines.

(3) Land classified as proposed game reserves larger than ten acres [i.e. areas which in accordance with current proposals the department is anxious to see included in category (1) but which have not yet reached the stage of category (2)].
These areas are edged by dotted blue lines.

Veterinary Reserves (Veterinary Department Contribution)

Prepare a map showing the following:

(1) Land gazetted as grazing reserves larger than ten acres.
These areas are edged by green lines.

(2) Land classified as approved grazing reserves larger than ten acres (i.e. areas approved by the State Executive Council but not yet gazetted).
These areas are edged by broken green lines.

(3) Land classified as proposed grazing reserves larger than ten acres [i.e. areas which in accordance with current proposals the department is anxious to see included in category (1) but which have not yet reached the stage of category (2)].

These areas are edged by dotted green lines.

Mineral Resource (Geological Survey and Department of Mines Joint Contribution)

Prepare a map showing the mineral development potential for the entire district sub-divided into four groups as follows:

(1) *Current Mining Land*—Land covered by current mining leases.

(2) *Potential Mining Land*—Land shown by prospecting results or inferred from geological records to contain more than 0.2 kati of cassiterite per cubic yard, or workable surface deposits of other minerals, e.g. iron-ore.

(3) *Possible Mining Land*—Land for which present evidence indicates a possible mineral potential but which needs to be more thoroughly examined before commercial development can take place; or unprospected areas which on geological evidence might contain a mineral potential; or unknown areas.

(4) *Non-Mining Land*—Land which has been prospected and shown to have no mineral potential, or which on geological evidence is unlikely to have any mineral potential.

These areas are edged by purple boundary lines and either shaded purple (Class 1) or hatched with right sloping, purple continuous (Class 2) or broken (Class 3) lines, or left blank (Class 4).

Soil Resource (Department of Agriculture Contribution)

Prepare a map showing the soil suitability for the entire district sub-divided into five groups as follows:

(1) Soils with no limitations to agricultural development.

(2) Soils with few minor limitations to agricultural development.

(3) Soils with at least one serious limitation to agricultural development.

(4) Soils with more than one serious limitation to agricultural development.

(5) Soils with at least one very serious limitation to agricultural development.

These areas are edged by brown boundary lines and hatched with left sloping, brown, continuous (Classes 1 and 2) or broken (Class 3) lines, or left blank (Classes 4 and 5).

Forest Resource (Forest Department Contribution)

Prepare a map showing the forest productivity potential for the entire district, sub-divided into four groups as follows:

(1) Highly productive forest with a basal area of commercial species of at least 50 square feet, or an approximate equivalence of at least 25 tons of round timber per acre.

(2) Productive forest with a basal area of commercial species between 35 and 50 square feet, or an approximate equivalence of 15 to 25 tons of round timber per acre.

(3) Marginal forest with a basal area of commercial species between 20 and 35 square feet, or an approximate equivalence of 10 to 15 tons of round timber per acre.

(4) Unproductive forest with a basal area of commercial species below 20 square feet or an approximate equivalence of less than 10 tons of round timber per acre.

These areas are edged by green boundary lines and hatched with vertical, green, continuous (Classes 1 and 2) or broken (Class 3) lines, or left blank (Class 4). Boundaries of gazetted forest reserves and areas which in accordance with current proposals the department is anxious to see included in the gazetted forest reserve category are also shown, edged respectively by continuous or broken green lines.

Water Resource (Drainage and Irrigation Department, Public Works Department and National Electricity Board Joint Contribution)

Prepare maps showing the following:

(1) Existing catchments, necessary for ensuring an effective water supply for existing schemes, including hydro-electric generation and potable and irrigation water supplies.

These areas are edged by blue lines, and hatched with horizontal blue lines.

(2) Proposed catchments, necessary for ensuring an effective water supply for proposed schemes, including hydro-electric generation and potable and irrigation water supplies.

These areas are edged by blue lines, and hatched with broken horizontal blue lines.

(3) Existing irrigation scheme areas, being areas presently supplied with irrigation water for agricultural purposes.

These areas are edged by red lines and hatched with horizontal red lines.

(4) Proposed irrigation scheme areas, being areas which it is proposed will be supplied with irrigation water for agricultural purposes.

These areas are edged by red lines and hatched with broken horizontal red lines.

(5) Isohytes, showing rainfall depths at 10 inch intervals.

Data Compilation (Natural Resource Capability Section Contribution)

This Section of the Economic Planning Unit is responsible for co-ordinating the work of the contributing departments in respect of the land capability classification programme, and for compiling two series of maps, known as Land Alienation and Gazettement Maps, and Land Capability Classification Maps, to cover each District and State. The Section is also responsible for compiling reports to accompany the maps for each District and State, and for preparing statistical summaries of the planimetric data contained on the contributed maps. The statistical summary is

prepared with the assistance of the mechanical processing section of the Department of Statistics.

(1) Land Alienation and Gazettement Map

This map shows areas of alienated and gazetted land and other present and proposed land use categories; sub-divided into the following groups:

(1) Land alienated for agricultural purposes, including approved applications, and land allocated for agricultural schemes in course of development, but excluding land held on T.O.Ls.

These areas are edged by black lines and hatched with horizontal black lines.

(2) Land alienated for mining, including land covered by mining titles and mining certificates.

These areas are edged by black lines and hatched with broken horizontal black lines.

(3) Land gazetted as Malay Reserve.

These areas are edged by black lines and hatched with broken vertical black lines, and differentiated from the other reserves by the abbreviation MAL.

(4) Land gazetted as Grazing Reserves.

These areas are edged by black lines and hatched with broken vertical black lines, and differentiated from the other reserves by the abbreviation GZG.

(5) Land gazetted as Aborigine Reserves.

These areas are edged by black lines and hatched with broken vertical black lines, and differentiated from other reserves by the abbreviation ABO.

(6) Land gazetted as Forest Reserves.

These areas are edged by black lines and hatched with broken vertical black lines, and differentiated from the other reserves by the abbreviation FOR.

(7) Land gazetted as Game Reserves.

These areas are edged by black lines and hatched with broken vertical black lines, and differentiated from the other reserves by the abbreviation GME.

(8) Land alienated on Town Land Title or Village Land Title, or utilised for other non-agricultural or non-mining purposes, including approved applications but excluding land held on T.O.Ls.

These areas are edged by black lines and hatched with a pattern of horizontal and vertical black lines.

(9) State Land, being those areas not alienated or gazetted or reserved for special purposes and shown in other categories of this classification.

These areas are left blank.

(2) Land Capability Classification Map

This map shows the relative capability of the land for mining, agriculture, productive forestry, protective forestry or other conservation use purposes, in a simple classification. The boundaries are derived from equivalent boundaries on the contributed resource maps for minerals, soils, and forests.

Class I—Land possessing a high potential for mineral development and therefore best suited to mining.

Class II—Land possessing a high potential for agricultural development with a wide range of crops and therefore best suited to diversification agriculture.

Class III—Land possessing a moderate potential for agricultural development with a restricted range of crops and therefore best suited to agricultural development with crops having a wide range of soil tolerance.

Class IV—Land possessing a potential for productive forest development and therefore best suited to commercial timber exploitation.

Class V—Land possessing little or no mineral, agricultural, or forest development potential but suitable for development as protective reserves for conservation, water catchment, game, recreation, or similar purpose, or possibly suitable in the future for productive forest plantations with introduced species.

The land alienation and gazettement map and the land capability map are both prepared on a scale of one inch to a mile and copies are distributed to the State and District Development Committees. Reduced copies, on a scale of one inch to four miles, are also prepared for inclusion in the Land Capability Classification Report.

The land capability classification map is reproduced as a transparent overlay to the land alienation and gazettement map, to facilitate comparison between the capability and the present use of the land.

(3) Land Capability Classification Report

The Report summarises the data shown on the maps and discusses the development opportunities which exist in the district. Liaison officers in the resource survey departments contribute material to this report, which is edited by the co-ordinator.

(4) Statistical Summary of Planimetric Data

The alienation, gazettement, proposed land use, and resource maps which comprise the basic data of the Land Capability Classification programme are a most valuable source of information concerning the present and proposed use of the land and the potentiality in respect of minerals, soils, forests, and water. This information is presented on the maps in the form of curved lines for the resource data, reflecting the natural boundaries of the mineral, soil and forest types, and usually in the form of an intricate pattern of straight line boundaries for the alienation, gazettement and proposed land use data, reflecting the cadastral survey boundaries of the alienated and gazetted land areas.

A knowledge of the areas covered by the different land alienation and resource classes is very useful for surveying, development planning and administrative purposes, and where the pattern is relatively simple, and free of overlapping boundaries, as is usually the case on a single map, the area can be determined by the

usual method of planimetric measurement. However, it is often desirable to have planimetric data for land categories made up of a combination of land use and resource qualities, which must be obtained by measurement from several maps. In such cases the boundaries of the different categories overlap and if all these lines were to be superimposed on one map the pattern would consist of an indecipherable maze of small irregular shaped units which would defy measurement by planimeter. Fortunately, mechanical data processing methods, using punch cards, can be used for this task, and a numerical code which takes account of all the land use and resource categories shown on the contributed maps is applied to each district in turn.

Advantage is taken of the fact that the one inch topographical map series for West Malaysia has a uniform grid superimposed on the maps dividing the country into 1,000 yard grid squares. The intersection points of the squares are used as the data recording positions and the quality of the land at each point is read off from the different land alienation and resource maps and recorded on punch cards for mechanical processing. By this method of systematic line sampling the area of any combination of categories shown on the maps can be assembled for individual mukims, for districts, for states, and for the nation as a whole.

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Supplement to:

LAND CAPABILITY CLASSIFICATION IN WEST MALAYSIA

AN EXPLANATORY HANDBOOK, 1967

As a result of experience gained during the early stages of the Land Capability Classification Programme, revisions have been made to the mineral, forest, and land capability classifications, which now read as follows:

Revised Mineral Resource Classification (Geological Survey and Department of Mines Joint Contribution)

(1) Probable mining land as deduced from prospecting results and geological evidence.

(2) Areas under mining lease or certificate, or areas in which active mining is taking place.

(3) Possible mining land as deduced from geological evidence.

(4) Areas which on geological evidence might contain mineral deposits.

(5) Areas for which no geological or other information is available.

(6) Non-mining land.

Revised Forest Resource Classification (Forest Department Contribution)

(1) Treated or regenerated forest or a forest plantation.

(1M) Productive Mangrove Forests.

(2A) Forest of high potential productivity with a basal area of all species of at least 80 sq. ft. or an equivalent volume of 64 tons round timber, including at least 50 sq. ft. or an equivalent volume of 40 tons round timber of commercial species per acre.

(2B) Forest of high potential productivity with a basal area of all species of at least 80 sq. ft. or an equivalent volume of 64 tons round timber, but including less than 50 sq. ft. or an equivalent volume of 40 tons round timber of commercial species per acre.

(3A) Forest of average potential productivity with a basal area of all species of 60-80 sq. ft. or an equivalent volume of 48-64 tons round timber, including at least 35 sq. ft. or an equivalent volume of 28 tons round timber of commercial species per acre.

(3B) Forest of average potential productivity with a basal area of all species of 60-80 sq. ft. or an equivalent volume of 48-64 tons round timber, but including less than 35 sq. ft. or an equivalent volume of 28 tons round timber of commercial species per acre.

(4A) Forest of marginal productivity with a basal area of all species of 40-60 sq. ft. or an equivalent volume of 32-48 tons round timber, including at least 20 sq. ft. or an equivalent volume of 16 tons round timber of commercial species per acre.

(4B) Forest of marginal productivity with a basal area of all species of 40-60 sq. ft. or an equivalent volume of 32-48 tons round timber, but including less than 20 sq. ft. or an equivalent volume of 16 tons round timber of commercial species per acre.

(5) Forest of limited potential productivity with a basal area of all species of less than 40 sq. ft. or an equivalent volume of 32 tons per acre.

(5M) Unproductive Mangrove Forests.

NOTE—

1. "Commercial" species are those included in Classes A to C of the Forest Department Linear Sampling (L.S.) List of Species.
2. Sub-classes "A" tend to have a higher economic value at present than Sub-classes "B".
3. Tonnage figures are gross estimates without allowance for defects.

Revised Land Capability Classification

Class I ... Land possessing a high potential for possible mineral development.

Class II ... Land possessing a high potential for possible agricultural development with a wide range of crops.

Class III ... Land possessing a moderate potential for possible agricultural development, because of a limitation in the range of crops.

Class IV ... Land possessing a high potential for possible productive forest development.

Class V ... Land possessing little or no mineral, agricultural or productive forest development potential, but suitable for possible alternative development purposes, such as protective forest reserves, water catchment areas, game reserves, recreation areas, etc.

These new classifications will apply for Land Capability Classification studies carried out during the First Malaysia Plan period in all States, except Pahang, Johore and Malacca, for which the earlier classifications apply.

Present Land Use (Department of Agriculture and Directorate of National Mapping Joint Contribution)

In addition to the foregoing, a present land use survey has recently been initiated. This survey involves the preparation of maps showing land use detail interpreted from 1:25,000 aerial photography exposed in 1966, according to the following classification:

(1) Urban and Associated Areas (1U).
(2) Estate Buildings and Associated Areas (1E).
(3) Tin Mining Areas (1T).
(4) Other Mining Areas (1X).
(5) Power Line Right of Ways (1P).
(6) Market Gardening (2M).
(7) Mixed Horticulture (2H).
(8) Agricultural Stations (2E).
(9) Rubber (3G).
(10) Oil Palm (3O).
(11) Coconut (3C).
(12) Pineapple (3N).
(13) Coffee (3K).
(14) Tea (3T).
(15) Cocoa (3A).
(16) Pepper (3P).
(17) Sago (3S).
(18) Banana (3B).
(19) Fibre Crops (3F).

(20) Orchards—(Rambutans, Durians, Citrus, Cloves, Nutmegs, etc.) (3X).
(21) Fish and Hyacinth Ponds (3H).
(22) Annual or Diversified Crops (4C).
(23) Padi (4P).
(24) Shifting Cultivation (4X).
(25) Improved Permanent Pasture (5).
(26) Lalang, Unimproved Coarse Pasture and Scrub-Grassland (6).
(27) Forest (7F).
(28) Scrub (7S).
(29) Cleared Land (7C).
(30) Swamp, Marshland and Wetland Forests (8).
(31) Unproductive Land (9).
(32) Unclassified (10).

These areas are differentiated on the maps by the symbols shown in brackets above. The land use maps are compiled and published on a scale of 1:25,000, and not 1:63,360 as is the case with the other land capability classification programme data described in the handbook.

Revised Report Presentation

With the exception of Pahang, for which separate reports for each district were prepared, land capability classification reports for the States in West Malaysia are in the form of comprehensive reports for each State, and these reports include statistical information derived from the contributed data.

Revised Map Presentation

With the exception of the reports for Pahang which have been completed, other State reports may include mineral, soil and forest resource maps on a scale of four miles to an inch in addition to, or instead of a land capability classification map, wherever it is considered that the additional information provided will be of use to facilitate development planning.

This method of presentation will enable areas of resource use conflict to be more readily identified, and thus aid in the identification of regions where further investigation, feasibility studies, etc., will have to be carried out. In addition, areas only suitable for one particular resource development purpose can be more fully delineated.

ECONOMIC PLANNING UNIT,
PRIME MINISTER'S DEPARTMENT,
MALAYSIA
17th October, 1967

JABATAN CHETAK KERAJAAN, KUALA LUMPUR
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Malaysian Soil Conference, 1966
... Kuala Lumpur

THE CLASSIFICATION AND EVALUATION OF LAND IN SARAWAK.

by

J.P. Andriesse

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1. INTRODUCTION

The ultimate aim of the Sarawak Soil Survey Division as in most countries is to assess the agricultural value of the soil and present such assessments in specific and well defined terms. For this purpose a standard evaluation system is necessary. Such systems are generally called Land Classifications.

Land Classifications are invaluable not only because they interpret complex technical information into simple terms of agricultural usefulness which is of immediate value to planning authorities, but also because they reveal more clearly which limitations for agricultural development are the most serious so that research can be directed towards possible remedies.

In Sarawak during the last 20 years a variety of land evaluation systems for different purposes have appeared on the scene. Many of these concern specific types of land classification while others have little or nothing in common with proper evaluation systems and their existence only adds to the confusion.

The purpose of this paper is to review the land classification systems used in Sarawak, to evaluate their usefulness, and to suggest what system would best serve the present requirements of agricultural development. The basic principles on which such a system could be developed are discussed.

2. TYPES OF LAND CLASSIFICATION

The Bureau of Reclamation Manual of the U.S. Dept. of the Interior (1953, part 2, p.3) defines Land Classification as follows:

> 'Land classification is the systematic appraisal of lands and their designation by categories on the basic of similar characteristics.'

There are many kinds of such classifications serving many different purposes. The Land Committee of the U.N. Resources Planning Board recognises the following categories:

I. Land Classification in Terms of Inherent Characteristics.
II. Land Classification in Terms of Present Use.
III. Land Classification in Terms of Use Capabilities.
IV. Land Classification in Terms of Recommended Use.
V. Land Classification in Terms of Programme Effectuation.

(F.A.O. Dev. Paper No.18, 1952, p.8).

Table 1

Class 1: Land which is flat or almost flat. There is no appreciable amplitude of relief. Some of the best agricultural land falls within this Class but it also includes peat swamps.

Class 2: Land with up to 150 feet amplitude of relief but not more than 10° slope.

Class 3: Land with an amplitude of relief greater than 150 feet but slopes not exceeding 20°.

Class 4: Land with less than 50 feet amplitude of relief but slopes of $10 - 35^{\circ}$.

Class 5: Land with an amplitude of relief of 50 - 150 feet and slopes of $10 - 20^{\circ}$.

Class 6: Land with an amplitude of relief of 50 - 150 feet and slopes of $20 - 35^{\circ}$.

Land in Class 1 - 6 is considered - on the grounds of topography - to be suitable for agriculture.

Class 7: Land with an amplitude of relief in excess of 150 feet and slopes of $20 - 35^{\circ}$. Land in this Class is considered marginal for agriculture.

Class 8: All land, regardless of amplitude of relief, in which slopes are greater than 35°. Such land is considered unsuitable for agriculture.

1. Land Classification in Terms of Inherent Characteristics

An example of the first type is a slope map prepared from contour data. Such maps have been made by the Soil Survey Division of Sarawak as an aid to soil mapping. Geological maps and soil maps belong also to this category. All such maps, by themselves tell nothing about the present use of the land, nor the usefulness of it, nor do they make recommendations of any kind. In an endeavour to partly overcome this shortcoming in Sarawak a system which classifies the terrain into 8 units by using slope and elevation as classifying factors was developed by the Soil Survey Division so that the usefulness of the terrain for agricultural development could be shown. Table 1 give the key for this system. It has proved useful for making a quick appraisal of the topographic value of land for agricultural use.

II. Land Classification in Terms of Present Use.

Land Classifications of this category divide the land in a system of classes or units based on existing use. An example of such a classification is the Land Use Map issued by the Lands and Surveys Department in 1956 (Sarawak Series No.10) which shows a division into cultivation systems (permanent and shifting) and a classification of natural forest types. In a well-developed agricultural country such a map, read against the background of a map of the first category would perhaps give most useful information on the value of certain soil types or land types for certain crops. In these countries there is commonly a close relation between land potential and land use. In a less-developed country this may not be so. Shifting cultivation practises in Sarawak are not normally related to the natural conditions although to some extent this may be the case. Slope, for example, may be a limiting factor in shifting cultivation as may be soil with very poor inherent characteristics. These limits however far exceed those set for a permanent cultivation system which is designed not only to produce crops economically but also to conserve land resources. Therefore, although a Land Use map serves some purpose its indicative value for soil fertility is limited in Sarawak since other factors such as accessibility and availability of land to certain groups of the community have been important in the development of the land-use pattern.

Although these maps are useful they nevertheless do not evaluate land and soil for agriculture.

III. Land Classification in Terms of Use Capabilities

Classifications of the third type predict the results that would follow if the land is used for a certain purpose. There are many types of this classification. More often then not such classifications are the result of a syntheses of maps of the two first mentioned categories and classification units are usually based on soil types or soil mapping units.

It is in this type of classification that the results of soil surveys can be fully employed. We distinguish for instance the Soil Quality maps which aims at the grouping of soils from a technical standpoint, that is the technical qualities important for a certain use of the soils or for their improvement (Vink 1963, p.47). These qualities may be varied and range from erosion hazard, suceptibility to flooding, and

Table 2

Example of a Soil Map key showing soil types with Tentative Agricultural Suitability, as used in Sarawak.

GREAT SOIL GROUP	MAPPING UNIT	ACREAGE	MAIN CHARACTERISTICS	SUITABILITY
Red-Yellow Podsolics (Upland members)	[Mrt] Merit family drainage phase 1	1870	Moderately well drained, generally shallow (less than 30 inches deep), weakly mottled, fine textured soils.	Suitable for rubber and with good management for pepper.
	[Mrt] Merit family drainage phase 2	107	Imperfectly drained, generally shallow, strongly mottled, fine textured soils.	Suitable for rubber. Drainage needed in flat terrain.
	[Bkn] Bekenu family drainage phase 1	310	Moderately well drained, generally shallow heavy loamy soils; weakly mottled.	Suitable for rubber and with good management for pepper.
	[Bkn] Bekenu family drainage phase 2	23	Imperfectly drained, generally shallow, heavy loam soils; strongly mottled.	Suitable for rubber. Drainage needed in flat terrain.
Grey-White Podsolics and Podsols.	[Srt/Bso] Saratok/ Buso family association	25	Saratok: gravelly loamy sands to sandy loams, porous, podsolised. Buso: gravelly loamy sands to sandy loams with strong podsol features and poor drainage.	Unsuitable for rubber and in general for agriculture.
Red-Yellow Podsolics (Lowland members)	[Sdu] Seduau family	44	Moderately well drained to imperfectly drained heavy loams with strong mottling in lower subsoils. Frequently overlying poorly drained shales.	Suitable for rubber and if irrigated for wet padi cultivation.
Recent Alluvium	[Trb] Terbat family	18	Well drained, dark brown to heavy loams overlying boulders.	Suitable for rubber and fruit trees, off-season crops and vegetables. Certain places need drainage. Flooding during wet season is main limitation.
Low Humic Gley Soils	[Bjt] Bijat family	82	Poorly drained, fine textured soils with strong hydromorphic features such as gleying. Water table generally within 24 inches from surface.	Unsuitable for rubber if drainage is not feasible. Suitable for wet padi cultivation with proper water control.
a	Steep land with slopes over 30 degrees comprising mainly parts of Merit and Bekenu soils (95 acres out of 2180 acres)			Unsuitable for rubber because of susceptibility to erosion.

(according to Soil Survey Report 44/2, 65)

permeability. Another type is the Crop Response map indicating the response of a crop on a certain soil type to a certain management (Vink, 1963, p.47). The most important classification of this nature however is the Soil Suitability or Soil Capability Classification which is defined by Klingebiel as: 'the grouping of individual kinds of soil - called mapping units - into groups of similar soils depending on the intended use - called capability units' (1950, p.160). In this kind of classification the limitations to general crop growth or cultivation systems are evaluated by using the natural soil units as a basis for classification. It gives no recommendations in terms of specific crops but only general indications of the most appropriate form of agriculture.

In Sarawak many tentative soil suitability or soil capability classifications have been prepared for different areas, as it was realised that, if the soil map is to be of value to the user some form of interpretation is necessary. In many instances a column has therefore been added to the key of the soil map indicating the tentative suitability of each mapping unit for agriculture. An example of such a key is given in Table 2.

Classifications of this type in Sarawak only satisfy the needs of the particular survey. Although they make the soil map more useful, they do not objectively classify soil capability. They lie between soil capability classifications and advisory classifications, and more often than not the map user forgets about the 'tentative' nature of the classification and takes the suitability rating as final.

It is important to note that these types of land classification, even though they may indicate the optimum use still do not constitute a recommendation as to the actual land use. It should be borne in mind that these classifications are made primarily with the object in mind to maintain the fertility level and the present conditions of the land and if possible to improve it. Soil improvement and soil conservation, although in the long run being part of the accumulation of capital in the form of natural resources, are commonly not the primary aim of the landuser. For them the purpose of land use is production, possibly on a high and sustained level and they therefore have neither the motive nor in most cases the means for the safeguarding of natural resources unless earnings from the land are sufficient.

One may mention the case, common in Sarawak, of a farmer using shallow soil on very steep slopes for profitable cultivation of pepper because apart from slope soil conditions are favourable. Pepper cultivation requires clean weeding and terracing is normally not done. Both factors accellerate erosion. Although the farmer may accumulate some wealth within a short time by adopting such a method he is ruining land which could be used almost indefinitely - but with a slower return - for a permanent tree crop.

Soil capability classifications are not therefore a grouping of soils according to the most profitable use to be made of the land from the farmers point of view, and economics are not considered in the compilation of maps of this nature. Classifications taking these factors into account are discussed next.

IV. Land Classifications in Terms of Recommended Use

Classifications in this category are Economic Land Use Classifications and Advisory Land Use Classifications. For the compilation of such classification maps it is necessary not only to study the capacity of the land to produce income but to study, with equal stress, the economic and environmental factors in relation to the crops to be grown. Such maps are in fact the result of long-term agronomy studies, economic research and accumulated experience.

Most of the information required for the compilation of such maps is not available in Sarawak, this being the reason why no attempt has been made to make such maps. However such an undertaking should not be the work of soil surveyors alone, because complex economic and social factors are involved. It may be noted that such work is partly outside the scope of the soil surveyor as has been nicely put by Vink (1963, p.48) as follows:

'The best use of the soil is not only a question of the soil itself, but of various social, political and economic considerations. Sometimes even religious considerations come to the fore, such as the possibility of keeping pigs in a predominantly Islamic country. The soil surveyor must concern himself with soil suitability, and should be very careful not to put himself in the chair of the administrator'.

V. Classifications in Terms of Programme Effectuation.

Such classifications are more than an evaluation or a recommendation. They are plans showing what will be done with the land and are based on Land Evaluation Maps and recommended Land Use Maps. Planting programmes on estates are in this category. Maps showing land subject to different rates of taxation are in this category as are maps showing planned subdivisions of agricultural land and urban area land.

For certain parts of Sarawak, maps of the latter kind are used by the Land Authorities, but they have not always been based on sound principles of land use.

Apart from the classification systems just described, there is one type of Land Classification in Sarawak, perhaps that with the longest history, which has not yet been mentioned. This is a Land Classification based partly on existing ownership in rights and partly on a planned land policy. In Sarawak such maps show a division in Native Customary Right Land, Native Reserve Land, Forest- and Government Reserves, Mixed Zone land and Interior Land. Mixed Zone Land is land which people other than natives are allowed to own. This classification bears no relation to any kind of land evaluation but is mentioned here since land ownership has, in Sarawak, a considerable effect on land use.

At present the Mixed Zone Land is almost all covered by permanent cultivation while Native Customary Right Land is, in the main, still used for shifting cultivation. Since the mixed zone areas were never selected on the basis of land suitability for permanent cropping the result in some places has been overfarming of the land and subsequent deterioration. In other places this is not the case. Also soils of basically inferior capacity have in some localities proved to be able to support economic holdings. A study of the reasons for these trends in the mixed zone land could prove to be of tremendous value for further land development in Sarawak for permanent cropping.

3. DISCUSSION

This review of existing types of land classification shows that Sarawak lacks useful Land Classification maps which would show the planners and administrators what to expect from the available land resources. Although a variety of classifications have been made for different areas, none of them are based on a system which defines in clear standardised terms what can be expected of the land when used and which can be employed throughout Sarawak.

Such a classification would be of the greatest practical value. Soil surveyors in Sarawak are frequently called upon to prepare maps showing recommended land use. The sound compilation of such maps is impossible at present because of lack in economic data. However, in a developing country such ad hoc recommendations are sometimes necessary but they are extremely dangerous because the soil surveyor does not know, all the economic factors involved.

For a considerable time to come recommendations or advice of this nature will, however, have to be given even though they will be based on meagre information. It is suggested that a sound system of evaluating basic soil properties or soil capabilities be developed. Recommendations could then be based on sound scientific appraisals of soil and land values and could be employed throughout the country. It is realised that the final selection of crops will still remain a difficult problem but with a proper land capability or soil capability classification it will at least be possible to give the alternatives from which a selection can be made by the planning authorities.

The first serious attempt in this direction was recently made by the Sarawak Land and Survey Department who in following discussions with the Soil Survey Division compiled an approximation to a Land Suitability Classification for Agriculture in Sarawak. The key to this Classification is given in Table 3.

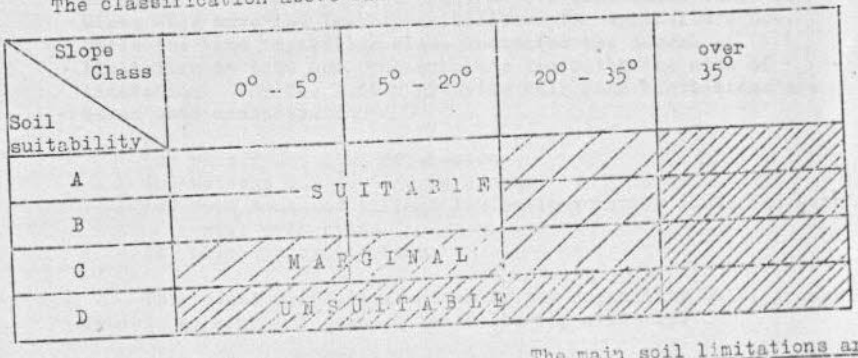
For assisting development planning, Sarawak is at present in need for a quick broad appraisal of all available land resources and this key had to be prepared as an interim measure since no time could be lost by too much deliberation. It can readily be seen that this classification is heavily leaning on land characteristics rather than soil characteristics, and although most soil limitations are mentioned, slope is the main one used for the separation of the various classes. Since this system was meant to cover the whole of Sarawak the other soil limitations could not be employed in full in this system because this would have required a soil survey cover of the whole of Sarawak which is not available at present.

Table 3

Land suitability classification for Agriculture in Sarawak

CLASSES	DEFINITIONS	SUITABILITY FOR AGRICULTURE
I	Flat to gently undulating terrain with slopes less than 5°.	Suitable for agriculture. Risk of flooding may exist.
II	Gently low-lying to moderately dissected hilly terrain with slopes less than 20° (including some hills less than 50 feet high with some slopes between 20 - 35°) Soil with no or few severe limitations.	Suitable for agriculture. But soil conservation measures needed on the steeper slopes.
III	Gently undulating to hilly terrain (slopes less than 20°) with soil with several severe limitations.	Marginally suitable for agriculture due to adverse soil factors. Expensive soil improvements needed.
IV	Strongly dissected terrain with slopes generally between 20-30°. Soil with no or few severe limitations.	Marginally suitable for agriculture owing to extreme danger of erosion. Very expensive soil conservation measures required.
V	Flat to gently undulating terrain with many severe soil limitations (mainly mangrove, nipah and peat swamp areas). Rugged country with slopes exceeding 35° in general; or with slopes of less than 35° occupied with soil with many severe limitations.	Not suitable for agriculture at present owing to adverse soil factors. Unsuitable for agriculture.

The classification above can be diagrammatically shown below:



Soil Suitable Classes:

A. No severe soil limitations

B. Few severe soil limitations

C. Several severe soil limitations

D. Many severe soil limitations.

The main soil limitations are:

a) fertility; b) rooting dep

c) salinity; d) flooding;

e) susceptibility to erosion.

The result is that areas without soil survey cover are classified on slopes only while areas which have a soil survey cover are classified on other factors as well. Apart from that the number of soil limitations and not the seriousness of a single soil limitation was used as a classifying factor so that soils having only one limitation are in this system placed at high level of suitability even if that limitation is sufficiently sever to render the soil completely unsuitable for agriculture.

Although having many shortcomings this system indicates with reasonable accuracy the areas which are definitely unsuitable for agriculture because of topographic features while the areas of Classes I to IV can still contain land which on account of adverse soil properties must be regarded as unsuitable. It enables development planners to concentrate their efforts on land-classes 1 to 4, and it will be the task of the Soil Survey Division to investigate these classes in more detail.

It is realised that this system is unsuited for permanent use and should be replaced by a more comprehensive one for which we have an excellent example in the Land Capability Classification worked out by the U.S. Soil Conservation Service (Agricultural Handbook No.61, 1954).

This Classification system has served as an example for many similar ones in other countries but needs modifying to serve local conditions.

4. THE U.S. LAND CAPABILITY CLASSIFICATION

A broad outline of the U.S. system is given in table 4. Land is classified at three levels, firstly in eight capability classes, secondly each class is subdivided into subclasses. At the lowest level of classification the subclasses are again subdivided into capability units.

The capability classes are set up in such a way that soils in Class I have the greatest alternative uses while those of Class VIII have the least possibilities for agriculture use. While the land capability class indicates the degree of limitation in land use, the subclass indicates the kind of limitation. For the latter grouping only four limitations are taken into consideration:

(e) runoff and risk of erosion
(w) wetness and need for drainage
(s) root zone and tillage limitations mainly connected with soil properties
(c) climatic limitations.

The lowest classification unit, the capability unit, groups individual kinds of soil on the following criteria:

1. Kinds and amounts of crops that can be grown successfully under a specified level of management
2. The ability of the soil to respond to management
3. Kind and amount of treatment required for soil conservation.

The capability unit should essentially be uniform in major characteristics.

Table 4

Outline of the U.S. Land-capability classification

Land use suitability (broad grouping)	Land-capability class (degree of limitations for use)	Land-capability subclass (grouped according to kind of limitations; shows examples only)	Land-capability unit (land management groups based on physical characteristics; shows examples only)
Suited for cultivation	I Few limitations. Wide latitude for use. Very good land. (Green on coloured map)	e Use in limited by moderate hazards of water or wind erosion	Moderately sloping, slightly acid soils on limestone.
	II Moderate limitations in use. Good land (Yellow)	c Climate	Moderately sloping, high acid soils on sandstone or shale.
	III Severe limitations in use. Regular cultivation possible if hazards are provided against. Moderately good land. (Red).	w Use in limited by excess water; drainage needed for cultivation	Imperfectly drained acid soils. Poorly drained neutral soils.
	IV Very severe limitations in use. Suited for occasional cultivation or for some kind of limited cultivated. (Blue)	s Use is limited by low water-holding capacity or by low plant-nutrient content	Sandy, rapidly permeable soils.
Not suited for cultivation.	V Not suited for cultivation because of wetness, stoniness, overflows, etc. Few limitations on use for grazing or forestry. (Dark green)	Grouping of sites according to kind of limitation	Sites significant in management of ranges, pastures, forests, etc.
	VI Too steep, stony, dry, wet, etc., for cultivation. Moderate limitations on use for grazing or forestry. (Orange)		
	VII Very steep, rough, dry, wet, etc. Severe limitations on use for grazing or forestry. (Brown)		
	VIII. Extremely rough, dry, swampy, etc. Not suited for cultivation, grazing or forestry Suited for wildlife, watershed protection, or recreation. (Purple).		

The factors used for arriving at a capability rating in this scheme are, except for the climate, collected in the field. In order to be able to judge the value of these factors with a view to local conditions the full range according to the U.S. Soil Conservation Handbook No.61 is given:

a. Effective depth of soil (as depth over rock, tough clay or hardpan)

Very deep	60 inches or more
Deep	36 - 60 inches
moderately deep	20 - 36 inches
shallow	10 - 20 inches
very shallow	0 - 10 inches

b. Texture of surface soil (fineness of constituent particles)

Very heavy	- heavy clay - (60 per cent or more 2-micron clay particles)
Heavy	- clay, silty clay, sandy clay
Moderately heavy	- silty clay loam, clay loam, sandy clay loam
Medium	- silt loam, loam, very fine sandy loam
Moderately light	- sandy loam, fine sandy loam
Light	- loamy fine sand, loam sand
Very light	- sand, coarse sand.

c. Permeability of subsoil

Very slow	- less than 0.05 inch of water percolation per hour
Slow	- 0.5 to 0.20
Moderately slow	- 0.20 to 0.80
Moderate	- 0.80 to 2.50
Moderately rapid	- 2.50 to 5.00
Rapid	- 5.00 to 10.00
Very rapid	- 10.00 or more

d. Permeability of substratum

Very slow	- less than 0.05 inch of water percolation per hour
Slow	- 0.05 to 0.20
Moderately slow	- 0.20 to 0.80
Moderate	- 0.80 to 2.50
Moderately rapid	- 2.50 to 5.00
Rapid	- 5.00 to 10.00
Very rapid	- 10.00 or more

e. Thickness of surface soil

	6 inches
Thin	- 0.6 inches
Moderately thick	- 6 to 12
Thick	- 12 to 24
Very thick	- 24 to 36

f. Available moisture capacity (inches of absorbed water per 60 inches of soil depth)

Very high	- 12 inches or more
High	- 9 to 12
Moderate	- 6 to 9
Low	- 3 to 6
Very low	- less than 3

g. Reaction

Acid	- 6.5 pH or less
neutral	- 6.6 to 7.3 pH
alkaline	- 7.4 pH or more

h. Natural soil drainage

Well drained	- well oxidized and free from mottling of colours in surface and subsoil.
moderately well drained	- well oxidized and free from mottling except in lower part of subsoil.
imperfectly drained or somewhat poorly drained.	- well oxidized surface, subsoil mottled.
poorly drained	- gray colour, mottling in surface and subsoil
very poorly drained	- dark surface soil and gray or mottled subsoil.

i. Inherent fertility

High
Moderate
Low
Very low

j. Organic Content

High
Medium
Low

k. Slope

Nearly level
Gently sloping
Moderately sloping
Strongly sloping
Steep
Very steep

l. Erosion

No apparent or slight
Moderate
Severe
Very severe
Very severely gullied land

m. Wetness

Slightly wet	- growth of crops slightly affected or planting dates delayed for brief periods, as less than a week
Moderately wet	- growth of crops moderately affected or planting dates delayed by a week or so
Very wet	- growth of crops seriously affected, or planting delayed as much as a month or more
Extremely wet	- swamp, marsh, too wet for cultivated crops or improved pastures.

n. Salinity

Slight	- crops yields slightly affected or range of crops slightly limited
Moderate	- crop yields moderately affected, or range of crops moderately limited
Severe	- crop yields seriously affected, or range of crops severely restricted
Very severe	- growth of useful vegetation prohibited except some salt-tolerant forms.

o. Frequency of overflow

Occasional overflows or overflows of short duration	- crops occasionally damaged, or planting dates delayed;
Frequent damaging overflows or overflows of long duration	- crops frequently damaged, or range of crops limited
Very frequent overflows, or overflows of very long duration.	- not feasible for cultivated crops

5. DISCUSSION OF BASIC PRINCIPLES FOR MODIFYING THE UNITED STATES LAND CAPABILITY SYSTEM.

1. Classes - In analysing the system outlined in the previous section a few major characteristics become apparent, namely:

a. It is mainly geared at classifying land for the cultivation of annual crops and soil factors are evaluated on this assumption.

b. The degree of limitation is classified with a view to mechanised farming and United States soil conservation requirements in relation to the climatic range within the United States.

To modify this system, considerable thought must therefore be given firstly to the types of cultivation of major importance in this region and secondly to our crops and soil requirements thereof and thirdly to the local climate in relation to soil conservation.

It is suggested

that since tree crops form a major part of the crops grown here there should not be 4 classes for Land unsuitable for agriculture,
that a division into 7 classes is sufficient to suit local condition,
that the interpretation of the definitions should be geared to express suitability to local cultivation systems,
that the degree of limitation should be rated with a view to local climatic conditions and crops normally grown in this region.

In order to achieve this the classifying factors listed in the foregoing section should first be evaluated for local conditions.

The following modifications are therefore suggested:

a. Effective depth of soil

To retain the subdivisions, but to keep in mind that tough clay is not a limitation in growing rubber.

b. Texture of surface soil

To rep ace this by a system taking the texture range of the whole profile into account since this is important for tree crops. Also surface textures vary widely over small areas in Sarawak.

c. Permeability of subsoil

To omit. This information is impossible to collect without detailed work and special equipment.

d. Permeability of saturations

To omit for reasons given under c.

e. Thickness of surface soil

To omit. See 'b'

f. Available moisture capacity

To omit, since it is impossible to collect this data without detailed work and it is not regarded as essential data in the Sarawak climate.

g. Reaction

To insert more groups in the acid range and the groups should be redefined considering that most tropical soils are acid. Suggested groups are:

Alkaline pH	7
Neutral pH	6 - 7
Weakly acid	6 - 5
Acid	5 - 4
Strongly acid	4

(pH concerns topsoils).

h. Natural soil drainage

To retain in full

i. Inherent fertility

To retain; but subdivisions should be based on C.E.C., base saturation, P value, and mineral reserve. Satisfactory grouping has to await more results from agronomy work since the exact relation between those factors and actual crop response is at present not known.

j. Organic content

To omit, since this is under local conditions of a non-permanent nature. To be substituted by:

Depth of organic horizons (35% loss on ignition)

shallow	- 0 to 10 inches
moderately deep	- 10 to 40 inches
deep	- more than 40 inches

k. Slope

To be retained but the following definitions are suggested

Nearly level	- 0 to 2°	Strongly sloping	- 10 to 15°
Gently sloping	- 2 to 5°	Steep	- 15 to 25°
Moderately sloping	- 5 to 10°	Very steep	- over 25°

l. Erosion

To be retained but classes need re-definition to suit local erosion hazards in relation to climate. Suggested divisions are:

1. Non gullied
2. Slight - few, shallow gullies, stable slopes
3. Moderate - few deep gullies, few landslides, - moderately stable slopes
4. Severe - many deep gullies, landslides common, unstable slopes
5. Very severe - severely gullied land, many landslides, very unstable slopes.

m. Wetness

To be replaced by the following suggested division

1. Slightly wet	- topsoil at saturation point only immediately after rain.
2. Moderately wet	- topsoil at saturation point for some period after rain.
3. Wet	- topsoil at saturation point throughout wet season.
4. Very wet	- topsoil at saturation point for most of the year.
5. Extremely wet	- submerged for most of the year.

n. Salinity

To be maintained with a change in definition of classes. Emphasis should be on Exchangeable Sodium and soluble Sodium content but at present in Sarawak electric conductivity of groundwater is the only practical means of measuring salinity. With this in mind, suggested classes are:

Non saline	- groundwater below 500 micromhos/cm at 25°C.
Weakly saline	- groundwater 500-4,000 micromhos/cm at 25°C, in dry season. Below 500 in wet season.
Moderately saline	- groundwater 500-4,000 micromhos/cm at 25°C, throughout the year.
Strongly saline	- groundwater 500-4,000 micromhos/cm at 25°C. during wet season, >4,000 in dry season.
Severely saline	- >4,000 micromhos/cm at 25°C. throughout the year.

o. Frequency of overflow

To be retained but called 'liability to flooding' and with a change in definition of classes. Suggested classes are:

1. Non-flooded
2. Occasional floods of short duration
3. Frequent floods of short duration
4. Occasional floods of long duration
5. Frequent floods of long duration

It is further suggested that the factor 'climate' should be abolished. In the United States Land Capability Classification this factor is regarded as important in relation to erosion hazard and land conservation measures but from this viewpoint climate is uniform for most areas in Sarawak. This factor should however be considered in selecting specific crops at high altitudes in a possible recommended Land Use Classification.

To suit local purposes, the sixteen classification factors of the United States' system can therefore be reduced to eleven.

In using these factors for placing soil units in the capability classes two considerations are of major importance. Firstly Klingebiel (1958, p.161) in analysing capability groupings in the United States recognizes the fact that differences in management or yields of perennial crops may be greater between soils within one class than between classes. In Sarawak this should be avoided as much as possible since tree crops are here more important than annuals. Secondly Klingebiel (op.cit.p.161) states that in the United States only the continuing limitations are classified meaning that where it is feasible to remove non-continuing limitations such as water, stones, excess salts etc., they are not being considered in the capability ratings. The removal of these non-continuing limitations are quite important in Sarawak from an economic point of view and it would be unrealistic not to consider them. Since we can normally not judge whether amelioration is within economic means it is suggested that in all cases Land should be classified on its present state.

Little attention has been given to the importance of chemical fertility in the United States, presumably because it is considered to be a non-continuing limitation which can be easily altered by fertilization. Factors related to response of fertilizer treatment are regarded as more important. This was also recognised by Baeyens (1959, p.102) who in connection with the evaluation of tropical soils in Central Africa considers that the chemical characteristics of a soil are least important since a soil under a favourable climate and possessing optimal physical and hydrological value is fertile, even when its percentage content of nutritive material is low. This may be open to question but the author is of the opinion that this can in general be confirmed by the behaviour of soils in Sarawak.

After taking into account these considerations it is possible to show in a diagrammatic form the minimum requirements of the capability classes distinguished in the modified scheme.

Table 5 gives the framework of a possible Sarawak Land Capability Classification. The classifying factors have been arranged in a suggested order of importance so that it may be possible to place a soil with some certainty even when classifying factors of minor importance are lacking. The Table does not indicate the maximum requirements so that soils placed for instance in class III can have better properties than noted but for the one limitation, the minimum requirement. The nature of the limitation is indicated by a symbol at the subclass level so that it is possible to judge whether the Land can be raised to a higher class if the limiting factor is remedied.

Table 5.

Suggested Grouping of classifying factors

	Capability Class	Classifying factors										
		Slope	Erosion	Effective depth of soil	Natural soil drainage	Wetness	Salinity	Flooding	Textures of soil profiles	Depth of organic horizon	Inherent fertility	Reaction
suitable for agriculture	Class I	gently sloping	none*	deep	well drained	slightly wet	none	no floods	moderately heavy to moderately light	shallow	?	weakly acid
	Class II	moderately sloping	slight	moderately deep	moderately well drained	moderately wet	weak	occasional of short duration	heavy to light	shallow	?	acid
	Class III	strongly sloping	moderate	moderately deep	poorly drained	wet	moderate	frequent of short duration	very heavy to light	moderately deep	?	acid
	Class IV	steep	severe	shallow	very poorly drained	very wet	strong	occasional floods of long duration	very heavy to very light	moderately deep	?	strongly acid
unsuitable for agriculture	Class V	-	-		Very poorly drained	extremely wet	severe	frequent floods of long duration	very heavy to very light	deep	-	-
	Class VI	very steep	very severe	shallow	-	-	-	-	very heavy to very light	-	-	-
	Class VII	very steep	very severe	very shallow	-	-	-	-	very light to very heavy	-	-	-

? requires definition.

Following the definition of classes V to VII suggested by Klingebiel et al (1961, p.9) Class V land is mainly excessively wet land unfit for normal crop production, while classes VI and VII consist of extremely steep land. Definitions of the classes are for the present not suggested since the system should first be tried out for a number of areas so that attention can be given to all implications in the phrasing of the definitions.

2. Subclasses and units

The four subclasses indicate the degree of limitation. It is thought however that four subclasses are insufficient to give a correct indication of the limitation involved. There is a great difference between soil wetness due to bad internal drainage and wetness due to flooding, and it is difficult to indicate in the given subclasses what limitation is really involved. Haantjens (1962, p.6,) in a modified version of this classification system for Australian New Guinea and Papua suggests a subdivision of the symbol 's' (soil limitation) into s_2 for inadequate moisture due to shallow profile of coarse texture and s_3 for poor drainage due to slow permeability while he adds subclasses 'd' for wetness due to a high watertable and f for wetness due to overflow. He also discards the American practise of assigning only one subclass symbol to any type of land and uses two or three symbols of necessary. It is likely that for Sarawak conditions a similar modification has to be adopted especially since not all soil limitations are of equal importance. The danger is that the number of subclasses become unmanagable and this must be avoided.

The fact is recognised that in the United States this difficulty is overcome by subdividing the subclasses into capability units at the third level of classification. It is however suggested that in Sarawak at this stage no units can be distinguished since this final subdivision is based on a considerable amount of managerial experience and research which is not available in Sarawak. The increase in the number of subclasses is therefore a logical consequence of omitting the units from this scheme.

Finally it should be realised that it is not possible to collect all the required information for a Land Capability map on a reconnaissance soil survey. In Sarawak these are based on a scale 1:50,000 to 1:100,000. The Bureau of Reclamation Manual (1953, 2/6/1) states that in the United States Land Capability Maps of a reconnaissance nature are on a mapping scale of 1:24,000 which is considered appropriate to semi-detailed soil mapping in Sarawak. A reconnaissance capability map can quite likely be compiled from a semi-detailed soil map.

VI. CONCLUSION

It is suggested that the establishment of a Land Capability Classification of the nature proposed and its application under present conditions in Sarawak is feasable and that development planning may benefit from it since such a classification gives in objective terms the relative value of each land type over the whole of Sarawak. As it is assumed that a detailed system of this nature has not yet been prepared in the other States of Malaysia it is suggested that where the fusion of soil classifications used in the various States may fail because of the natural emphasis on local conditions in such classifications, a Land Capability classification for the whole of Malaysia may have more chance of success since such a classification would be based on inherent land characteristics which are essentially the same throughout the country.

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A PROPOSED SOIL SUITABILITY CLASSIFICATION FOR MALAYSIA

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CONTENTS

INTRODUCTION

An agricultural soil survey is more complete when the end products are not only soils maps but also soil suitability maps, for it is only when soil suitability maps are at hand that the land use planner (at the Regional or State level) can proceed with sound land use planning. Otherwise the land use planner may have to keep referring to the soil surveyor, who may not always be at hand, in order that correlation can be made between the soil mapping units and the crops for which they are suitable.

Before a soil suitability map can be produced, however, the soil properties which affect crop growth need to be listed so that soils that are mapped can be classified according to their suitability for crop cultivation on a sustained yield basis.

This is the aim of the present scheme of classification for the soils of Malaysia.

COMPARISON WITH OTHER CLASSIFICATION SYSTEMS

The Soil Suitability Classification for Malaysia has been enlarged from the Soil Suitability Classification for West Malaysia (Wong,1966). It is similar in approach to the Land Capability Classification set up by Klingebiel and Montgomery (1961), Haantjens (1963) and Andriesse (1966); the soils are classified according to the severity of soil factors which limit agricultural development. It is different from the Land Capability Classification of the Technical Sub-Committee of the Economic Planning Unit, Prime Minister's Department, West Malaysia (Panton, 1966), which is a classification of land according to its natural resources potentials, that is, mineral , agricultural and forestry potentials.

The soil suitability classification for Malaysia is further similar to those of the U.S.D.A. (Klingebiel and Montgomery, 1961), C.S.I.R.O. (Haantjens 1963, 1967) and Sarawak (Andriesse, 1966) in having subclasses based on the kinds of limitations to agricultural development.

Moreover, like the systems of Haantjens and Anriesse but unlike that of Klingebiel and Montgomery, the Malaysian system takes into consideration perennial (tree) crops and padi cultivation besides arable farming as forms of land use.

Climate has not been considered as a limiting factor because the high temperatures and generally high rainfall encourage more than limit crop growth.

Suitability classes are subdivided into subclasses. There are no further subdivisions into units as is the case in the American system. This is because of a lack of data on management practices, crop performance and yields and also because the soil mapping units are based mainly on reconnaissance and semi-detail surveys.

Contrary to the other three systems, there are only 5 suitability classes in the Malaysian classification; class 1 soils are the most suitable for crop growth on a sustained yield basis and the suitability decreases to class 5 in which the soils are least suitable for long term crop cultivation.

As the Drainage and Irrigation Department is capable of carrying out major reclamation projects of swampy areas, very poorly drained soils cannot be considered completely unsuitable for agriculture especially for padi cultivation. Thus, in contrast to the other three systems, in the Malaysian classification, waterlogged soils can be considered suitable for agriculture though the choice of crops is very limited.

ASSUMPTIONS AND EXPLANATIONS

1. The Soil Suitability Classification for Malaysia is a special purpose classification which is geared solely to crop growth.

2. It is a scheme based on the soil factors, which when present in a soil, would limit continuous cultivation on a sustained yield basis.

3. A moderate level of management is assumed, that is, one which will conserve a soil while the latter is being utilized for crop cultivation.

4. The suitability classification may be changed by major reclamation projects (e.g. drainage and irrigation) which permanently alter the limitations to crop growth. The classification will then be based on the remaining limitations which have not been removed.

5. The system is based mainly on physical limitations since these are generally more permanent and difficult to rectify; where applicable, however, severely limiting chemical properties are also taken into consideration.

6. Accessibility and proximity to markets, do not influence the grading. This also applies to the skill or resources of individual operators who can put in a level of management higher than that of those who are capable of only a moderate level of management.

7. The interpretations attempt to express current knowledge and as new experience is acquired new interpretations may be necessary e.g. the limits of the parameters may need to be changed according to new knowledge on crop behaviour.

8. The system is not a soil suitability classification for specific crops e.g. rubber, oil palm or padi. Interpretations of soil maps for such purposes may require different groupings of the soil mapping units according to the specific needs of each crop.

9. Agronomic data and other observations of crop performances are used as the bases for classifying the soils in suitability subclasses and classes. Where there is a lack of data on crop response to soils, the placing of such soils in the respective subclasses and classes is based on the interpretation of soil properties according to general principles about use and management developed for similar soils elsewhere.

FACTORS LIMITING CROP GROWTH

In defining the suitability classes and subclasses, only general statements of conditions can be given. In practice, however, more specific parameters are needed to guide the allocation of mapping units to the various suitability subclasses and classes. For this purpose, in Malaysia, the factors limiting agricultural development have been separated into four groups, namely:-

a. Very serious limitations.

b. Serious limitations.

c. Moderate limitations.

d. Minor limitations.

The seriousness of a limitation is determined by the extent to which it will inhibit crop growth. Accordingly, a very serious limitation will not only retard but may even totally inhibit crop growth. A serious limitation, however, is not detrimental to all crops; while some of the more sensitive crops may not survive such conditions, others may even thrive in them e.g. padi and sago under wet conditions.

Moderate limitations affect a limited range of crops which may be very sensitive to some soil conditions. For most crops these limitations can be surmounted by proper management.

Minor limitations are those which can affect a very selected number of crops; the effect is more in terms of yields than in terms of crop survival.

The parameters given below are based on current knowledge of crop response to soils; with more empirical data on crop performances they may need redefining.

a. Very serious limitations

1. Gradient and Texture (g); Steep slopes (above 25^{o} with textures coarser than sandy loam. (above 35^{o} with textures of sandy loam or finer.

2. Depth to continuous impenetrable layer (1); less than 6 inches.

3. Acid sulphate layer (a); 0" - 6" from the surface.

4. Rockiness (r); extreme (more than 75% of soil surface covered.)

5. Nutrient imbalance (n); Toxicity caused by extremely high contents of certain elements.

6. Human (h); disturbed land.

b. Serious limitations

1. Gradient and Texture (g); moderately steep slopes (12^0 to 25^0 with textures coarser than sandy loam or 20^0 to 35^0 with textures of sandy loam or finer.)
2. Drainage (d); very poorly to poorly drained or excessively drained.
3. Depth to continuous impenetrable layer (i); 6 inches to 1 ft. .
4. Texture and structure(t); very heavy textured and weakly or coarsely structured or very light textured and weakly structured.
5. Salinity (s); saline condition 0 - 1 ft. from the surface.
6. Acid sulphate layer (a); 6" - 1 ft. from the surface.
7. Organic horizon (o); 4 ft. thick or thicker at the surface.
8. Rockiness (r); moderately extreme (50% - 75% of soil surface covered)

c. Moderate limitations

1. Gradient and texture (g); strongly sloping slopes; . (6^0 - 12^0 with textures coarser than sandy loam or (12^0 - 20^0 with textures of sandy loam or finer.
2. Drainage (d); imperfectly drained or somewhat excessively drained.
3. Depth to continuous impenetrable layer (i); 1 to 2 ft.
4. Texture and structure (t); moderately heavy textured and weakly or coarsely structured or moderately light textured and weakly structured.
5. Salinity (s); saline condition 1 - 2 ft. from the surface.
6. Acid sulphate layer (a); 1 - 2 ft. from the surface.
7. Organic horizon (o); 2 to 4 ft. thick at the surface.
8. Rockiness (r); moderate (25 - 50% of soil surface covered)
9. Nutrient imbalance (n); acute nutrient deficiencies.

d. Minor limitations

1. Gradient and texture (g); gently sloping slopes (2^0 - 6^0 with textures coarser than sandy loam or 2^0 - 12^0 with textures of sandy loam or finer.
2. Drainage ; moderately well drained.
3. Depth to continuous impenetrable layer; 2 to 3 ft.
4. Texture and structure; heavy or light textured and weakly structured.
5. Salinity; saline condition 2 - 3 ft. from the surface.
6. Acid sulphate layer; 2 - 3 ft. from the surface.
7. Organic horizon; 1 to 2 ft. thick at the surface.
8. Rockiness; slight (10% - 25% of soil surface covered.)
9. Nutrient imbalance; moderate nutrient deficiences.

SOIL SUITABILITY CLASSES

Class 1. Soils with no limitation or one or more minor limitations to crop growth

The soils in Class 1 are suitable for the widest range of crops. They can be profitably cultivated under a moderate level of management. These soils occur on flat to rolling terrain (0^0 - 12^0). They have good water-holding and nutrient-retaining capacities and are well suited to continuous cropping on a sustained yield basis.

The most versatile soils in this class are those found in flat areas where they can be utilized for a very wide range of dryland crops or irrigated for padi cultivation; these are deep, well structured soils with a very high clay content.

Class 2. Soils with one or more moderate limitation to crop growth

These soils are suitable for a narrower range of crops than Class 1 soils. A moderate level of management is necessary to obtain economic returns from crops grown on them. Management practices may include erosion control measures, minor drainage and irrigation works, or improvements in the air and water relations.

Class 3. Soils with at least one serious limitation to crop growth

As these soils possess at least one serious limitation besides one or more moderate limitations, they are restricted to a narrow range of crops. Even so, a high standard of management is necessary to develop or conserve them for long term crop cultivation. Necessary management practices may include erosion control measures, an intensive fertilizer programme and/or drainage and irrigation works involving moderate expense.

Class 4. Soils with more than one serious limitation to crop growth

In having more than one serious limitation these soils are limited to a very narrow range of crops, often only to specific crops. Even though the choice of crops is very narrow, the level of management for these soils has to be increased if their continuing productivity is to be maintained. Major conservation or amelioration measures are necessary before these soils can be cultivated on a long term basis.

Class 5. Soils with at least one very serious limitation to crop growth

The soils included within this class, in their present condition, are the least suitable for agricultural development. Where they are not built over for urban development or excavated for mining and quarrying purposes they are best allowed to continue under mature and/or regenerating forest.

SOIL SUITABILITY SUBCLASSES

Soil suitability subclasses are subdivisions within suitability classes. They are formed on the basis of the kinds of limitation affecting crop growth. Their formation and inclusion in soil suitability maps will give potential users of such maps a better guide regarding the management practices which may be needed for long term cultivation of land.

As there are altogether ten different types of limitations to crop growth in Malaysia, subdivision of suitability classes into subclasses is based on these ten limitations. They are listed below with respective letter symbols which will indicate on soil suitability maps the kinds of limitation possessed by different mapping units. The tenth (disturbed land)although not a limitation in the sense of the other nine, is included because all land that is presently being mined or is under urban development is not available for agriculture and therefore cannot be considered for crop growth in the present scheme.

- g = gradient & texture
- d = drainage
- i = depth to continuous impenetrable layer.
- t = texture and structure
- o = organic horizon
- s = salinity
- a = acid sulphate layer
- r = rockiness
- n = nutrient imbalance
- h = disturbed land

Gradient & Texture

Gradient, plays an important role in influencing the choice of land use. Soils on sloping land are subject to water erosion under the wet climate of this country where heavy thunderstorms are common;

This phenomenon occurs more commonly in soils with textures coarser than sandy loam; sheet erosion can occur in these light textured soils even on gentle slopes when violent thunderstorms occur; soil slumping is common on steeper slopes. Thus, terracing for such soils on sloping land is an essential conservation measure although considerable expense may be involved. Soils having sandy loam or finer textures are more resistant to water erosion so that slope limits for them can be increased. These slope limits are given in table 1 where it will be seen that the upper slope limit for heavy textured soils is 35° while that for light textured soils is 20°.

Drainage

The soil drainage classes adopted in this suitability classification are the same as those given in the Soil Survey Manual (U.S.D.A. Handbook, No.18, 1951).

Accordingly, very poor and poor drainage in a soil would not be a limitation for wetland crops such as wet padi and sago palm but would be a serious limitation for dryland crops, such as rubber and oil palm. Similarly, excessive drainage in a soil is a serious limitation not only to wetland crops but also to dryland ones. Imperfect and somewhat excessive drainage are moderate limitations which are significant to the more moisture-sensitive crops. A soil with a moderately well drained status has a minor limitation which could become serious during periods of prolonged drought.

Depth to continuous impenetrable layer

Massive thick laterite, unweathered rock, pans and compacted sand are included under this heading. The growth of trees such as rubber, oil palm and coconuts is restricted by shallow soils. Often other detrimental effects are associated with shallow soils; these could be low water-holding capacity and inadequate nutrient retention. Root crops such as tapioca, yams and sweet potatoes are also affected by shallow soils, and although arable farming can be practiced on such soils special management techniques e.g. ridging, have to be applied if economic returns are to be expected.

Texture and Structure

Texture and structure are considered together because they affect plant growth in combination; heavy textured soils with well developed structures are usually well drained and well aerated so that together with their relatively high water-holding capacity and high nutrient exchange capacity they are eminently suitable for a wide range of crops; heavy textured soils with poorly developed structures, on the other hand, are usually poorly or very poorly drained so that anaerobic conditions may prevail thus retarding or completely inhibiting root development; light textured soils, such as beach sand, are normally very weakly structured; a weakly structured soil is easily compacted so that its pore space is drastically reduced with the result that plant roots are inadequately aerated or supplied with moisture.

Organic horizon

Organic or bog soils in Malaysia are associated with bottom lands which are usually waterlogged. They vary in organic matter content from true peats to organic clays and mucks. High acidity is frequently associated with such soils. Peats are poor anchoring mediums for trees and this is clearly indicated by coconut and oil palms growing with their trunks leaning close to the land surface. Because of their high porosity their permeability is very rapid. Very frequently, in deep peats, large logs occur which impede tillage operations. The maintenance of a correct water table level is critical in the proper utilization of peats - overdraining produces very rapid initial shrinkage followed by irreversible drying and oxidation of the organic matter at the surface while lack of draining results in waterlogging and inhibition of root development which in trees can result in poor anchorage and consequent leaning. With proper draining, however, the cultivation of shallow-rooting crops is a feasible proposition and it has been shown that pineapple cultivation is very successful under such conditions.

Salinity

Salinity is associated with heavy textured marine alluvium inundated by sea water. Research on saline soils has shown that when the salt concentration in the soil reaches the level at which a saturation extract of the soil gives a conductivity reading of 4 to 8 millimhos per cm. at 25°C crop growth is inhibited. When the conductivity reading is above 8 millimhos per cm. at 25°C no crops do well (Hayward, 1956). Such high salt concentrations can be considered under the heading of toxicity.

Salt concentrations giving a conductivity reading of 4 to 8 millimhos per cm. at 25° are therefore taken into consideration in this suitability classification scheme. The depth to which this range of conductance is encounterrd in saline soils is therefore important in the determination of the suitability of a soil to crop growth.

only tolerant crops thrive.

Besides containing excess salts saline soils are usually poorly drained and massive in structure. Rapid draining results in the formation of large structural units which dry to a rock-like consistence making land preparation very difficult.

With proper drainage and bunding to keep out the sea-water saline soils can be improved for crop growth.

Acid Sulphate Layer

A considerable acreage of marine alluvial soils in Malaysia are highly acid due to the presence of excessive amounts of oxidisable sulphur compounds. These sulphur compounds are produced by the microbiological reduction of sulphur derived from sea water. When the soil is drained oxidation of the sulphur compounds to sulphate takes place. Hydrolysis of the sulphate in water results in the soil becoming acid. In areas where crop growth has been retarded, a pH of 2.5 or lower has been recorded. Drainage and irrigation of a sulphide-containing soil causes a severe deterioration of its condition and very many years of continued aeration and leaching must elapse before the soil can become suitable for cultivation.

Rockiness

This limitation includes rocks, stones and concretions of varying sizes ranging from large boulders to stones. The parameters set up for this limitation are a modification of those given in the Soil Survey Manual (U.S.D.A. Handbook No.18, 1951) where the effect of rocks and stones on machinery is considered. In Malaysia, tillage machinery is used to a limited extent partly because hand tillage is still practiced and partly because the major crops cultivated are perennial trees. As tillage machinery is used to a limited extent only in Malaysia the parameters for rockiness and stoniness can be extended to suit local conditions.

Nutrient Imbalance

Although the soils in Malaysia are considerably leached, nutrient deficiencies in them cannot be considered as permanent but only as a temporary limitation to crop growth on a sustained yield basis since it is possible to remedy this situation by correct fertilizer application. Nevertheless, a soil with acute nutrient deficiencies needs better management than one without such problems, so that the former cannot be raised to a status equal to that of the latter, all other conditions being equal.

On the other hand, the presence of excessive quantities of some elements such as nickel, boron and sulphur can be toxic to plants. Fertilizer application alone will not correct such excesses easily. Continuous applications of chemicals and years of continuous leaching may be necessary before the toxicity can be brought under control.

Disturbed Land

Land that has been disturbed by human activity, particularly by mining and urbanization, is least suitable for crop cultivation in its present condition. When such land has been allowed to return to its native condition it can then be considered for agricultural development; its suitability classification will then depend on the properties it has developed as a result of the charge in land use.

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FACTORS LIMITING CROP GROWTH

SYMBOL	TYPE	VERY SERIOUS	SERIOUS	MODERATE	MINOR
g	GRADIENT AND TEXTURE	> 20° slopes with light textured soils. or > 35° slopes with heavy textured soils.	12°–20° slopes with light textured soils. or 20°–35° slopes with heavy textured soils.	6°–12° slopes with light textured soils. or 12°–20° slopes with heavy textured soils.	2°–6° slopes with light textured soils. or 2°–12° slopes with heavy textured soils.
d	DRAINAGE	—	Very poorly to poorly drained or Excessively drained.	Imperfectly drained or Somewhat excessively drained.	Moderately well drained.
i	DEPTH TO CONTINUOUS IMPENETRABLE LAYER	Less than 6 inches.	6 inches to 1 foot.	1 to 2 feet.	2 to 3 feet.
t	TEXTURE AND STRUCTURE	—	Very heavy textured and weakly or coarsely structured. or Very light textured and weakly structured.	Moderately heavy textured and weakly or coarsely structured. or Moderately light textured and weakly structured.	Heavy or light textured and weakly structured.
s	SALINITY	—	Saline condition 0 to 1 foot from the surface.	Saline condition 1 to 2 feet from the surface.	Saline condition 2 to 3 feet from the surface.
a	ACID SULPHATE LAYER	0 to 6 inches from the surface.	6 inches to 1 foot from the surface.	1 to 2 feet from the surface.	2 to 3 feet from the surface.
o	ORGANIC HORIZON	—	4 feet thick or thicker at the surface.	2 to 4 feet thick at the surface.	1 to 2 feet thick at the surface.
r	ROCKINESS	Extreme (> 75% of soil surface covered).	Moderately extreme (50–75% of soil surface covered).	Moderate (25–50% of soil surface covered).	Slight (10–25% of soil surface covered).
n	NUTRIENT IMBALANCE	Toxicity caused by extremely high contents of certain elements.	—	Acute nutrient deficiencies.	Moderate nutrient deficiencies
h	HUMAN	Disturbed land.	—	—	—

THE LAND CAPABILITY CLASSIFICATION OF WEST MALAYSIA.

Several Government Departments in West Malaysia have been undertaking programmes of natural resource evaluation for a long time, and a need for closer co-operation between these different groups has always been felt, particularly as the results of surveys carried out often revealed a conflict in the use potential of the land surveyed. In recent years it has becoming increasingly apparent that the data from these surveys were important for national development planning, particularly following a Ford Foundation Report to the Malayan Government in 1962 on agricultural diversification, when a sub-committee of the National Development Planning Committee, which later became the sub-committee on Land Capability Classification, was formed to draw up a programme for data collection, analysis and presentation, designed to be carried out during the First Malaysia Plan period and to be completed in good time for it to be applied to the preparation of the Second Malaysia Plan in 1970. This sub-committee included representatives from all government departments involved in resources survey and several of the major land and natural resource use interests.

Technical assistance was sought and obtained from the Canadian Government in the form of aerial photography covering the whole country, and several specialist personnel in field and economic geology, land use survey, forest inventory and wild life evaluation. Finally, the Natural Resources Section of the Economic Planning Unit was set up in 1965 to co-ordinate the above programme and apply the results to the work of the Economic Planning Unit.

Basically the Land Capability Classification Programme depends on the contribution of data by three main natural resource survey groups on mineral potentility, soil suitability and forest productivity. In addition data on water resource, land use and wild life are also provided. Land use data was originally presented only in the form of boundary details reflecting the legal land alienation and gazettement status, but with the completion of the 1966/7 aerial photography, actual land use survey data based on photo interpretation is also being provided. This latter survey has been initiated by some of the Canadian specialist personnel referred to above, working with Department of Agriculture and Directorate of National Mapping personnel.

The data from the three main resource surveys are evaluated to determine conflicts in land capability potentials and from this is derived a simple land capability classification. The details of these classifications are shown in the accompanying hand-book and the attached supplement, but certain features of the classifications and their relation to the land capability classification need to be emphasized.

The mineral resource potential classification indicated the potential of an area for mining development based on evidence from field prospecting results and interpretation of the geological pattern as determined by the past work of the Geological Survey. In the classification adopted, only those areas which have been shown from actual prospecting results as containing

probable economic mineral deposits or are actually under mining lease are considered to have a high potential for mining. Such areas are placed under Class I of the land capability classification. It may be mentioned here that priority is given to mining development. This has been adopted since from past experience and trends for the foreseeable future it appears that where economic deposits of minerals occur mining development would provide a better return in comparison to other forms of land use. For the same reason agricultural development has been given priority over forestry development.

The significant feature of the soil suitability classification which has been adopted is that it lays emphasis on identifying soils suitable for the cultivation of the two main economic tree crops in West Malaysian agriculture - oil palm and rubber. Accordingly it has quite important limitations and would not be generally applicable where interest centres on a wider range of crops. These limitations are beginning to be felt even in West Malaysia where, in response to an increasing need to further diversify the agricultural crop pattern, areas suitable for large-scale cultivation of crops such as maize, tapioca, sugar-cane, etc. are being sought. It is hoped that in a second stage project a revised classification will include sufficient details for such areasto be identified.

The soils classification is based on increasing limitations of the soils to crop growth, the best soils being those with no limitations and therefore suitable for the cultivation of a wider range of crops. These limitations depend on a variety of factors including terrain conditions, physical factors limiting root development such as water-logging, shallow soils, soil compaction and lateritic horizons, or chemical limitations such as nutrient deficiency, toxicity or excessive acidity.

The soils with no or only minor limitations are considered suitable for the cultivation of oil palm and areas with these soils, unless there is conflict with a mining potential are placed under Class 2 of the Land Capability Classification. Areas of soils under a lower category of the soil suitability classification with a potential for the cultivation of rubber are placed under Class 3 of the Land Capability Classification. The remaining soils, which without major soil improvement practices are unsuitable for continued agricultural use, including swampland, worked out mining land and steep land with a slope of greater than $18\frac{1}{2}^{\circ}$ are considered best suited for forestry development. Areas of such soils where they have a potential for productive forest development are placed under Class 4 of the Land Capability Classification, while those areas which appear to have only a potential for protective forest development are placed under Class 5 of the Land Capability Classification.

The data is presented in the form of Tables showing the resource potentials, with cross-tabulations to show conflicts in resource use as well as other restraints on resource development such as legalland alienation or gazettement status, rainfall or contour levels. The analysis of these data is facilitated by coding the data according to the 1000 yard-grid intersection points of the 1 inch to 1 mile (1:63,360) topographic sheets and analysing these machanically. In addition $\frac{1}{4}$ inch maps of

the three major resources of minerals, soils and forests, a land capability map and a land alienation and gazettement map are presented with the reports which are now presented for individual states.

The results of the programme when completed for individual States are applied as appropriate and based on the completed programmes for the State of Pahang and Johore, areas have already been identified as suitable for further detailed studies to facilitate planning for the development of these areas. At the present time the emphasis is on agricultural development, but planning will also include the development of forest and mining industries. These areas have been selected due to the relative ease of access, the availability of relatively large areas of land suitable for agricultural development and the minimum of conflicts arising from alternative uses of land.

In conclusion it is emphasized that the Land Capability Classification programme is not intended to provide plans for development. Its objective is to provide the necessary background data on which decisions determining long range prospects for development of land and natural resources may be based. In practical application it may be regarded as a first approximation to determining the future land use prospects of the country at a National, or Macro-planning level, from which areas may be selected for more detailed studies of particular resource potentials in order that sound, economically viable, development may take place in areas of major opportunity.

Economic Planning Unit,
14th May, 1968.

MALAYSIA

NOTES FOR
RESIDENT STAFF OF
TANJONG PENGERANG AND
JOHORE TENGAH REGIONAL
MASTER PLAN PROJECT
1969 - 1971

Hunting Technical Services Ltd.,
6, Elstree Way,
Boreham Wood,
Herts.

S/4352

August 1969

Ian. Tasselander

PREFACE TO NOTES ON S.E. JOHORE PROJECT

1. PROJECT TITLE: TANJONG PENGGERANG AND JOHORE TENGAH PROJECT JOB No. S.4352

(NOTE: Two spellings of TANJONG PENGGERANG have been used in documents relating to the S.E. Johore project. The above is used in the Agreement and will be adopted as the official terminology).

2. CLIENT: GOVERNMENT OF MALAYSIA

3. Client's Representative:

Chief Secretary to the Government,
Prime Minister's Department (Economics),
Kuala Lumpur,
MALAYSIA.

Cables: ECONOMICS KUALALUMPUR

4. Personalities:

A separate list of personalities and contacts will be issued.

5. Project Office will be in Johore Bahru - the address to be notified in due course, together with telephone and telegraphic details.

6. Briefing Instructions to Hunting staff have been issued - copy attached for information. Project conditions applicable to all Project staff are also attached.

7. Project Instructions will be issued as necessary to all Project staff and copies sent to Principals.

8. Duration of the Project:.

The Letter of Intent to proceed is at present qualified pending final approval by the Ministry of Overseas Development and the grant of security clearance by the Malaysian Government. The Project is scheduled for completion within a maximum period of 24 months from the date of the Notice to Proceed.

9. Staff joining dates:

Hunting staff have been advised of their provisional joining dates. Principals of the other participating organisations are requested to notify H. T. S. (Mr. Spooner of provisional dates for their staff. Please note that staff and families cannot proceed to Malaysia without security clearance having been given.

Issued by Hunting Technical Services Limited,
6, Elstree Way,
Boreham Wood, Herts.

August 1969.

In. Tesselmidden

TANJONG PENGGERANG AND JOHORE TENGAH PROJECT.

BRIEFING INSTRUCTIONS : ADMINISTRATION AND FINANCE.

1. Letters of Appointment to the Project will be issued by the Chief Accountant specifying oversea allowances payable and conditions of service applicable to this Project. Oversea allowances will be payable in Malay Dollars, the current conversion rate being M$7.2 to £1 sterling. Allowances are payable from the date of leaving the U.K. (provided the direct air route is taken) and no additional in transit allowances will be payable.

2. Leave: Project leave will be earned at the rate specified in the letter of appointment Due to the tight work programme project leave will not be granted during the project term. Casual leave in Malaya may be granted at the discretion of the Project Manager at the rate of 10 days for 12 months service.

3. Insurance: Staff are insured by the Company and it is obligatory for family insurance to be taken out when wives and children join the staff member. This is a personal charge and will be arranged by Mr. Hampshaw.

   Personal effects (and containers) are also insured by the Company for staff members to a maximum of £150. All other insurance of this nature can be arranged by Mr. Hampshaw.

   All staff must see Mr. Hampshaw regarding insurance prior to their departure for the Project.

4. Medical Examination and Inoculations: All staff must see Nurse Inwood to ensure that inoculations are up-to-date and that they are fit to proceed overseas. Wives and children must also be medically examined prior to proceeding overseas.

   Inoculations required are:-

   Smallpox
   Cholera
   Gamma Globulin
   (Yellow Fever is optional)

   All staff are advised to have their blood group determined and noted in the health certificate book.

5. Visas and Work Permits if required will be arranged by Government.

6. Travel: Staff will be required to travel by air (Economy class) by the direct route London/Kuala Lumpur, unless otherwise notified or agreed with the Area Manager. Family members will also be required to travel by air (Economy class) unless approval through the Administrative Manager in Johore Bahru is first obtained (e.g. for sea travel).

7. Baggage entitlement:

(i) For all staff (i.e. staff members only)

Accompanied air freight - 30 kgs (inclusive of ticket allowance).

(ii) For staff to be joined by families:

(As (i) above).

Sea freight or equivalent air freight to a maximum cost of £100 each way.

(iii) For other staff:

(As (i) above).

On short term assignments (under 6 months) additional allowance of £10 each way.

On long term assignments (over 6 months) sea freight or equivalent air freight to a maximum cost of £50 each way.

8. Malaysian Income Tax on personal earnings will be reimbursed by the Client in the event that exemption is not granted by the Income Tax Authority. This concession relates only to staff recruited outside Malaysia.

9. Project Finance and Administration:

As designated representative of the Project Manager (in terms of the Agreement), the Administrative Manager will be responsible for application and control of project funds.

No expenditure may be incurred against project funds or the Private Account either in the United Kingdom or Malaysia without prior approval being given by the General Manager or the Administrative Manager. This relates to the charging of time and services and the purchase of stores and equipment. Instructions will be issued to all staff on the procedure to be followed in the accounting for funds and the purchase and control of equipment and stores.

10. Accommodation: Free furnished accommodation will be provided for all staff including a refrigerator, cooker and air conditioning. Staff will be required to provide soft furnishings, linen, crockery, cutlery and kitchen and other domestic equipment. Domestic and other household staff will not be provided.

11. Transport: Project transport will be allocated as required by the Project or Administrative Manager and may not be used for private purposes without the prior authority of the Project Manager.

12. Field Allowance: Night out allowance will be payable at the rate of $7.5 per night spent away from the normal duty station or area.

When visiting Kuala Lumpur on project duty the Project Rest House should be used. Should this not be available, reasonable hotel bills will be reimbursed.

13. Staff registration and movement: All staff should register with their respective High Commissioner or Ambassador on arrival. When moving away from base (Johore Bahru), full details of the travel must be entered in the Project Tour Diary.

14. Schooling: Regrettably no information can yet be given regarding the availability of schools in Johore Bahru, although it is understood that Military schools do take expatriate children both in Johore Bahru and Singapore. There are also religious schools available in Singapore, but we are not sure at the moment of the travel situation between Johore Bahru and Singapore.

15. Medical services in Malaysia: Arrangements will be made in Johore Bahru for treatment of staff and their families - probably through the local hospital. Full medical and remedial dental treatment will be provided for staff members; wives and families will receive free medical treatment (except as directly concerned with maternity), but not hospitalisation or dental treatment.

Gamma Globulin will be available in Johore Bahru at a charge of $7.5 per injection for wives and children.

16. Security: Attention is specifically drawn to the following extract from the Agreement:-

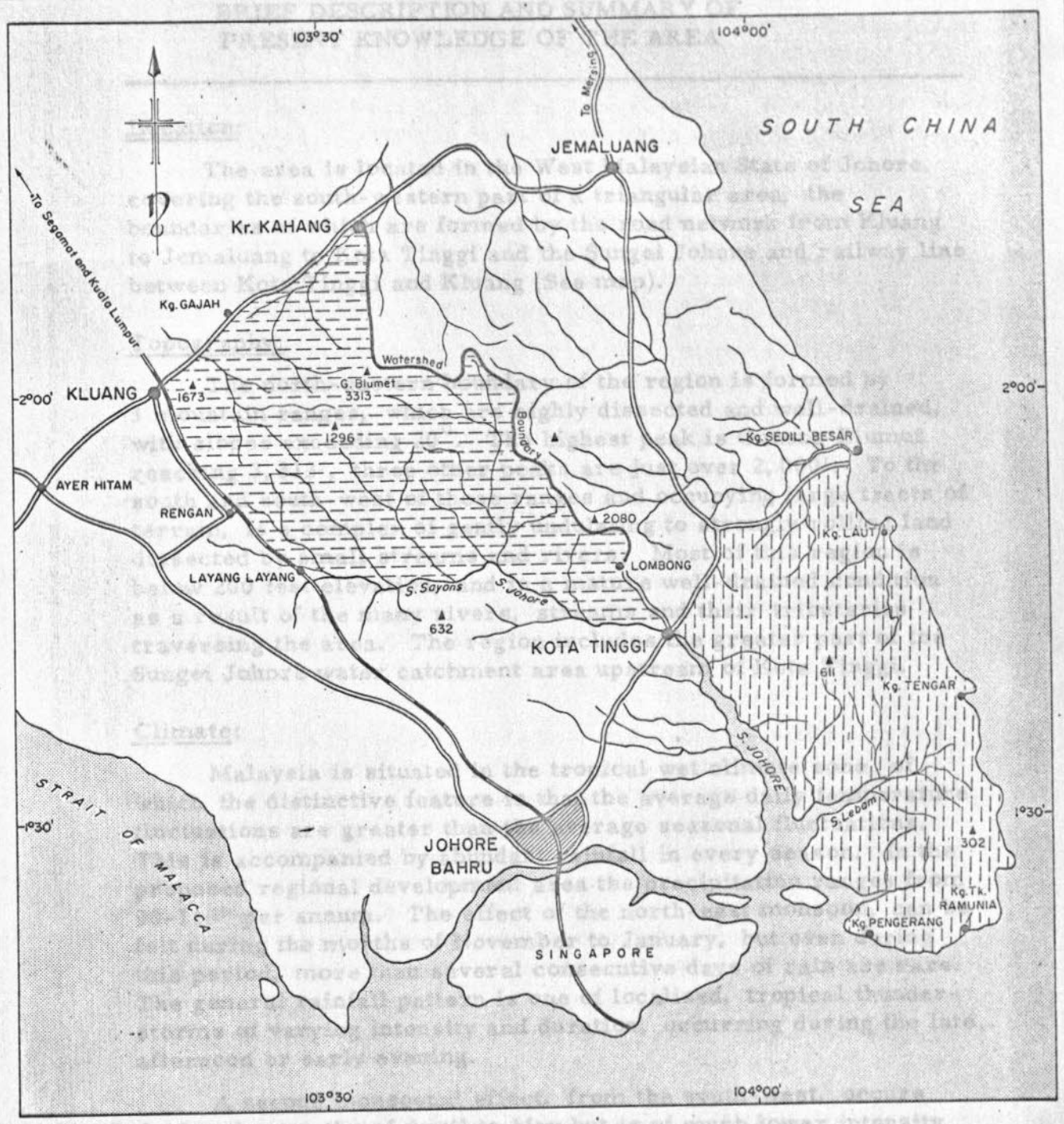
> "3. Except as the GOVERNMENT shall otherwise agree, all information which comes into the hands of the CONSULTANTS by reason of their work in connection with the performance of the duties in ARTICLE III shall be communicated only to the GOVERNMENT. Any confidential information relating to the operation of a company which comes to the knowledge of the CONSULTANTS shall only be made available to the GOVERNMENT in such a way that the particular company cannot be identified via such information, except insofar as the company concerned shall otherwise agree".

17. Additional Allowances:

(a) All staff will be entitled either to first kit allowance of £30 or annual renewal of £15 in the event of this not having been drawn for 1969.

(b) A special allowance of £25 will be paid to staff resident in Malaysia for 6 months or more as a contribution towards packing charges.

SOUTH EAST JOHORE



SCALE 1:760,320
12 MILES TO ONE INCH

JOHORE TENGAH PROPOSED DEVELOPMENT REGION. 370,000 ACRES

TANJONG PENGERANG PROPOSED DEVELOPMENT REGION. 330,000 ACRES

ACCOMPANYING PROPOSAL BY HUNTING TECHNICAL SERVICES LTD.

JOHORE TENGAH PROPOSED DEVELOPMENT REGION
BRIEF DESCRIPTION AND SUMMARY OF PRESENT KNOWLEDGE OF THE AREA

Location:

The area is located in the West Malaysian State of Johore, covering the south-western part of a triangular area, the boundaries of which are formed by the road network from Kluang to Jemaluang to Kota Tinggi and the Sungei Johore and railway line between Kota Tinggi and Kluang (See map).

Topography:

The north-eastern boundary of the region is formed by 3 mountain ranges, which are highly dissected and well-drained, with slopes exceeding 20°. The highest peak is Gunong Blumut reaching 3,313', three other peaks are just over 2,000'. To the south and south-west of these ranges and occupying large tracts of terrain, is a complex of gently undulating to strongly rolling land dissected by small streams and rivers. Most of this region is below 200 feet elevation, and in a mature well-drained condition as a result of the many rivers, streams and their tributaries traversing the area. The region includes the greater part of the Sungei Johore water catchment area upstream of Kota Tinggi.

Climate:

Malaysia is situated in the tropical wet climate zone, of which the distinctive feature is that the average daily temperature fluctuations are greater than the average seasonal fluctuations. This is accompanied by abundant rainfall in every season. In the proposed regional development area the precipitation ranges from 90-115" per annum. The effect of the north-east monsoon, can be felt during the months of November to January, but even during this period, more than several consecutive days of rain are rare. The general rainfall pattern is one of localised, tropical thunder-storms of varying intensity and duration, occurring during the late afternoon or early evening.

A second monsoonal effect, from the south-west, occurs during the months of April to May but is of much lower intensity than from the north-east.

Vegetation:

A typical Malayan Dipterocarp rainforest is the natural vegetation covering most of the free draining upland area. This forest, which is usually dense but not to the point of completely restricting ground movement, is composed of many tree species. In the hill ranges generally above 800-1,000' and below 2,500' elevation hill dipterocarp forests occur.

Present Land Use:

The area extends to approximately 370,000 acres or 580 square miles. The greater part of this acreage has been gazetted as Forest reserves and Forest cum Game reserve. Three major Forest reserves, the Rengam forest reserve, the greater

part of the Kluang forest reserve and half of the Panti forest reserve are located in the area. Part of the Kluang Forest reserve has also been gazetted as a Game reserve, which is part of the Endau-Kota Tinggi Wild Life reserve. The total estimated area gazetted as forest reserve is approximately 233,000 acres. Land alienated on agricultural title is entirely confined to the land in the south-west corner of the region close to the railway line in the north-west and along the road from Kluang to Jemaluang. The total area of land alienated for agriculture, which is almost all under estate management producing rubber and palm oil, accounts for 61,000 acres.

Land alienated for mining covers approximately 9,600 acres, principally in the area around Lombong and along the road from Kota Tinggi to Lombong. The current alluvial mining in these areas is all tin, extracted almost entirely by gravel pump method.

A small area of 160 acres has been gazetted as an orang asli reserve, a few miles upstream from Kota Tinggi along the Sungei Johore.

A present land use map cover for the area, on a scale of 1:25,000 prepared by analysis of the 1966 aerial photographs will be available by the end of 1969.

Soils:

The soils in the area have been mapped on a schematic reconnaissance basis*1 by the Soil Science Division of the Department of Agriculture. This mapping project formed part of the first national inventory of soil resources in West Malaysia. This broad scale soil survey is aimed at providing basic soils information and guide lines to land use planning in general and agricultural land development in particular. It is largely on the basis of the information provided by reconnaissance soil surveys that the present region has been identified as one of particular development potential.

For ease in interpreting the soils data, the various soils mapped were divided into 5 suitability classes*2 based essentially on criteria for tree crops since tree crops cover over 80% of the cultivated acreages in West Malaysia. Consequently, this classification has certain limitations particularly in relation to annual crops. According to present knowledge and experience, class 1 and 2 soils are assessed to the above average in agricultural potential and suitable for a fairly wide range of crops while class 3 soils should only be used for crops which have a wider range of soil tolerance. Soils of class 4 have a limited agricultural potential while class 5 soils should be reserved for either productive or protective forest. The reconnaissance soil survey carried out in the area has revealed that there are some 264,000 acres of land

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*1 Reconnaissance Soil Survey of Southern Johore - W.S. Null, C.J. Acton, and I.F.T. Wong. Soil Science Division, Department of Agriculture.

*2 Soil Survey Manual for Malayan Conditions.

which are suitable for agricultural development. However, 60,000 acres have already been alienated for agricultural purposes and are under estate management. Of the remaining 200,000 acres 75% consist of class 1 and 2 soils, while the other 25% consist of class 3 soils. An appreciable acreage in this class comprises alluvial soils of variable potential. It can be concluded from the above that there exists a reserve of land suitable for agricultural development in the area.

Geology:

Rocks of Permian age composed mainly of slate, phyllite, micaceous siltstone, sandstone, tuff, and minor limestones occur in this region overlain by sediments and volcanics believed to be of Triassic age comprising sandstone, siltstone, slate and conglomerate, and acid to intermediate lavas and pyroclastics respectively. Granitic rocks, of possibly Jurassic age, underlie a substantial part of the area. Gently-dipping sandstone, mudstone, and minor grit of Cretaceous age have been recorded and lie unconformably on the Triassic volcanics, and non-conformably over the granite. Unconsolidated sediments consisting of gravel, sand, silt, and clay of Pleistocene to Recent age are also represented.

The only ore mineral which has been extensively exploited is cassiterite (Tin dioxide). At present tin mining is taking place in the area west and northwest of the Kota Tinggi-Lombong road. This tin ore is almost entirely recovered by gravel pump method. This area has contributed the greater part of the total tin output of the State of Johore in recent years. Present information indicates that some other small tin-fields exist within this area. Furthermore, xenotime, a high-priced mineral, occurs as an accessory, and can be recovered as a by-product of tin mining. Besides these minerals there is an abundant supply of granitic as well as lateritic road metal. Small amounts of clay, possibly suitable for the ceramic, brick, and tile industry have also been recorded.

Forestry:

Extensive areas of lowland and hill Dipterocarp forests occur in the three forest reserves which are wholly or partly located in the area. The majority of these forests, consisting of Red Meranti-Keruing Forest, are found on the undulating and rolling lowlands and hill slopes.

Kapur forests are found in the north eastern part of the area as far south as the Panti Forest Reserve. Kapur is well distributed throughout this area at elevation limits of between 300 and 1,400 feet. The greatest concentration is located on steep slopes, just below the Seraya Ridge types at an elevation of approximately 700 feet.

Hill dipterocarp forests occur in the hill ranges, generally above 800-1,000' and below 2,500' elevation. These forests tend to be highly productive, particularly in areas which are rich in Seraya. In the Kluang Forest Reserve Seraya is found on the exposed ridges between 350 and 2,500', while at higher elevation it is restricted to steep slopes. In general the Seraya found in the above area is of a poorer quality than those which occur in other areas of West Malaysia.

The entire area has been covered by a forest reconnaissance survey,* involving a broad classification of the forest into productivity and ecological types on the basis of aerial-photo-interpretation supplemented by limited field checks and records of the Forest Department. The total area of productive forest has been estimated from this survey as covering approximately 200,000 acres, but part of this has since been selectively logged or is under extant logging permits.

Topographic Maps:

The region has recently been re-mapped by the Topographic Division of the Directorate of National Mapping and published sheets in colour, on a scale of 1:63,360 (Series L7010), with 50 ft contours are available. 1:25,000 scale compilation sheets are also available for more detailed survey purposes.

Aerial Photographs:

The entire area was photographed on a scale of 1:25,000 in 1966, and contact, rectified and enlarged prints of these photographs can be produced locally on request by the Directorate of National Mapping, Kuala Lumpur. Two sets of contact prints of this photography will be provided in the first instance, while additional prints could be prepared on request, given reasonable notice. The quality of this panchromatic photography is of a high order, while little change has taken place in the land use pattern over the area since the date of photography. Larger scale photography for special purposes can be carried out using local facilities if considered necessary.

Accessibility:

Access to the area is provided by a number of roads. A main road from Kluang to Jemaluang runs along the north western boundary of the area. From this road especially between Kluang and Kg. Gajah several roads lead into the area for several miles, the longest one being the road from Kg. Gajah to the Sungei Kahang.

The northern and eastern boundary coincide with the boundary of the Sungei Johore water catchment, with the exception of the road from Kota Tinggi to Lombong. The southern boundary is formed by the Sungei Johore, which is partly navigable, and the railway line between Singapore and Kuala Lumpur from the point where it meets the Sungei Sayong, a tributary of the Sungei Johore. The alienated land to the east of the railway is well served by the private road systems of the estates.

In addition forest tracks lead into those parts of the area where timber exploitation is taking place in forest reserves. These roads however, do not penetrate more than 15-20 miles into the area.

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* Forest Resources Reconnaissance Survey of Malaya, Report No. 8, Kota Tinggi District Johore, Forest Department, Malaysia.

Current and Proposed Studies in the Area:

The Malaysian Government has entered into agreement with the undermentioned agencies for the carrying out of the following studies which may be relevant to the future development of this region:

(1) Pilot Plantations for Quick-growing Industrial Tree Species Project (United Nations Development Programme-Special Fund). Field studies in connection with this project have recently commenced in West Malaysia, (late 1967) and are designed to continue for a 5 year period. The industrial tree species potential of certain areas within the Johore Tengah Proposed Development Region are included for consideration in the above project.

(2) Forest Industries Development Project (United Nations Development Programme - Special Fund). This is a Pan-Malaysian study of the forest industries development potential which will commence in mid-1968 and continue for several years. This study will take into account the forest industrial development possibilities of the Johore Tengah Proposed Development Region.

TANJONG PENGERANG PROPOSED DEVELOPMENT REGION
BRIEF DESCRIPTION AND SUMMARY OF PRESENT KNOWLEDGE OF THE AREA

Location:

The area is located in the West Malaysian State of Johore to the east of the Johore River. The area is bounded by water on three sides, while the road network between Kota Tinggi, which is the district administrative centre, and Ulu Sedili Bosar, a small fishing village on the east coast of the peninsula, forms the north western boundary (see map).

Topography:

Most of the area is undulating to rolling land below 250 feet elevation except for about 50,000 acres of swamp which occurs particularly towards the eastern side of the peninsula, and a few steeply sloping hills which rise to around 600 feet above sea level and are particularly common in the centre and southern tip of the peninsula.

Many streams and their tributaries traverse the area, and as a result most of the region is in a mature well drained condition, with narrow, seasonally waterlogged flat valley bottoms dissecting the undulating land.

Climate:

Malaysia is situated in the tropical wet climatic zone, of which the distinctive feature is that the average daily temperature fluctuations are greater than the average seasonal fluctuations. This is accompanied by abundant rainfall in every season. In the Tanjong Pengerang area the precipitation ranges from 110-130" per annum. The effect of the north-east monsoon can be felt during the months of November to January, but even during this period, more than several consecutive days of rain are rare. The general rainfall pattern is one of localised, tropical thunderstorms of varying intensity and duration, occurring during the late afternoon or early evening.

Vegetation:

Dipterocarp rain forest is the natural vegetation covering the major part of the free draining, upland area. This forest, which is usually dense but not to the point of completely restricting ground movement, is composed of many thousands of tree species. The areas that are semi-permanently submerged contain freshwater alluvial swamp forest, with mangrove forest in extensive situations around the coast. Secondary forest and scrub cover a large proportion of the area.

The structure and floristic composition of these forests varies widely, depending on the environmental conditions dominant at any particular site. The most common vegetation types are those dominated by timber trees of the family Dipterocarpaceae.

Present Land Use:

The area extends to approximately 330,000 acres or 500 square miles. The greater part of this acreage is state land which is under

forest, much of it secondary in character, together with a few thousand acres of forest reserve. Four small Malay reserves and an Orang Asli reserve also occur close to the coast.

Land alienated on agricultural title is almost entirely confined to the land bordering the west coast of the peninsula, facing the Sungei Johore. Most of these areas are cultivated with estate rubber. The total area of land alienated for agricultural purposes and more or less developed in the past for this purpose accounts for approximately 70,000 acres. More recently several thousand additional acres have been allocated for development by the Federal Land Development Authority and are currently been developed.

Land alienated for mining covers approximately 5,000 acres, principally towards the southern tip of the peninsula, where several bauxite mines are situated.

Present land use maps covering the area, on a scale of 1:25,000, prepared by analysis of the 1966 aerial photographs mentioned below, will be available before the end of 1969.

Soils:

The soils in the area have been mapped on a schematic reconnaissance basis*1 by the Soil Science Division of the Department of Agriculture. This mapping project formed part of the first national inventory of soil resources in West Malaysia. This broad scale soil survey is aimed at providing basic soils information and guide lines to land use planning in general and agricultural land development in particular. It is largely on the basis of the information provided by reconnaissance soil surveys that the present region has been identified as one of particular development potential for agriculture.

For ease in interpreting the soils data, the various soils mapped were divided into 5 suitability classes*2 based essentially on criteria for tree crops since tree crops cover over 80% of the cultivated acreages in West Malaysia. Consequently, this classification has certain limitations particularly in relation to annual crops. According to present knowledge and experience, class 1 and 2 are assessed to the above average in agricultural potential and suitable for a fairly wide range of crops, while class 3 soils should only be used for crops which have a wide range of soil tolerance. Soils of class 4 have a limited agricultural potential while class 5 soils should be reserved for either productive or protective forest. The reconnaissance soil surveys carried out in the area have revealed that there are some 158,000 acres of land which are suitable for agricultural development. Of this approximately 100,000 acres (63%) consists of class 1 and 2 soils which are most widely distributed along the centre and west sides of the peninsula.

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*1 Reconnaissance Soil Survey of Southern Johore - Null, W. S.; Acton, C. J.; Wong, I. F. T. 1965.

*2 Soil Survey Manual for Malayan Conditions.

The remaining soils suitable for agriculture are predominantly class 3 suitability, covering approximately 58,000 acres. An appreciable acreage in this class comprises alluvial soils of variable potential which occur adjacent to the many small streams and rivers. The soils in this category are rather variable and there are opportunities for more specialised crop production in many small areas. This particularly applies to the lowlying areas which in places may be ideally suited for short term food crops.

It can be concluded from the above that there exists a considerable reserve of land suited for agricultural development in the area, and that these areas are not only suitable for oil palm and rubber but in many cases for a variety of other crops.

Geology:

The oldest rocks occurring in this region include a mixed argillaceous and arenaceous series of possibly Carboniferous to Permian age. The dominant rock types are quartzite, schists, phyllite and slate. These rocks are overlain by acid to intermediate volcanics, mainly pyroclastics (tuffs) of possibly Triassic age, particularly at the southern end of the peninsula where they occur interbedded with sediments. Granite and allied rocks also occur in this area. Sediments of Pleistocene to Recent age are present and they overlie the older rocks, particularly along the eastern seaboard where they occur as dissected terraces, beaches and swamps.

Bauxite deposits which occur at the southern tip of the peninsula are being actively exploited at present. The major treatment plants are centred at Tanjong Ramunia. Small iron ore deposits occur in the same area and tin and gold have been mined along the central axis of the peninsula. Besides these ore minerals, abundant reserves of road metal (granite and laterite) are available. Clay deposits, suitable for pottery works, and manufacture of bricks and tiles have been recorded in some localities.

Forestry:

The natural primary lowland forest has largely been destroyed as a result of past gambier cultivation in the early 19th century. Secondary vegetation dominated by Adinandra damosa and Gleichenia sp. resulting from this period covers about 100,000 acres of the area. Remnants of the primary forest, which are distinct among the Malayan vegetation types and are of considerable ecological and scientific interest, do occur on the steeper hills and coastal sands, but these occurrences are scattered and total only about 10,000 acres. The only other productive inland forests are about 15,000 acres of marginally productive freshwater swamp forests. The remaining major vegetation types are unproductive inland swamp forests dominated by Pandanus sp. and productive mangrove swamp forests along the estuarine reaches of the Sungei Johore and its tributaries*.

* Forest Resources Reconnaissance Survey Report No. 8 - Kota Tinggi District. N.R. Cerra. 1966.

Topographic Maps:

The region has recently been re-mapped by the Topographic Division of the Directorate of National Mapping and published sheets in colour, on a scale of 1:63,360 (Series L7010), with 50 ft contours are available. 1:25,000 scale compilation sheets are also available for more detailed survey purposes.

Aerial Photographs:

The entire area was photographed on a scale of 1:25,000 in 1966, and contact, rectified and enlarged prints of these photographs can be produced locally on request by the Directorate of National Mapping, Kuala Lumpur. Two sets of contact prints of this photography will be provided in the first instance, while additional prints could be prepared on request, given reasonable notice. The quality of this panchromatic photography is of a high order, while little change has taken place in the land use pattern over the area since the date of photography. Larger scale photography for special purposes can be carried out using local facilities if considered necessary.

Accessibility:

Access to the area is poor, and is confined largely to timber extraction tracks which serve the current forest concession areas in the north. The estates and mine sites are served by local, mostly private, road systems leading from jetties situated every few miles along the west and south coasts. Foot tracks provide additional access to small scattered rubber cultivation patches in other parts of the region.

Current and Proposed Studies affecting the Area:

The Malaysian Government has entered into agreement with the undermentioned agencies for the carrying out of the following studies which may be relevant to the future development of this region:

(1) Pilot Plantations for Quick-growing Industrial Tree Species Project. (United Nations Development Programme - Special Fund). Field studies in connection with this project have recently commenced in West Malaysia, (late 1967) and are designed to continue for a 5 year period. The industrial tree species potential of certain areas within the Tanjong Pengerang Proposed Development Region may be included for consideration in the above project.

(2) Forest Industries Development Project (United Nations Development Programme - Special Fund). This is a Pan-Malaysian study of the forest industries development potential which will commence in mid-1968 and continue for several years. This study will take into account the forest industrial development possibilities of the Tanjong Pengerang Proposed Development Region.

SCOPE OF WORK

A. NATURAL RESOURCES

Details of the studies required in the various natural resource fields are as follows:-

(1) Agriculture:

The object of the studies is to assess the agricultural potential of the regions, and identify specific areas for cultivation of a wide range of economically attractive crops. The scope of the study shall include:-

(a) A terrain classification

(b) A semi-detailed soil survey as necessary

(c) A soil suitability classification

(d) An evaluation of irrigation and drainage requirements

(e) An agronomic and economic assessment of crops that could be grown in the area, with particular attention given to the suitability of the area for crops other than rubber and oil palm.

Map compilation should be on a scale of 1:25,000, with published reductions at suitable scales.

(a) Terrain Classification:

This will be based on the analysis of existing aerial photographs and topographic maps, and the classification shall follow that adopted by the Department of Agriculture.

(b) Semi-detailed Soil Survey:

Schematic reconnaissance soil surveys have in recent years been concluded over both regions and these surveys have made it possible to evaluate the broad scope of the agricultural development potentials. More detailed soil surveys, described as semi-detailed, have more recently been completed for 150,000 acres in the Johore Tengah Region, and it is intended that the Department of Agriculture will complete the semi-detailed soil survey of this region during the 1969 field season. These later surveys may provide sufficient information to facilitate the preparation of a development masterplan, to the extent that the Consultants may only require to conduct familiarisation and confirmatory field checking in the areas concerned, but in other areas more detailed soil surveys are now required to supplement the existing data on the distribution pattern and quality of the soils sufficient for development masterplan preparation purposes.

Experience has shown that under the dense, largely trackless, and relatively uniform forest cover which exists over most of these regions, aerial photographs are of limited use for soil surveying purposes, and accurate mapping is based on detailed field examination of the soils along tracks or traces (locally termed rentis) which are specially cut to provide access and denote position.

The data collected in the course of the schematic reconnaissance soil surveys show that the soil distribution pattern, at series level, varies in complexity from place to place. In some areas, where this pattern is relatively simple and considerable uniformity exists within the series, the information collected during previous surveys is probably sufficient for masterplanning purposes, and little or no additional ground survey work may be necessary.

In other areas, however, the pattern is more complex and there is a greater variation within the series, so that ground examination at a greater intensity, along rentis lines spaced at approximately one mile to half a mile intervals apart, will be necessary. Based on past experience, soil examination at approximately 10 chain intervals will be desirable along these traverse lines.

Soil surveying in the swamps, which occur particularly in the eastern side of the Tanjong Pengerang Region, presents special problems. The available evidence suggests that the soils in these areas are largely deep peats and some confirmatory evidence, based on a few exploratory probes around the edge of the swamps, should be sufficient in view of the fact that the agricultural potential of the deeper peat soils is severely limited.

No ground surveys of soil are considered necessary in the highlands or other areas of low agricultural potential.

The soil maps shall be prepared to show the boundaries between the main soil series and association or complexes, with subdivisions where these are of agricultural significance and detectable at the scale of map compilation. The terminology and classification of the soils should follow those of the Department of Agriculture. Soil survey reports, maps and records of the Department of Agriculture will be made available to the consultants. In order to facilitate the task of correlating the soils of the area with the Department of Agriculture soil classification system, it is recommended that a close exchange of ideas and information should be maintained with the staff of the Soil Science Division. Soil correlation services will be provided by the senior staff of that division.

(c) Soil Suitability Classification:

A soil suitability map will be produced based on the results of the semi-detailed soil survey. The soil suitability classification should be based on the characteristics of the soils and their suitability for the cultivation of appropriate economic crops in addition to oil palm and rubber.

(d) Irrigation and Drainage Requirements:

Identify areas requiring irrigation and drainage works suitable for lage scale cultivation of padi or other crops and determine both drainage and irrigation requirements for these areas according to the cropping pattern recommended, based on a study of soils and topographic level surveys to be carried out at approximately half a mile intervals as well as of features of natural water-ways which may be used as water conduits. In particular, recommendations for

the sources of supply of water for padi irrigation should take into consideration the latest reports on the water requirement of padi published by the Department of Agriculture.

(e) Agronomic and Economic Assessment of Crops and Livestock:

This study will determine the feasibility of increasing the range of crops that may be grown economically to supplement the well established range of crops including rubber, oil palm and coconuts. The study will involve the assessment of all available agronomic and economic (production and marketing) data on potential diversification crops including for example cereals, legumes, sugar-cane, tapioca, sweet potatoes, bananas, other fruits and tobacco in addition to rubber, oil palm and coconuts, and where appropriate make recommendations for the phasing of pilot projects necessary to facilitate the establishment of larger scale commercial planting of the more promising diversification crops during the early phases of the development plan. Particular attention will be given to the current proposals for Banana Estate development in the Tanjong Pengerang area, which are now being considered by the State and Central Governments.

The study will also cover the animal husbandry and fresh water fisheries development prospects, giving special attention to the possibilities for mixed farming in the smallholder sector.

(2) Forestry:

The study will determine the development potential of the region based on the forest resources and will involve the following:-

(a) Carry out a survey of the forest resources so as to provide adequate data on the utilisable volume of the standing crop according to present and future utilisation standards. The data should be in sufficient detail to plan for the development of forest industries according to a phased exploitation of the timber resources as well as for the management of that part of the forest which is to be retained as a permanent forest estate, a preliminary location of which has been made on the basis of recently completed land capability classification studies. The forest survey, details of which will be discussed between the consultants and the Forest Department, will be based on analysis of the most recent aerial photographs (dated 1966) providing the basic stratification for ground sampling. Sampling will be according to randomly selected strips one chain wide within each photo stratum; should not exceed a sampling fraction of 1.25%. i.e. one line per mile; and should provide the following information:-

(i) Utilisable standing crop by stem numbers and volume according to species or species groups.

(ii) A forest productivity map in the form of compilation sheets on a scale of 1:25,000 showing the distribution of (a) above according to a pre-determined classification which shall be developed following close consultations between the consultants and the Forest Department.

Separate surveys as outlined above will be carried out for three main categories of forests as follows:-

(i) Productive hill and lowland forests.

(ii) Productive fresh-water swamp forests, the limit of productive forest to be determined from aerial photo-interpretation and ground sampling.

(iii) Selectively logged forests according to maps showing the location of these forests to be provided by the Forest Department.

(b) Recommend the location of forests suitable for development as permanent productive and/or protective forest estates.

(c) Recommend the location of primary forest communities suitable and desirable to be preserved for study, research and other scientific purposes with particular attention to the preservation of a genetic pool for tree breeding and extension purposes.

(d) Advise on a working plan necessary to develop and increase the productivity of the natural forest resource of the permanent forest estates including presently unproductive forests.

(e) Submit proposals for new forest industries to be established to harvest and process the anticipated yield of timber from the existing forest resource, including their impact upon the existing local industries and determine their need for advisory services.

(f) Advise on the infrastructural requirements necessary to develop the forest resources and the optimum development of the forest industries, including the provision of financial and institutional incentives and policy changes where appropriate.

(g) Advise on the feasibility of introducing industrial plantations of fast growing exotic tree species for the supply of timber for pulp products as well as other forest industries.

(3) Mining:

Study the mining potential to determine the areas likely to contain workable deposits of exploitable minerals where further prospecting should be carried out. This information is necessary to ensure that mining development possibilities are fully considered in the masterplan and that, at a local level, the phasing of agricultural and forest development activities should not conflict with possible mining developments.

The study will involve analysis of all available geological, mineral prospecting, and mining data for the region and the consultants will be expected to work closely with the staff of the Geological Survey and Department of Mines. Recommendations for carrying out prospecting work in the future particularly in respect of minerals other than tin, will be required.

(4) Water Resources:

The study of the water resources shall include:-

(a) A review of available rainfall and hydrological data.

(b) A study of the possible changes in the discharge of rivers arising from the development proposed, including urban and industrial discharges, and where such changes are significant, recommend soil, river and water conservancy measures to prevent or reduce the incidence of flooding, silting and pollution in the lower reaches. There remarks apply particularly to the catchment of the Sg. Johore and its tributaries upstream from Kota Tinggi where a new intake and treatment plant for the Singapore Water Supply is situated.

(c) Locate the source of supplies of water for potable, industrial and irrigation purposes where schemes for such use of water are proposed.

(d) An assessment of the requirement for industrial and potable water supplies with a projection of needs over thirty year period.

(e) The preparation of an economically realistic plan for the development of water supplies, phased according to the development of settlements and industrial requirement, including the location of access roads to the source and treatment works.

(5) Recreational Resources:

Based on the data gained from the natural resources studies already described, supplemented by information available from relevant agencies (e.g. Game Department, University of Malaya) the Consultants will be required to advise on the development of areas suitable for recreational use purposes and as National Parks and Wild Life Reserves.

Recommendations will be required regarding the possible development of tourist amenities related to the above, and particularly to the areas of scenically attractive and largely unspoiled coastal terrain, which are a prominent feature of the Tanjong Pengerang Region.

Special attention shall also be given to the identification of limited areas worthy of preservation for purposes of scientific studies of natural biological communities which may be unique to the region.

B. INFRA-STRUCTURAL, URBAN AND INDUSTRIAL DEVELOPMENT

Based on evaluations of the potential for development of the natural resources the consultants will be required to assess the requirements and submit proposals for the overall infra-structural, urban and industrial development as follows:-

(1) Transport and Communications:-

(a) Following an assessment of available data on the existing transport systems, taking into account the existing peripheral road systems and standards and bearing in mind the report on "Transport Development in Malaysia", submitted by the U.N. Survey Group, plan the lay-out of major and subsidiary roads for the region, including broad specifications for the design of the roads.

(b) Prepare a schedule for the construction of roads including the requirement of staff, equipment and plant, phased according to the pace of natural resource and land development.

(c) Examine additional means of transport and communications that will facilitate the internal development of the area and provide effective external links, and submit proposals for their development including specifications of capacity and lay-out.

White studying the transportation requirements, the consultants shall at all times take into consideration existing proposals for such development by the Government.

(2) Urban and Industrial Development:

(a) Plan the overall pattern of distribution of urban centres and industrial facilities for processing of agricultural, forest and the other products.

(b) Assess the requirements of these centres for water, power, telecommunications and other physical infra-structures, such as hospitals, schools, public buildings etc.

(3) Institutional Infra-structures:

(a) Combined with the economic analysis and evaluation of alternative development programmes for the two areas, study the organisational requirements for effective implementation. Assess the present system of administration applicable to the areas and other relevant institutions and submit proposals for change.

Among others, recommendations should be made for the establishment of organisation(s) to take overall responsibility for the implementation, progress evaluation and future planning of the development of the areas, clearly defining functions. Special attention should be given to the interrelationships between such organisation(s), Federal, State and local governments departments and agencies and the private sector. This work should be done in cooperation with government departments and with particular assistance from DAU. The main emphasis of the consultant's work should be on organisational structure rather than on problems of internal management and procedure.

Special attention should also be given to the capital and personnel requirements of the proposed organisation(s). With regard to the latter, emphasise training needs in order to ensure the establishment of an effective development organisation. Moreover the above requirements should be worked out in terms of priority over time to ensure their availability when required.

(b) Assess the existing institutions such as Co-operatives, Farmers' Associations, etc. with regard to their effectiveness in providing facilities such as marketing, credit, and extension services and submit proposals either for their improvement or for the introduction of new institutions particularly relevant to the Tanjong Pengerang and Central Johore regions.

C. SOCIO-ECONOMIC ASPECTS OF THE DEVELOPMENT PROGRAMME

The purpose of the socio-economic studies in this project are to:-

(a) identify high priority projects for budgetary allocation purposes during the whole of the Second Malaysia Plan;

(b) make broad recommendations for the development of the study regions in terms which are consistent with national, social and economic goals; and

(c) prepare a phased programme for the development of the regions covering the period up to 1990, and to evaluate the impact of such a development on the national economy.

The optimum pattern of land use for the region and the regional master plan will be drawn up so as to maximise the net present value of the benefits to the Malaysian economy, subject to policy constraints set by both Central and State Governments.

The study and resulting recommendations will be responsive to the need for assessment of possible changes in economic variables. Sensitivity analysis will be used throughout this study, and the results will be presented in such a way as to:-

(a) indicate the effects of changes in the main assumptions about future values of economic variables (e.g. costs of clearing or developing land, prices of inputs or outputs, yields of various crops) and in socio-economic assumptions (e.g. about productivity and versatility of labour, the effects of various forms of organisation and the rate of inflow of private capital into ancillary activities etc.) on the recommended pattern of development;

(b) suggest the vulnerability of various development strategies to possible variations in prices, costs, etc. At the same time the presentation will aim to indicate the nature of the information to be collected and analysed after the start of the implementation of the project, which is likely to be important in suggesting revisions to the design and pattern of development through time. The long development periods for some of the potential projects (e.g. rubber and oil palm planting) limit the possibility of making rapid changes in the regional plans, despite the accepted need for programme flexibility.

Sensitivity analysis is therefore particularly relevant to this study for revealing the likely benefits to be achieved from, for example, building in "stage by stage construction" in particular schemes.

The cost benefit studies will enable the government to assess the overall contributions of the programme to the National Product including the major ancillary developments associated with it, its cost, and allow comparisons of alternative strategies for development both within the region and in a national context. Each project will be evaluated and compared on the basis of its Net Present Value and Internal Rate of Return. The range of interest rates used to calculate Net Present Value will be decided after consultation with the Economic Planning Unit in Kuala Lumpur, and other government departments and agencies. In all cases, in the economic analysis, transfer payments will be ignored and an attempt will be made to assess the real opportunity costs of resources used in particular projects. Only changes in relative prices will be taken into account and all projects will be compared on the basis of the same 20 year period, using where necessary terminal asset values to reflect different project lives.

An important and closely related part of this study is the investigation of alternative forms of organisation, including the possibility of various mixtures of public and private development. This will entail study of existing organisations and inquiry into possible new forms, taking into account the physical resources and economic potential of the area and the characteristics of the people who are likely to become agricultural settlers or to move into the area for other purposes. The recommended plan of implementation will be framed to help to create, within certain constraints, an environment favourable to the future development of employment - and income-creating activities. Recommendations may also be made for different forms of organisation to be tested in the early stages of implementation.

The socio-economic factors which will be considered in the study are discussed hereunder. Some of the information required for the analysis of these factors has already been mentioned under several specialist headings earlier in this description of the scope of work. Repetition here is for the sake of presenting a comprehensive picture on the all-important socio-economic aspects of the study. Close liaison between the specialist and economic members of the Consultant's team in obtaining and processing the information will clearly be essential.

1. Agriculture

The study will involve the assessment of all available agronomic and economic data on potential crops including rubber, oil palm, coconuts, bananas, pineapples, cereals, legumes, sugar cane, tapioca, tobacco, padi, etc. This will require the study of:-

(a) Market prospects for these crop products;

(b) production requirements and consequent costs involved in both smallholder and large-scale estate development;

(c) Probable yields under different environmental conditions;

(d) The needs of each crop for marketing, processing, credit, extension and infra-structural services.

In addition, the possibilities of cash cropping and livestock to assist in financing the establishment of plantation crops and in aiding diversification and the suitability of alternative forms of organisation for the various types of crop development will be investigated. Factors to be taken into account will include the success of similar schemes and the employment and income opportunities likely to be generated by each type of development.

Following these investigations cost-benefit analyses of alternative schemes will be prepared, and within the context of the development programmes, pilot projects will where necessary be proposed to:-

(a) test the viability of promising diversification crops;

(b) assess the feasibility of different organisational structures, including the possibilities for mixed farming in the smallholding sector following a study of the prospects of animal husbandry, fresh water fisheries, etc.

2. Forestry

Following the detailed survey of forest resources, the marketing and industrial potential of the tree types will be assessed. A comparison of the alternative uses of land and a calculation of the returns from the commercial exploitation of the timber will be made. A master plan of exploitation including industrial processing and where applicable re-planting or preservation will be drawn up for each sub-region.

3. Mineral Resources

An assessment will be made of the extent to which the minerals in the regions are likely to be commercially exploitable. Particular use will be made in this part of the study of risk and sensitivity profiles, in view of the difficulty of estimating mining costs and mineral yields and prices. Recommendations will be made of the sort of organisation most suitable to each area and to each type of mining, and development and prospecting proposals would be formulated.

4. Water Resources

An economic assessment will be made of the various sources of supply of water for human, industrial and agricultural purposes and the economic implications of plans for the development of water supplies will be analysed.

5. Recreational Resources

An analysis will be made of the existing data on tourism (including wild life reserves) in West Malaysia and more generally in adjoining areas of South-East Asia.

The potential for the development of tourism in the regions will then be assessed by:-

(a) identifying suitable natural sites; and

(b) evaluating the costs and benefits of developing the various locations.

Recommendations would be made on:-

(a) government measures necessary to promote tourism in the area, including land alienation and planning, financial inducements and organisation;

(b) possible pilot projects;

(c) the infrastructural needs of such tourist and recreational development.

6. Transport and Communications

The transportation and communication requirements of each part of the project will be examined in detail, and as the final content of the development programme takes shape, trafic desire lines will be projected and an "ideal" transportation network constructed. This network will then be altered to take account of existing transport facilities in and near the areas and to take account of the transport facilities recommended by the UN Survey Group and planned by the government. Recommendations for a phased transport programme over the next 20 years will then be made.

7. Industrial Development

An initial screening will be undertaken of possible industries by reference to their domestic and export markets, their labour, material and capital requirements and the marketing and distribution facilities required. Following the initial screening, a series of preliminary feasibility studies will be carried out to determine those industries which could, most economically, be set up in the study regions.

The final stage of the analysis will then be to recommend the size, timing, nature, location and organisation of the individual industries. Close consultation will be maintained with Federal Land Development Authority, the Federal Industrial Development Authority and other government departments throughout the whole of the industrial analysis.

8. Human and Sociological Aspects

These aspects will receive considerably more attention than in some previous studies (e.g. the study of the Jengka Triangle). Plans for the physical development of the regions will be co-ordinated with plans for the establishment of human communities within them and projections of the lines on which they may be expected to develop.

More detailed investigations are required for the development of the regions in respect of the physical and human resources, e.g. existing population, first settlers and later immigrants, their institutions, directions of potential development etc. More detailed studies need to be made in order to prepare recommendations on, say size of holdings, settlement organisation and location, training, general education, the relative merits of estates and smallholdings and the possibilities of developing various activities within the public or private sectors. Studies of the human and sociological aspects will be closely co-ordinated with the studies of physical resources and economic aspects, with constant feed-back between them.

A general description of some aspects of the studies required is given below. The matters to be investigated can be placed under four headings, as follows:-

(a) Smallholder and Settlement Characteristics

Smallholding size, incomes and other characteristics

Settlement size, layout and organisation

Settlement and family incomes

(b) Manpower

Labour supply

Age distribution, family size etc.

Labour migration

Labour requirements and employment opportunities

Education, skills and job training.

(c) Occupancy characteristics

Land tenure

Land inheritance

(d) Public Services

Town and settlement layout

Water; sewage and other utility requirements

Local government organisation

Public services including education and health

In studying all these matters it will be important to give special attention to the long-term implications over the next 20 years or more.

The first phase of the work on human and sociological aspects will consist of an examination of previous studies made in Malaysia by members of the University of Malaya, by authorities responsible for settlement programmes and by other agencies - of the sociological aspects of agricultural development, established settlement schemes, training, industrial use of rural labour, urban development and other relevant matters. Discussion will also be held with those who have been directly involved in research and administration and with residents of existing settlements and of observation in the field.

Further studies will be carried out as necessary by the social anthropologists from the University of East Anglia in co-operation with Malaysian social anthropologists or sociologists. They will concentrate first on the problems and implications of settlement of agricultural workers on estates and smallholdings. The general approach will be as follows:- settlement programmes create new social conditons - including new organisations, procedures, regulations, opportunities and incentive systems - in which settlers must decide and act. Development plans assume or require certain behaviour. Achievement of the required results may be assisted by the following kinds of study:-

(a) A study of the characteristics of potential settlers. Information needs to be gathered on the social equipment or as sometimes called the "cultural outfit", e.g. skills, institutions and customs)

of potential settlers. It should also include information about the long term benefits which settlers hope to derive from settlement schemes. This information should make it possible, to some extent, to reconcile the constraints imposed by development and by the Governments' long term policies, with settlers' own preferences and established patterns of behaviour. It may be particularly important if groups of settlers are drawn from different origins, since differing responses to new conditions can be expected.

These studies can be accomplished through the collection and analysis of biographical data of potential settlers, including data on family size and composition, occupational skills, income etc. But it is desirable that they should be accompanied by more detailed studies of samples of potential settler families in their existing environment. The studies will focus on the factors mentioned above and be directed towards: (i) the relationships between the knowledge and skills possessed by potential settlers and the pattern of enterprise recommended for various crop areas; and (ii) the anticipation of problems of adjustment to the new environment which might hinder the overall programme.

(b) The study outlined in (a) requires identification of the groups or areas from which potential settlers may be drawn. This entails the study of existing methods of settler selection and of possible alternative methods and criteria.

(c) A study of reports on existing settlement schemes concerning their experiences in establishing new villages and towns as viable communities. The expertise and accumulated experience of both project managers and veteran settlers will be drawn upon through detailed interviews. Particular attention will be given to the spatial distribution and phasing of development of areas of work, marketing, residence, education and recreation, and to the possible implications of these for the development of social networks in the long term.

This study overlaps with and contributes to the studies of existing agricultural service institutions required by Section B. It will also contribute to the study of settler selection.

(d) A study of the long term implications of development in the regions.

Long term projections of population and occupational projections need to be prepared, taking into account the results of investigations of economic development potential. Some projections are required for planning the physical development of villages and towns and the provision of education, social services, transport and utilities. Particular attention will be given to formal education and the provision of skills necessary to future employment.

More generally the nature and problems of the societies in the regions in the future will be strongly influenced by the kind of development that takes place over the next 20 years. A study of the long term socio-economic implications of alternative development proposals and the questions on which policy decisions will have to be taken is therefore necessary.

D. OVERALL MASTER PLANNING

Preparation of the overall Master Plan will be the final stage of the assignment. The fundamental objectives of the Master Plan will be to provide (a) the broad outlines for development of the regions over the 20-year period (1971-90) -- including co-ordination of various activities and the consistency of objectives and means, the recommended phasing, resources required, etc. (b) detailed development of projects, ranked by priority, to be commenced during 1971-75, and (c) guidelines for revising the pattern of development, as may prove necessary due to changing conditions, particularly during the later years (1976-90) of the Plan.

The stages through which the studies will proceed may be set out broadly as follows:-

1. The establishment of the set of alternative strategies for development which are most likely to meet the various objectives of the Central and State Governments. These strategies will be based on assessments of the potential development of the natural resources of the region and associated economic and sociological studies including economic and demographic projections. In the examination of these alternative strategies and their later presentation in the draft report it will be important not only to compare the potential advantages and disadvantages of each, on certain assumptions (e.g. regarding commodity prices) but also to show, at least broadly, how possible changes in these main assumptions would affect the nature, direction and pace of development.

2. Those projects which appear from these broad assessments to have a high economic potential will be subjected to more detailed cost-benefit studies, on the basis of which a number will be selected as having particularly high priority.

3. Following discussions and further study of the alternative strategies of development, a series of regional programmes will be prepared covering the period from 1971-1990. These will be prepared in such a way as to meet the objectives and constraints imposed by the National and State Governments as well as those imposed by national economic conditions:-

   (a) The programme for 1971-75 will be considerably more detailed than that for the later years.

In particular, the programme will be backed by speficic projects content (see 2 above) including programme phasing on the basis of network analysis.

(b) The programme for 1981-90 will be less specific and less detailed. The most important feature of the Plan for these later years will be the element of flexibility to adopt the pattern of development to changing conditions.

(c) The overall master plan should include delineation of project boundaries, indicating specific land uses such as agriculture, forestry, mining, industry, settlements, public utilities, transport, etc. together with proposals on the relative responsibility of development by the public and private sectors, individual organisations and statutory bodies for the various projects.

The plan for the development of the regions over the development period (1971-90) should be presented in such a way that the pattern of development can be revised during that period in the light of future changes in prices, costs etc., and of new information about other assumptions made in the study, and in the light of experience and events such as the rate of private sector development affecting these regions or development elsewhere in Malaysia. This implies that the detailed plans for development in the later part of the period should be presented in a somewhat different way from the plans for immediate implementation, allowing more flexibility (consistent with the other objectives). The plans for the later period should indicate how the pattern of development should be revised in response to various changes in assumptions and indicate the information which will be most important in signalling the need for revision and which should therefore be collected and studied after implementation has begun. In short, for the later parts of the period, the Master Plan will provide a framework within which the pattern of future development can be revised periodically as new information becomes available and as the regions' development is observed and evaluated.

E. POLICY GUIDANCE

The Government will set up a Co-ordinating Committee comprising representatives of the major Ministries/Departments/ State Governments concerned to provide general policy guidance to the Consultants and for clarification and discussion of any substantive points which will arise in the course of the study.

PROVISIONAL JOB SPECIFICATION

These job specifications are by way of illustration only at this stage. Additions and or amendments will be notified by the Project Manager as may be necessary from time to time.

Would all other members of the Consortium please issue similar specifications for their resident staff with copies, by air mail, to the Project Manager in Johore Bahru. (Address will be notified as soon as possible).

Detailed time and phasing programmes will be drawn up in Johore Bahru and issued to all resident staff.

ADMINISTRATIVE MANAGER

To be responsible for Project Administration inclusive local staff, project accounts, cash and financial control, transport and security.

SURVEY LIAISON AND REPORT CO-ORDINATOR

To be responsible for field survey co-ordination especially base lines, liaison with Government Survey and project field parties. Set up and run the Project Drawing Office including library, maps, aerial photographs and records. Be responsible for the organisation and control of stores for progress/programme records, report compilation and drawings.

PROJECT SOIL SURVEYOR

To be responsible for the conduct of the soil surveys as defined by the Client in the scope of work statement; assist in preparation of land capability maps with the agronomists and foresters; draw up and agree in consultation with the Soil Science Division a detailed programme for the soil investigations and laboratory analyses, drafting of soils reports and departmental liaison.

1. API covering soils and forestry will commence at Elstree. AP's - 1966 and 1" maps are available. Mosaics have been requested from K. L. Forestry work will be discussed with C. F. I. Any soil API work outstanding at end of August may have to be completed at Johore Bahru H. Q. It is hoped that the forest maps can be completed at least for Johore Tengah region in August so that the enumeration can be planned and fieldwork commenced as soon as monsoon conditions permit. Soils will also have to concentrate on the Tanjong Pengerang region in order that rentis work can be planned and commenced soonest.

2. This is the preliminary to the fieldworks period and will cover setting up in Johore Bahru, completion of works outstanding from above, examination of available data, land and water access and complexity of soils for purposes of rentis layout for T. P. area and completion and or check work in J. T. region with short field visits for familiarisation purposes,

methods etc. Draw up and agree detailed programme with S.S. Division of D. of A.

3. Arrange for and direct team as to methods, standards and techniques by familiarisation visits and commence rentis and base line cutting.

4. Supervise all field work with Johore Tengah region being accorded priority. Prepare, in association with agronomists and foresters, land capability and terrain classification maps for J. T. Select and check the sample areas in Tanjong Pengerang region. The J. T. work assumes that Client has completed the semi-detailed survey and report in which case not more than 200 observation sites required. (These works will overlap with (3) above).

5. If monsoon holds up fieldwork and mapping as above in T. P. region (Nov- Jan) then complete in February-April.

6. Co-ordination of map compilation and report writing inclusive text, analyses, descriptions and tables.

7. Carry out additional field works and checks as be necessary after consultations with Client.

8. Finalise soil section of draft report.

9. Masterplan - report stage.

SOIL SURVEYORS

To be responsible under the direction of the project soil surveyor for the physical surveys in the project area in accordance with the detailed plan of operations to be drawn and agreed at the beginning of month one in Malaya. The work will also include report writing and mapping.

1. API covering soils and forestry will commence at Elstree. AP's - 1966 and 1" maps are available. Mosaics have been requisited from K. L. Forestry work will be discussed with C. F. I. Any soil API work outstanding at end of August may have to be completed at Johore Bahru H. Q. It is hoped that the forest maps can be completed at least for Johore Tengah region in August so that the enumeration can be planned and fieldwork commenced as soon as monsoon conditions permit. Soils will also have to concentrate on the Tanjong Pengerang region in order that rentis work can be planned and commenced soonest.

2. The initial period will cover local mobilisation and orientation including discussions with officers of the Malaysian Soil Survey Division in order to familiarise themselves with the works so far completed and the methodology and mapping techniques of the S. S. D.

Desk studies will be supplemented by field visits, a survey of the selected areas and further examination of the aerial photographs in order to understand and standardise on the methods to be used in the field and office. Base line and rentis cutting will also commence in this period.

3. Carry out any confirmatory field checks on the semi-detailed soil survey believed to have been completed by the S. S. D. in the Johore Tengah Region and, or assist with the completion. Compile in association with agronomists and foresters terrain classification and land capability maps. Select and check sample areas in Tanjong Pengerang Region.

4. Carry out a semi-detailed soil survey of the Tanjong Pengerang Region and produce terrain classification and a land capability map on part of the area by month 5 and complete the field works and maps on the remainder as and when monsoon conditions permit.

5. Preprare a draft soils report with supporting maps, analyses, descriptions and tables with special reference to nutrient status, crop water availability and potential, if any, of the areas classified I. S. A.

N. B. - Includes final debriefing and departure.

PROJECT AGRONOMIST

To be responsible for land capability maps in association with the project soil surveyor and forester; co-ordination of agricultural studies as defined by the Client in the scope of work, definition of agricultural projects and assistance with master planning and report writing. The fields covered will be: agroclimatology, land use, crop selection, cropping patterns, crop water requirements, agronomic techniques, holding size, farm/estate inputs and yield projections, livestock systems and management, pilot stage developments, fisheries potential and integration of livestock and fisheries. In this work the initial process of literature research, data review and first field visits will be the responsibility of the agricultural economist and the agronomist/fisheries officer who will commence evaluating and summarising prior to the arrival of the project agronomist.

1. To conduct a critical examination of the team's preliminary agricultural data analyses and evaluations, consult with technical heads of appropriate government departments, specialist agencies and research institutions inclusive the private and commercial sectors, make field visits and conduct further studies as required, check first approximation of feasible crops and livestock potential and study physical input requirements. At this stage a decision must be made as to whether or not adequate data and expertise are available to enable the long term livestock potential to be assessed and projections made.

2. As soils data become available the first crop lists will be reviewed and selections made bearing in mind the Client's diversification requirements, conservation aspects will be studied and a land capability map prepared for the Johore Tengah region with a draft L. C. map covering some 50 per cent of the Tanjong Pengerang region. Note: This will minimise the effect of the monsoon season on the overall plan of operations.

3. Propose the farming patterns and methods to include livestock and fish farming if thought feasible with special consideration being given to irrigation and drainage and systems i. e. smallholdings, group farms, nucleus estates and estates all leading to initial project identification.

4. Project total yields or outputs for marketing and processing studies, review inputs requirements and estimates (e. g. manpower, horse-power, fertilisers, seeds, insecticides, supervision) for purposes of economic analysis.

5. Complete land capability map for Tanjong Pengerang region and complete works as specified above.

6. Final data analysis, forecasts of agricultural trends, staffing and participant selection and phasing of agricultural developments. Discussions.

7. Discussions with Governments and decisions by end of month 14 i. e. agreement by Client on outline of development strategy and high priority projects.

8. Additional period for study and analysis.

9. Draft as per plan of operation, discussions with Client leading to final policy definition by Client.

10. Drafting of Master Plan and editing.

AGRICULTURAL ECONOMIST

To assist in the preparation of the detailed plan of operations using network techniques, be responsible for the day to day monitoring of the project inclusive forecasting of bottlenecks, and supervision of the economic and social aspects of the regional study, inter team and government departmental liaison on social and economic aspects of the study and minute significant economic policy considerations stemming from the recommendations contained in draft report, and in particular to advise on the organisational and financial implications. Also, to carry out specific agricultural economic studies.

1. Assistance with preparation of detailed plan of operations.

2. Assistance with monitoring of projects, co-ordination of interdisciplinary data flow and report analysis.

3. Carry out literature research and data review, make field visits and discuss economic aspects with specialists, government departments, agencies, schemes, estates etc. Note: Work will be in association with the agronomist/ fisheries member of the agricultural study team and the project economist of the socio-economic team.

4. Carry out detailed agricultural economic studies for planning purposes in respect of:-

   (a) Smallholding economic survey for smallholder planning.

   (b) Economic aspects of livestock husbandry and fish farming and integration.

   (c) Smallholder/Estate relationships.

   (d) Economics of mechanisation and processing.

5. Feed in of physical agricultural data - inputs and outputs, and planning aspects.

6. Assistance with co-ordination and production at draft report stage.

7. Drafting of master plan, inter discipline monitoring and editing.

AGRONOMIST AND FISHERIES

To be responsible for the study and reporting on the fisheries potential of the regions and subsequent development planning as set out in the Client's scope of work. Also, to be responsible in association with the agricultural economist for the initial literature research, data review, station visits, exploratory field trips and preparation of a summary report and to assist the project agronomist as stated.

1. Carry out data review and literature research, consult with specialists, government officers and others associated with the agricultural and livestock industries, make field visits as required and prepare a summary situation report.

2. Produce first approximation of feasible crops and the potential for incorporation of livestock in the pattern.

3. Assist the project agronomist with further studies including field trips etc. as defined in items (1-3) of the project agronomist's work schedule.

4. Carry out a review of fisheries data and conduct literature research inclusive visits to fisheries stations and the field inclusive markets, processing centres and transportation.

5. To make a study of the environment for fisheries purposes covering: soils, water resources, fish stock, land classification, climate and determine possibilities for integrated developments and discuss technical aspects with fisheries officers.

6. Plan specific fisheries developments covering all activities and techniques.

7. Further assist in agricultural studies and planning.

8. Carry out further fieldworks and studies on fisheries aspects as required.

9. Assist on draft report with special responsibility for the fisheries section and any review necessary after Client consultation.

IRRIGATION AGRONOMIST

To be responsible for agronomic considerations and development planning for those crops selected for irrigation; to provide the necessary consumptive-use requirements and lay down guide lines for any proposed developments requiring supplementary water.

1. Examine all summarised data inclusive water quality, check crop lists, consult with the Departments of Agriculture and Irrigation and make such field visits as necessary.

2. Determine consumptive use requirements, calculate the monthly irrigation requirements for each crop, estimate the monthly overall requirement for any postulated rotation, determine, in consultation, the water efficiency rates to be adopted, suggest guide lines for development, operation and management inclusive inputs and such other data as is required for economic appraisal.

3. Prepare a draft report with recommendations supported by tables and technical appendices, discuss with appropriate government departments and check draft.

FORESTRY-INITIAL PHOTO-INTERPRETATION AND MAPPING

(H. T. S. and C. F. I. in U. K.)

1. Assemble all existing maps, air photographs and the Forest Department's reconnaissance survey report on Johore Tengah at Elstree.

2. Prepare mosaics, interpret and map communities etc. as proposed on pp. 1/18 to 1/19 of the HTS Proposal assisted by C. F. I.

3. Plan the forest inventory and lay down the mensurational and recording system as per Jengka and arrange computer work (C. F. I.).

4. Compute data after enumeration (C. F. I.).

FOREST LIAISON

The Conservator i/c in the study area will be responsible for government liaison, data collection and preliminary analysis, the inventory, data feed back, preparation of maps and report writing and assistance to the T. U. specialist.

1. Data review and analysis, staffing, preparatory work for the inventory and field familiarisation studies.

2. Supervise the inventory and prepare summary sheets for feeding back to the C. F. I.

3. Identify and map areas to Client's specification and detailed in our Proposal and prepare report giving quantitative information on the exploitable prospects of each.

4. Obtain and tabulate information on commercial species, size assortments by consultation with Government and the Trade and assist the T. U. specialist.

5. Prepare draft report and discuss.

N. B. The Jengka work will be taken as a guideline and strict adherence to the Client's scope of work is essential.

ENUMERATION SUPERVISOR

Will be responsible for the day to day field control of the rentis and inventory parties to the Forest Liaison Officer.

TIMBER SPECIALIST

To advise on the development potential of the region, advise working plans, new forest industries inclusive use of fast growing species, processing and marketing, infrastructures and advisory services.

1. Review data, and all available information inclusive report of the inventory conducted, consult with Government and Trade and assess potential.

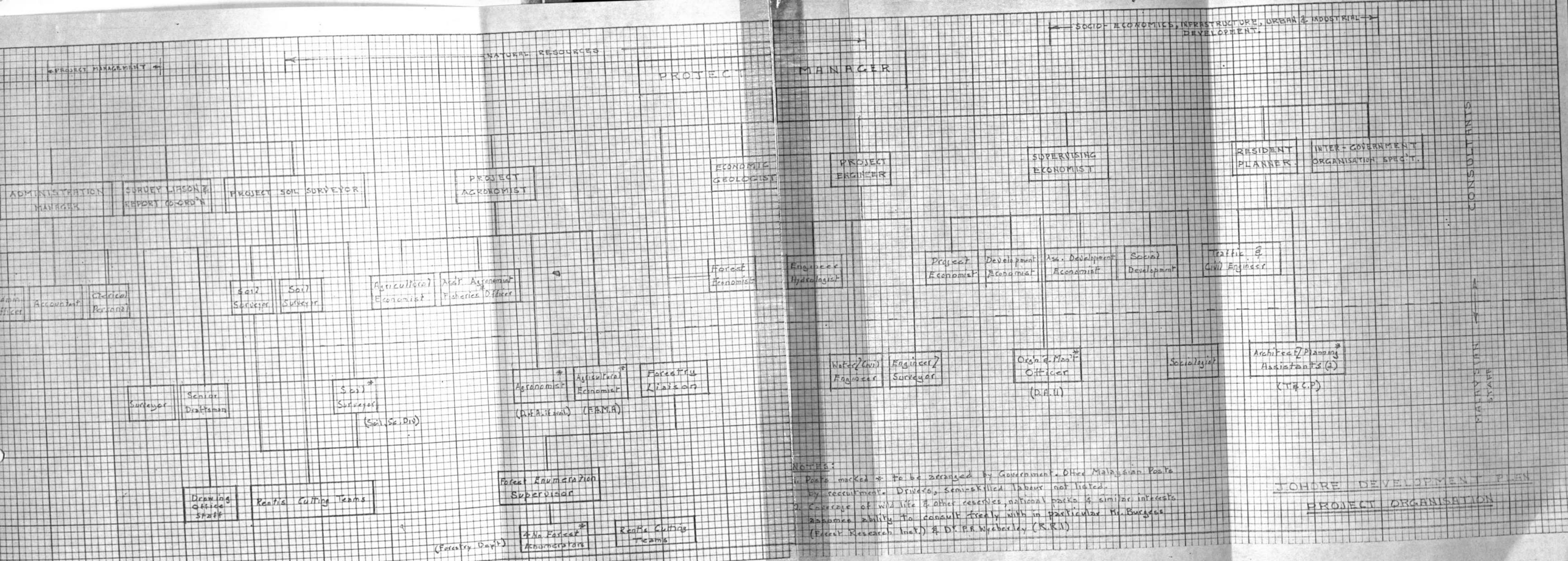
2. Submit proposals for exploitation of all usable stands as mapped by the inventory with advice of C. F. I. and discuss with Forest Economist and Government.

3. Prepare 'Draft" detailed report for the optimum development of forest industries including the provision of financial and institutional incentives, policy changes where appropriate and possible supply of timber for pulp and paper products and other forest industries.

ECOLOGIST (Wild Life and National Parks) - BOTANIST (Special Communities)

To be responsible for studying and reporting on the location and nature of animal communities in the project areas. To recommend the means by which communities of special interest could be regulated and contained so as to retain their natural balance. To make recommendations as to the location of specific enterprises such as Wild Life Reserves and National Parks together with an assessment of the financial costs involved.

The Botanist would be responsible for studying and reporting on the location and nature of plant communities of special botanical interest. He will make recommendations concerning the maintenance of the environmental habitats involved, including their incorporation into special reserves and National Parks.



NOTES:

1. Posts marked * to be arranged by Government. Other Malaysian Posts by recruitment. Drivers, Semi-skilled labour not listed.
2. Coverage of wild life & other reserves, national parks & similar interests assumed ability to consult freely with in particular Mr. Burgess (Forest Research Inst.) & Dr. P.R. Wycherley (R.R.I.)

SOIL SURVEY PROGRAMME.

Immediately after arrival in Malaysia discussions to be held with:

a) Dep. of Agriculture, Soil Science Division (Panton & Law Wei Min etc), arrangements to be made for field excursions to familiarise team with Malay soil series. Also to be discussed lay out of rentis lines and programme of soils investigation and chemical analyses.
All relevant field data, soil maps and aerial photographs required from Dep. of Agric

b). E.P.U., discuss survey plan.

Tanjong Pengerang Survey Area

Actual rentis lay out to be decided on the base of:

a) previous surveys done
b). areas of low agricultural potential will have lower observation density.
c). steep land ~~for~~ may be excluded.
d). swamp land observation density 1 / sq. mile.
e) aerial photo interpretation.

Base lines could be turned 45° (see access map, 4 miles to 1"), so that these run NW – SE. for easier access. To avoid crossing a rentis twice rentises should be not longer than 2–3 miles, where needed extra access lines parallel to the base lines should be cut.

Tanjong Pengerang Area total	330,000 acres
Area unsuitable for agriculture	80,000 "
Area to be surveyed	250,000 "

Total to be surveyed 250,000 acres or 390 sq. miles.
Overall observation density, semi detailed survey
12 sites per sq. mile.
Total number of observation sites 4680.
Total length of rentis will be based on ½ - ⅓ mile interval depending on agricultural potential and soil pattern.
Distance between observation sites along rentis ⅛ - ⅓ mile depending on the complexity of the soil pattern.
(10 chains = ⅛ mile = 200 metres).

Since field work has to be completed in 9 months work load to be shared as follows:

1.Y. soil correlation + liason with ~~Dept~~ Dept. of Agric.	700 + 750	obs. sites
DAH	1350	1327 " "
RDT	1350	1327 " "
F.W. or Roberts	1350	1327 " "
	4800	4681 obs. sites

NB.: based on a soil survey month of 20 days per month 148 (150) recorded observation sites have to be completed (per surveyor/month) in the field.
Profile pits and soil correlation discussions are included ~~in the office~~ aerial photo-interpretation

A pre-field will be carried out overseas, followed by a detailed survey of not more than 3 sample areas (size ? sq. miles), to enable the team to standardize survey methods and texturing, and familiarise themselves with the West Malaysian soil classifica

Johore Tengah Survey Area.

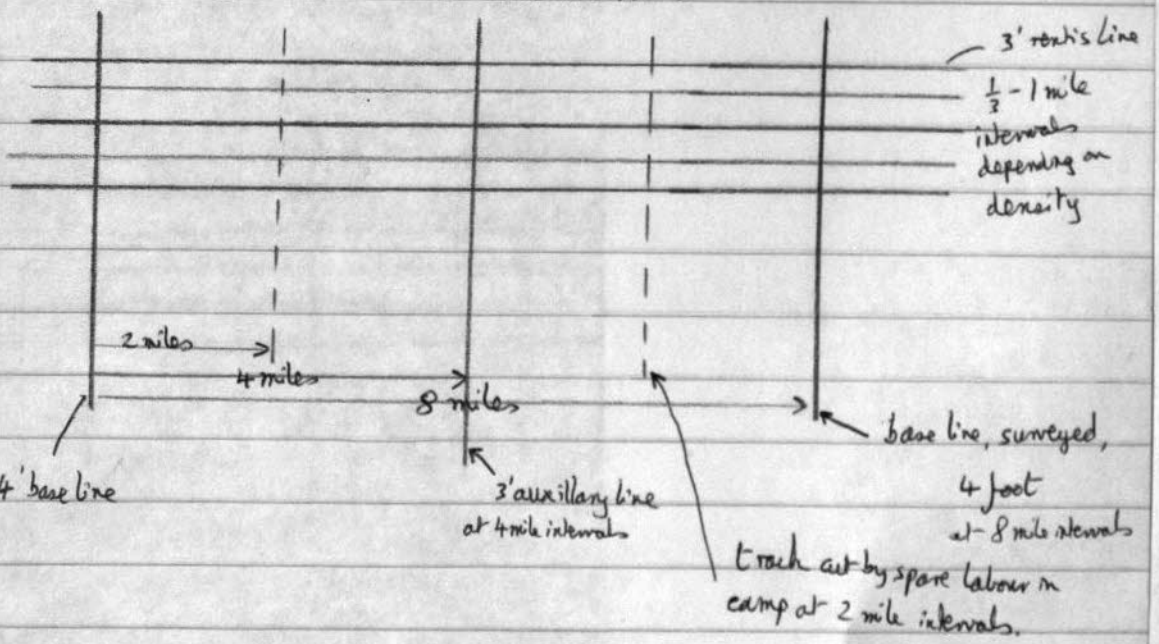
Total area 370,000 acres, soil survey on some detailed level completed over 150,000 acres. The remaining 220,000 will be completed during 1969.

For this area no survey is required, only field checks of confirmatory and familiarising nature are needed. No extra time needs to be budgeted for this purpose.

1 man/month at least

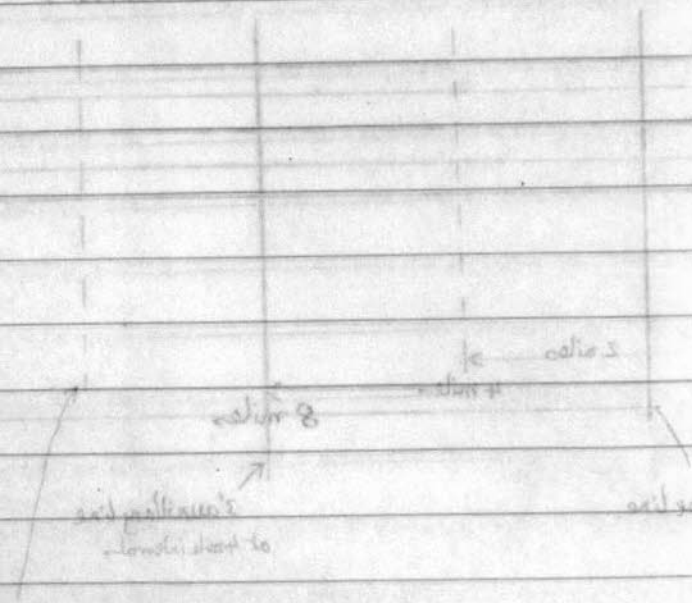
Survey procedures

- It is proposed that only one field survey team operates. This reduces difficulties in correlation and co-ordination, and expenditure on camp equipment. Administration from base is simplified. ~~and~~ In general, 3 surveyors will be in camp at a time. 2 to 5 miles of rentis can be surveyed per day, depending on density, but generally ~~3~~ miles would be ~~the maximum~~ average, ~~(2 miles out, 2 miles back, provided access lines and base lines at 2 mile spacings)~~. with 9-12 bores at a maximum. It is proposed that two surveyed base lines are cut, NW-SE, 8 miles apart, with auxillary lines of access at 4 mile intervals. Spare labour in camp can then be used to cut tracks at 2 mile intervals



A team of 3 surveyors has 15 labourers, needed for porterage during camp shifts, + 1 cook. 6 labourers only (2 per surveyor) are required on soil survey, leaving 9 spare. With 2 left behind in camp ~~for~~ with the cook, for watching, carrying water, dhobi, leaves 7 spare men to cut access tracks as required.

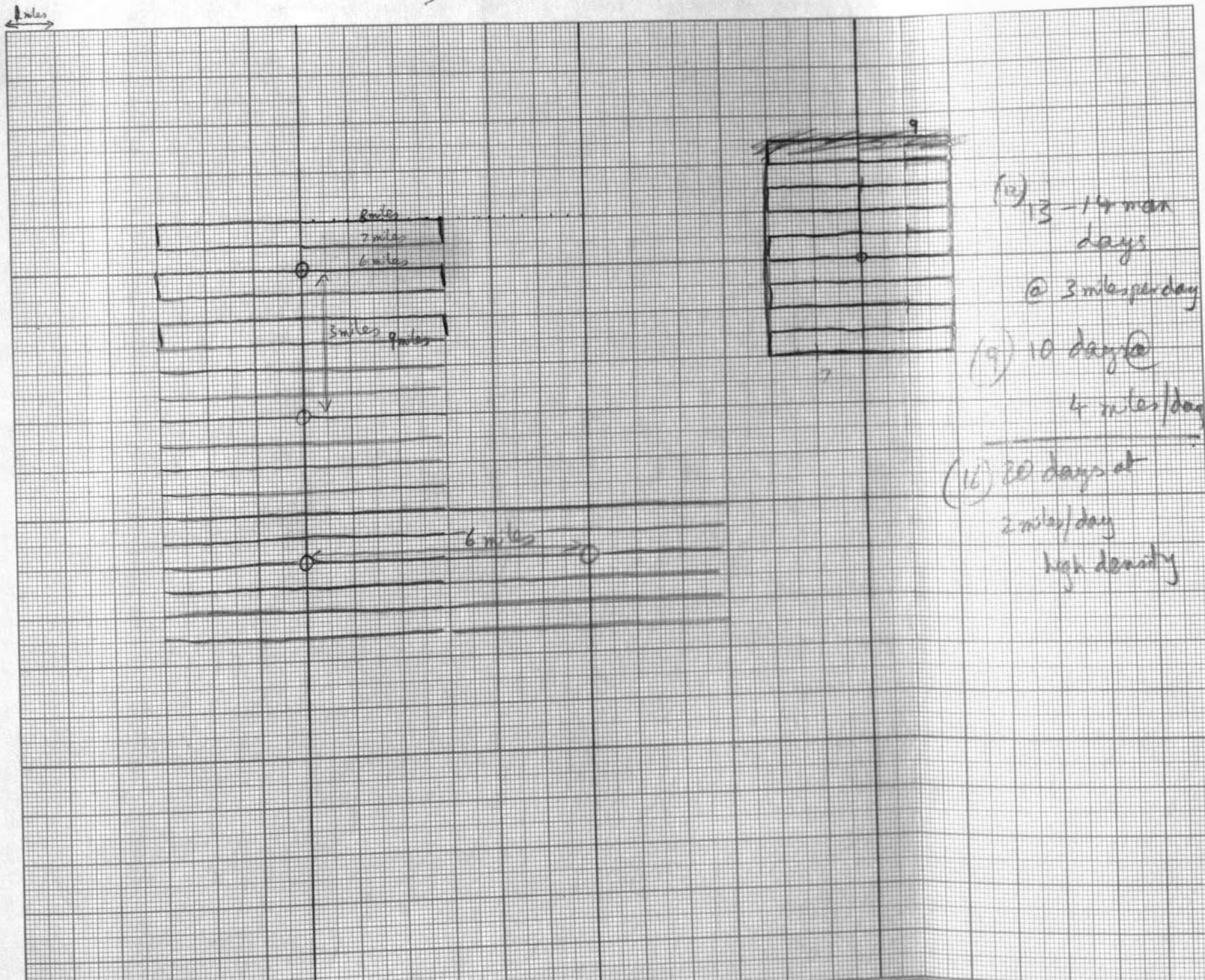
Surveying procedures



JCE/DKS

6
12 man/days per campsite @ 2 surveyors per camp = 6 working days

3 " " = 4 "

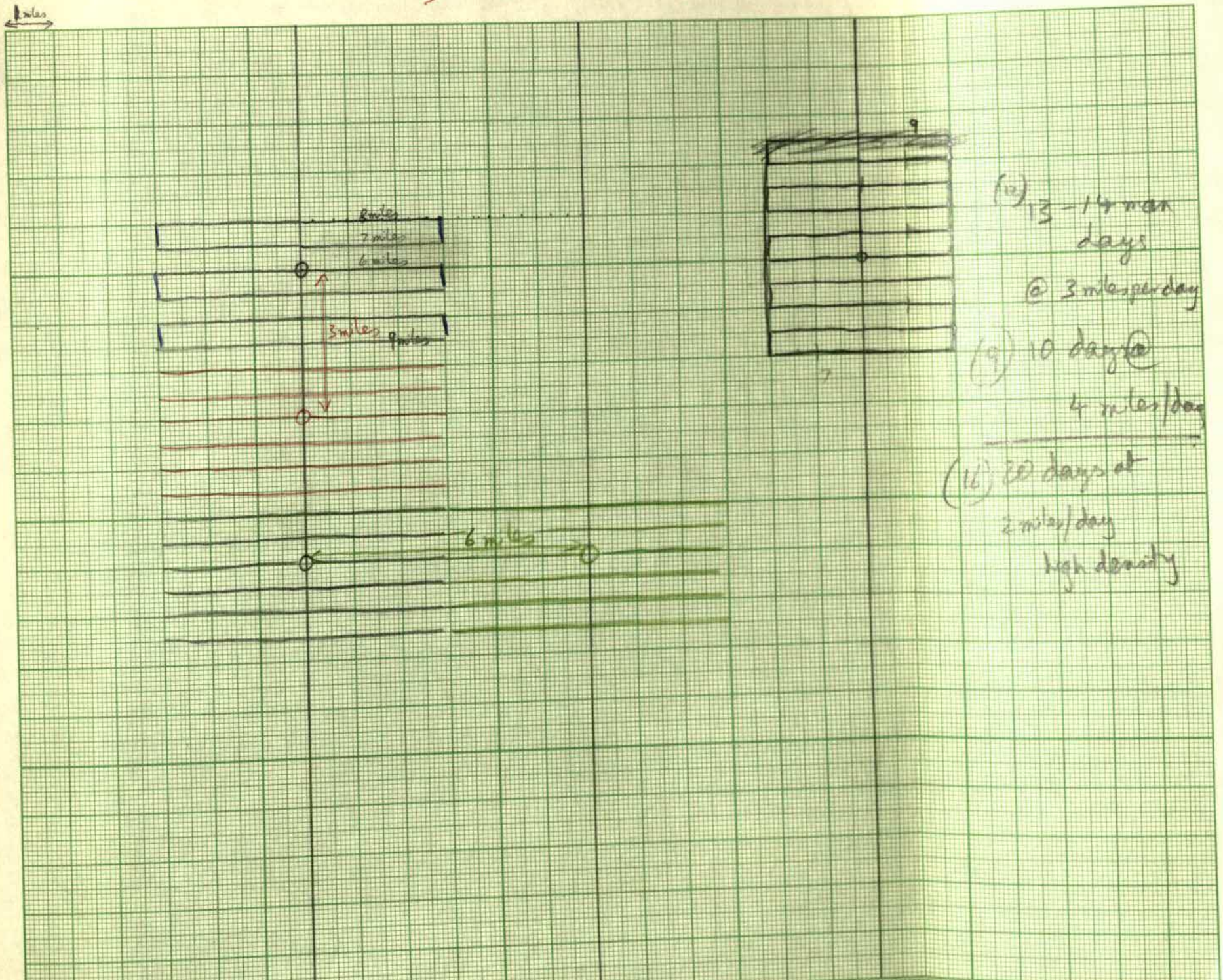


(i) 13 – 14 man days @ 3 miles per day

(ii) 10 days @ 4 miles/day

(iii) 20 days at 2 miles/day high density

12 man/days per campsite @ 2 surveyors per camp = 6 working days
6
3 " " = 4 "



(a) 13 - 14 man days @ 3 miles per day

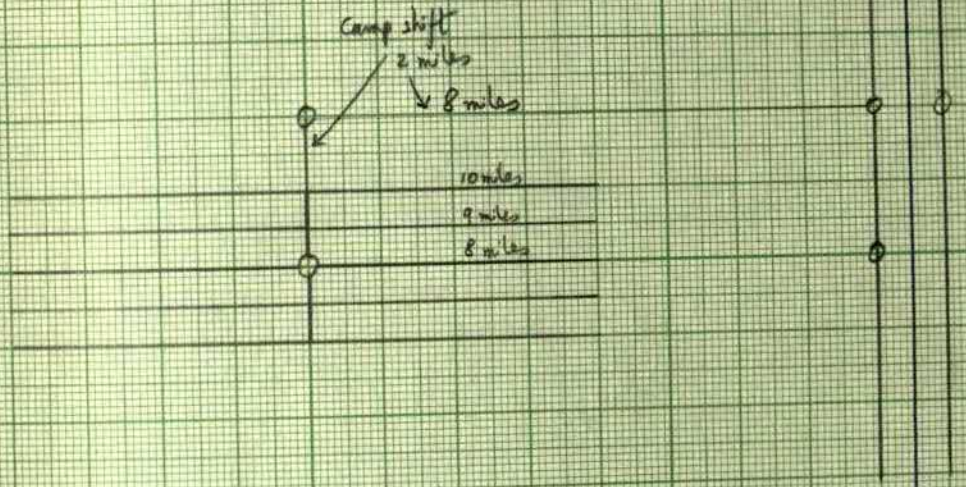
(b) 10 days @ 4 miles/day

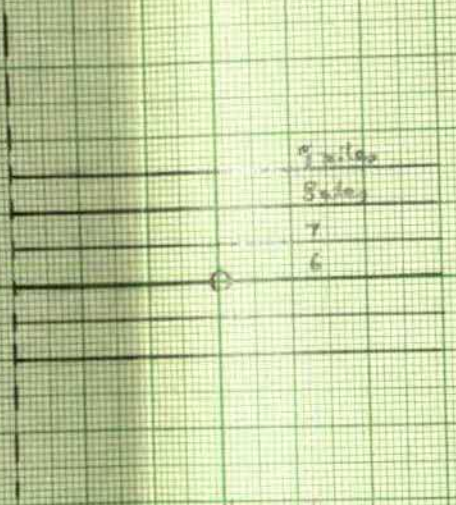
(c) 20 days at 2 miles/day high density

O = campsite

Horizontal lines = surveyed rentis ; Vertical lines = access along base/access line

1 mile





Case 1. Base/access lines 8 miles apart.

Camp shift along base line 2 miles

4 miles surveying + up to 6 miles walking per day.

4 miles = 12 to 24 bores per day

10 man days per campsite

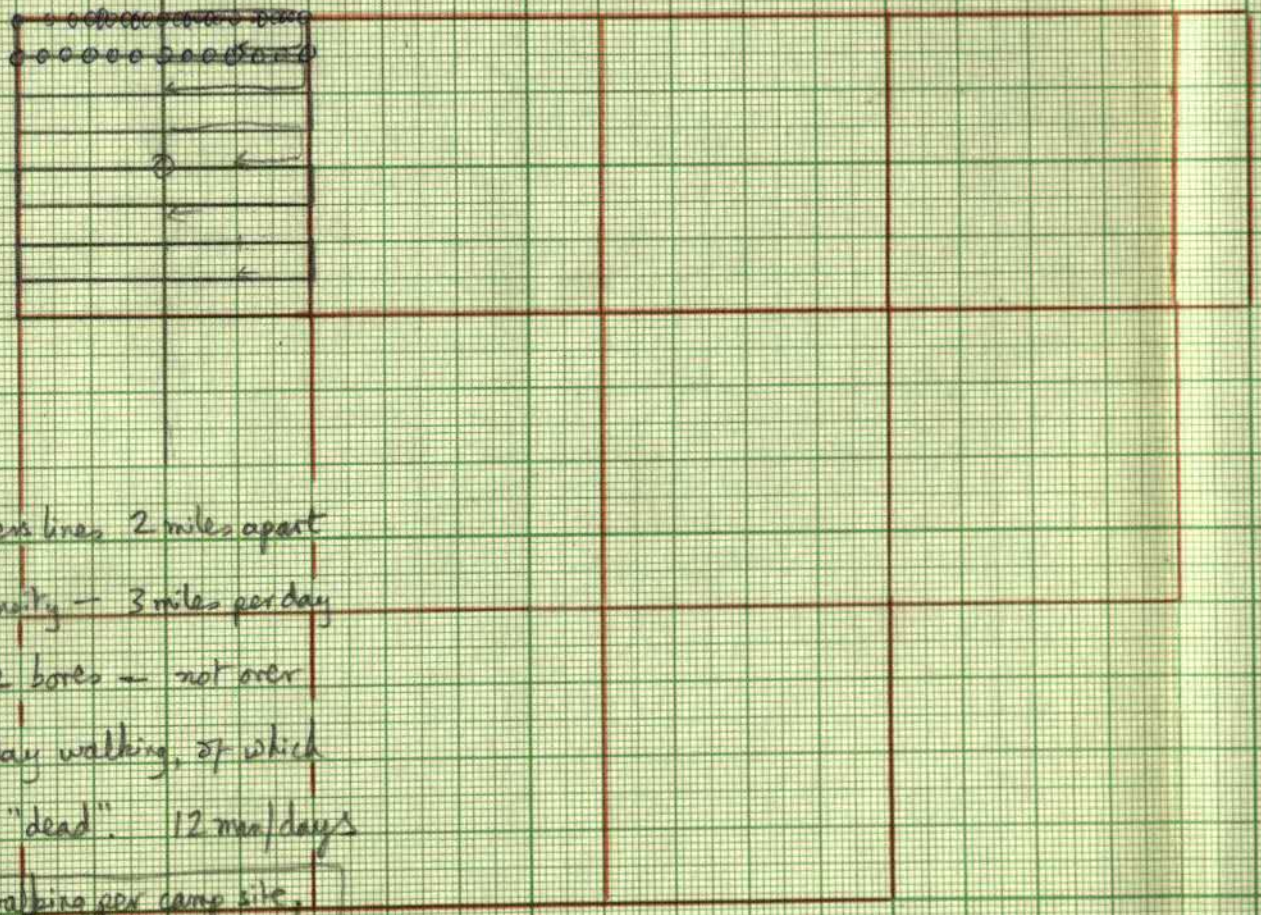
Too much "dead" walking, 12-24 bores a day too high, no relief when rain stops play

Case 2 Base/access lines 9 miles apart

High density areas, 3 miles surveying per day (9-18 sites) + 6 miles "dead" walking. (access lines 6 miles apart)

Low density areas, with 3 mile access lines, 6 miles surveying per day (6-18 bores), with up to 6 miles "dead" walking.

6-12 man days per campsite



Base/access lines 2 miles apart

Average intensity — 3 miles per day

with 9 - 12 bores — not over

8 miles a day walking, of which

5 miles is "dead". 12 man/days

~~20~~ miles walking per camp site.

36 miles surveyed

max 8 miles per day, 9 bores.

ILAY

JCE/FAS
ILAY
JVH
WCS/ASM
From CBE
Date ; 14/4/71

Clearing and the use of residual timber

1. This is the first part of section 4.2 of Volume 5 -'~~fp~~Forestry and Conservation' . Please read, comment and pass on quickly. Do not edit -- this is the first of 2 or even 3 drafts. A small amount of further work will be done on residual timber and land clearing capacity. Recommendations and phasing will be contained in sections 5.1 and 5.2 Section 4.2.4 will contain some more stuff on the use of res. timber for reconstituted wood products.

2. Comments please from the following on the following;

JCE/FAS - on all the section but esp. on capacity , phasing, and methods . Should FLDA's comments be obtained?

ILAY - comments on page 5 - soil effects - please?

JVH/WCS /ASM - should this volume 5 be called Forestry and Land clearing? If mechanical clearing is adopted under a Department such as the proposed Settler Dev.Corps, this could be a possible aid project. Should this be mentioned to Suleiman? What connections if any with the DEv. Coppn. ?

4.2 The economics of land clearing, logging and timber processing

This section discusses the economics of the processes listed below:

1. Land clearing and the use of residual timber
2. Logging
3. Sawmilling
4. Further processes

These are then followed by a general discussion and summary. The information is presented with reference to conditions in Johor but, with the exception of transport costs, the information is applicable to conditions in West Malaysia. The information on costs and selling prices contained in these sections has been used in the sections on implementation in Johor Tengah and Tanjong Penggerang, and the discussion of costs, particularly capital costs, has been based on the sort of annual capacity ranges likely to be encountered in logging and sawmilling operations in the South East Johor regions.

4.2.1 Clearing and the use of residual timber

The alternatives described - The traditional method of land clearing in Malaysia has been by hand; the stages of the process are described in Chapter 1 of Bevan, Fleming and Gray (1966). Recently, following some experimental promotional work done by Tractors Malaysia, land clearing using bulldozers had been proved feasible. The stages of this 'mechanical process are:

- Bulldozers clear and fell trees up to 4' 6" girth.
- Trees over this size are felled conventionally
- The timber is left to dry for about 3 months.
- Bulldozers stack the timber in windrows which are then burnt and reburnt.

Financial Cost Comparisons

Costs of land clearing differ significantly between areas of the country; prices are higher for example, in Pahang, where higher rates must be paid to attract labour and where vehicle servicing would be more expensive, than in Johor.

Costs of mechanical clearing will also be affected by the type of terrain and stand of forest. Bulldozers would work more slowly in wet ground and on steep slopes; more hand felling would need to be done in virgin jungle. The Johor Tengah inventory suggested that there would be 15 true tons of timber remaining in trees of over 4' girth after conventional logging; whereas in secondary jungle, as in Tanjong Penggerang, very little land felling would be needed. In one area mechanically felled in Ayer Tawar II there was little sign after the burn that the area had been under jungle at all.

The following table sets out figures based on quotations received by FLDA for clearing secondary jungle in Johor;

OIL PALM

Mechanical	$ per acre	Manual	$per acre
Cut to ground level	60	Fell	60
Stack & burn	40	Burn	5
Restack & reburn	35	Prune, Stack, reburn	47
Construction of Jeep Tracks $6 per chain in machine cleared area at 1 to 1.5 chains/acre	8	Construction of Jeep Tracks $7.50 per chain at 1 to 1.5 chains/acre	10
		Cut and remove timber at:-	
		(1) planting points 60 x $0.25	15
		(2) harvesting paths $1.00 per chain at 10-12 chains/acre	11
	143		148

RUBBER

Mechanical	$ per acre	Manual	$ per acre
Cut to growth level	60(1)	Fell	68
Stack and burn	40(1)	Burn	5
Restack & reburn	35(1)	Prune, stack, reburn	50
Construction of Jeep Tracks $6 per chain in mechine cleared area at 1 to 1.5 chains/acre	8	Construction of Jeep Tracks $8 per chain at 1 to 1.5 chains per acre	10
		Removal of timber along interraced planting rows $1.40 per chain at, say, 32 chains per acre	45
	143		178

(1) Same as oil palm estimate; separate figures not available.

Two points should be noted concerning these estimates:

(i) They make no allowance for manual felling of large trees on mechanically cleared ground. In the area in question, there are very few large trees; but in virgin jungle there would be up to 15 tons (true measure) of trees over 4' girth; current felling rates are between $2 and $3 per ton[1]. The whole of this cost would have to be added for mechanical felling; it is not clear whether such a large addition would have to be made for manual clearing.

(ii) The rubber land clearing estimates assume no land is terraced; if some land is terraced the cost differential is likely to be reduced.

The first point is an important one; available estimates for mechanical clearing are as follows:

Source	State	Cost ($ per acre)
Quotation for FLDA	Johor	143
Sungei Tekam[2]	Pahang	268
Bukit Garam[3]	Sabah	239

(1) Confidential information from FLDA

(2) Sungei Tekam Project; Report and Analysis; Tractors Malaysia Bhd.

(3) Bukit Garam Land Clearing Project; Final Report; Tractors Malaysia Bhd.

The Johor area had virtually no large timber in the area whereas the Pahang and Sabah areas both contained some large trees. But the information seems to suggest that

(i) in secondary jungle mechanical clearing is slightly cheaper than manual clearing;

(ii) in primary jungle and on wet ground the attractiveness of mechanical clearing is reduced.

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(1) A tree of 6' girth and 80' long has a volume of 5 timber tons.

Other considerations

The financial costs are not however the only considerations. Some additional factors such as employment and soil effects tend to favour manual clearing whereas others such as speed of clearance and overseas agency financing tend to favour mechanical clearing. These are therefore considered in more detail below.

Soil effects

Mechanical clearing is likely to adversely affect the physical structure of the soil by sealing the surface and encouraging erosion. However the precise effects are not known. (Reen's comments please - should we recommend MARDI - Selati ya and the in soil effect on soil of logging on slopes of 20° + ...
do research?)

Speed of clearing

Some FLDA officials said that they prefer mechanical clearing to manual clearing for the following reasons:

(i) Mechanical clearing is faster;

(ii) Mechanical clearing is "cleaner" making lining easier and reducing difficulty of movement across the land to be planted.

Why not?

Neither of these arguments is particularly convincing; in both mechanical and manual clearing the timber is left to dry for up to 3 months before burning although it was said that the burning of mechanically cleared land can go on during the wet season whereas the burning of manually cleared land cannot. There seems to be no reason why the number of people employed on manual clearing should not be expanded to meet a specified target but this point is discussed later in this section in connection with capacity.

Financing by an overseas agency

It may be easier to get overseas aid for a mechanical land clearing programme than for a manual land clearing programme, since the mechanical programme will be more foreign equipment intensive[1]. If Malaysia wants to meet a specified target of overseas financing but cannot produce a long enough 'shopping list' then it might be sensible to obtain foreign financing for the mechanical land clearing programme and expand employment by faster locally-financed land development. *

Employment

In West Malaysian conditions of ~~extensive~~ un- and under-employment, a project employing more labour, particularly unskilled labour, will be preferable to one employing considerably less labour, other things being equal. As has already been pointed out, it is not certain whether other things are equal, but it is clear that manual clearing is very much more labour intensive than mechanical clearing. More than 80 percent of the cost of manual clearing consists of wage payments to unskilled labour, whereas less than 10 percent of the cost of mechanical land clearing consists of wages to labourers. Labourers on land clearing receive a wage of about $6 a day, but if in the absence of this work, they would be unemployed, or producing very little, the cost of their labour to society is probably considerably less than $6 a day. If they would otherwise be unemployed and not contributing anything to production, the cost of their labour to society (social cost) is nil (see also Volume 10 - Objectives and Appraisal Methods - for a fuller discussion of this point). If therefore their wages are deducted from the costs of clearing, the cost of

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[1] The capital equipment requirement for mechanical clearing is likely to be about $250 per acre per annum. That is, for an annual programme of about 20,000 acres, the capital requirement would be about $5 millions.

* Hood tells me that Perm is the agency for Tractor Malaysia.

manual clearing is likely to be less than half that of mechanical clearing.

Manual clearing requires, according to Bevan, Fleming and Gray (1966 - page 3), something like 16 man days per acre cleared. According to experience on Ayer Tawar III, the requirement was about 18 man days per acre. For mechanical clearing, on the other hand, the labour requirement is only about one and a half man days per acre. Put another way, for every 10,000 acres cleared over a period of say a year, manual land clearing creates about 600 jobs, whereas mechanical clearing creates only about 50 jobs over the same period.

Problems and alternatives

Employment considerations therefore suggest that land should be cleared manually. But if this is done there will still be some problems;

(i) if the land is cleared by a contractor, manual methods will need to be specified since mechanical methods are in financial terms marginally cheaper;

(ii) if manual methods are used, FLDA should probably pay the difference between the manual and mechanical costs rather than pass on the whole of the cost to the settler;

(iii) if manual methods are specified, contractors may find it difficult to provide sufficient capacity either in the form of unskilled labour at a wage of $6 per day or in terms of supervisory labour[1]. Rather than delay the land development programme, it will be better to adopt mechanical methods. On the other hand it may be possible to meet the target by expanding the FLDA youth brigades (see Volume 4.5 - 'Youth')

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1 Supervisory requirements are not however very extensive; two foreman were employed on each of the Ayer Tawar III operations, (manual and mechanical), both of which were clearing at an annual rate of about 3,000 acres.

into what have been termed Settlers Development Corps (see file J.27). Whichever method is used, FLDA should attempt to make their land clearing requirements known well in advance so that contractors can make the necessary preparations. This is particularly important where mechanical methods are being used;

(iv) the Draft Project Report stated that there is a considerable tonnage of what was described as residual timber in both the South East Johor regions. (see 2.1.2 and 2.2 of Volume 1). It was thought that in ~~JP~~ Johor ~~Tengah~~ Tanjong Penggerang this might be exploited in conjunction with land clearing and therefore reduce clearing costs, whereas in ~~JP~~ Johor Tengah the exploitation of residual timber could either be combined with conventional logging or again be combined with clearing. However the report also stated that little was known about the extent to which this timber could be processed and sold, and a "chipping" study and blockboard trials were recommended as matters of urgency (see section 4.1 of Supporting Report IV to the Draft Report). These recommendations were however rejected and in the absence of such studies, the potential use of 'residual ' timber is still uncertain.

Residual timber logging and land clearing

The definition of residual timber will depend on current logging and timber processing practices. What is residual timber and whether it is used depends on how intensively acceptable species are used, which species are acceptable, and therefore on how much timber of various species remains after the extraction of the acceptable species.

The issues can best be clarified by discussing the South East Johor regions separately. In Johor Tengah about half the area which is under forest but which is to be cleared for

agriculture contains conventionally marketable timber. The remaining half is more or less in the same state as the whole of the forest area in Tanjong Penggerang - that is, it contains no conventionally marketable timber.

In those areas where no conventionally marketable timber exists but which are to be cleared for agricultural development - about 83,000 acres in Johor Tengah and 106,000 acres in Tanjong Penggerang - the total volume of timber of 2 feet GBH and over is about 4.7 million tons tv. About 2.5 million tons is in Johor Tengah and 2.2 million tons is in Tanjong Penggerang. The density per acre varies from about 10 to over 30 tons tv per acre[1]. (see section 2, Chapter 2, Supporting Report IV, Draft Project Report).

The sole operator engaged in harvesting and chipping rubber wood for export to Japan has expressed interest in handling the residual forest in the project area at a rate of one million tons of chips per annum. A plant is being installed for handling rubber wood alongside the new port area in Johor Baharu which could handle the production from Tanjong Penggerang. Residual timber from the Johor Tengah region would probably best be chipped in a new factory located at the proposed New Town.

At present rubberwood[2] chips are being exported at a price of about $38 per cubic ton but little is known about import prices in Japan, costs of chipping and transport, and prices paid to plantations and smallholders for rubberwood. Even less is known about the market, prices and chipping costs

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[1] The yield of rubberwood is also between 10 and 30 tons t.v. per acre.

[2] For a discussion of the uses of rubberwood, see "Timber of Old Rubber Trees", P.R. Wycherley, Scientific Malaysian, No.1, July 1968.

for tropical hardwoods, but it seems that all except the very hard hardwoods such as keranji, kempas, derom and chengal can and are being chipped.

Clearly in the absence of further information, it is difficult to identify the extent to which clearing costs can be reduced by selling or processing the residual timber. But if a company such as Daishowa or Associated Pulp and Paper Mills Ltd. were to pay, say, an average of only $3 per ton tv[1], the average revenue price per acre based on an average utilisable yield (excluding the unchippable species, and defective logs) of say 10 tons per acre would be $30 which is equivalent to more than 20 percent of the clearance cost. This saving would at least be equal to the cost of felling these trees.

Clearly either the Forest Department should do further research into this potential or FLDA themselves should when clearing land see whether the residual timber is likely to be worth anything. Having then established an average price for such timber, FLDA could then negotiate a standard clearing charge with a contractor for a large area or could negotiate for each block on the basis of an inventory done by FLDA for that particular area. But in the absence of further studies, it is impossible to make any further recommendations beyond those made in the Draft Report (but see also Section 4.2.4 of this report).

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[1] At a selling price (fob - Johor Baharu) of $38 per ton, a chipping cost (including capital depreciation and profit) of $20 per ton, a total transport cost (including handling and port charges) of $10-15 per ton, the price payable to the clearance contractor at the clearance site would be about $3 to $8 per ton.

Tentative.

Two main points on residual timber:-

(a) Do we have any idea of the additional cost in clearing of felling separately, hauling trimming and stacking of timber to be taken for chipping.

(b) Haulage and road capacity problems. The Semenchu area S. of Ayer Tawar will be cleared this year and amounts to c 7000 acres. This I would think from inspection would have at least 20 tons per acre of usable timber or 140,000 tons in all. Felled over the October - January period this means about 1400 tons per day to be hauled or c 280 lorry loads per day. Could the Ayer Tawar road system stand this traffic during the N.E. monsoon wet period? More generally could we expect to extract this residual timber without a completed highway to the edge of the area being cleared. This will occur in Tengah with the phased logging programme, but not in Penggatarang in the S.M.P. period, with the possible exception of the St Wah Ha area.

check with Johnson.

9.C.E

Clearing and the use of residual tribes. - FAS.

p.3. The difference between costs of manual felling of primary/secondary stock/reborn - between rubber & oil palm presumably reflects the difference in terrain on which those crops are grown. This difference should also be reflected in mechanical clearing - vide statement on p. 2.

p.4. The mechanical clearing quotes are for Ayer Tawas. ~~Does~~ Could you check with FELDA That there were no special circumstances attached to this. I got the impression from S. Singh That there might be in this particular situation.

The high costs of mechanical clearing in Sungai Tekam & Bukit Goram may be influenced by the relative inaccessability of these two areas.

p.5. Agree That research is necessary on soil effects. Sungai Tekam is having some difficulty with grass establishment on mechanically cleared slopes - low Tree crops should not be affected so much - if at all noticeably.

The arguments for mech clearing are certainly convincing to a manager with a very tight annual schedule or a high target