Report No.60

Report on a Semi-Detailed Soil Survey
of the

NONOK COASTAL AREA

1st. Division

by
J. P. Andriesse
(Soil Surveyor)

September, 1964.

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Dept of Agriculture
Sarawak

REPORT ON THE SEMI-DETAILED SOIL SURVEY OF THE NONOK COASTAL AREA (Area 60) - 1ST DIVISION

by
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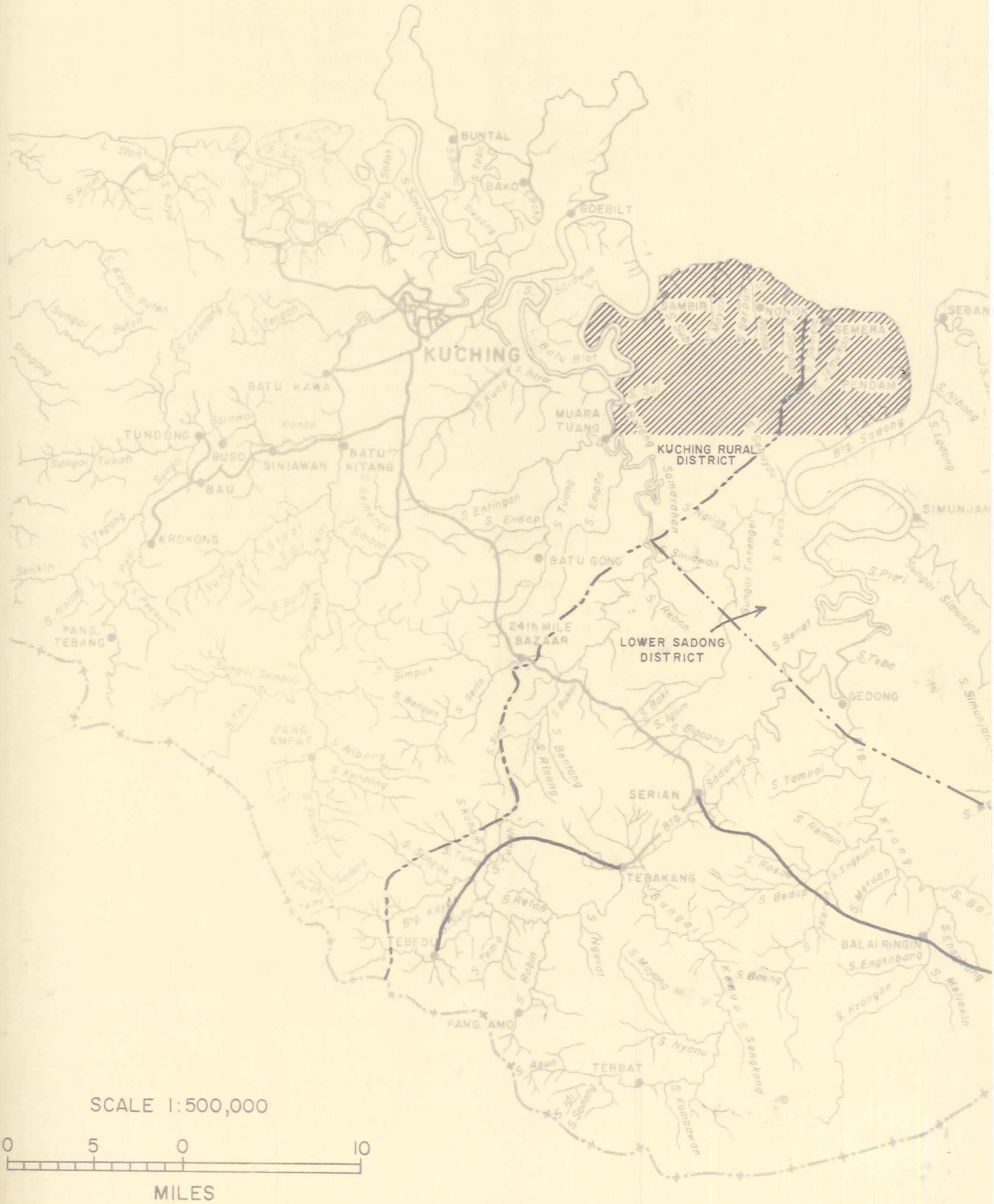
In folder: Soil map of Nonok Coastal area, (drawing No. 103a)
Land Use map of Nonok Coastal area, (drawing No. 103b)
Topographic map with Survey Data, (drawing No. 103c)
All maps on scale 1:50,000.

LOCATION OF NONOK COASTAL AREA



SUMMARY

A semi-detailed soil survey was carried out in the Nonok Coastal area (approximate acreage 82,000) with the aim of investigating the total acreage of land suitable for agriculture, assessing the acreage of land which could be reclaimed after realization of the bunding scheme proposed by Sir Bruce White and Partners, to comment on the use of peat land for agriculture and to recommend alternative crops to coconut and wet padi which are at present the main crops grown in the area.

The present acreage of suitable land for agriculture is approximately 20,000 acres to which another 10,000 acres can be added if reclaimed after bunding. Reclamation involves leaching of salts, preventation of further salt infiltration and the providing of drainage. Improved drainage is required for most of the area regarded as suitable for agriculture. The fertility status of the soils suitable for agriculture and those which can be reclaimed is high for Sarawak conditions and a capital expenditure of $150 to 200 per acre is considered justified if the conditions in these 30,000 acres of land can be ameliorated to such an extent that production can be greatly increased with modern farming methods involving proper cultivation, fertilization and possibly double cropping. Land reclamation should be followed by planned land use possibly involving the introduction of new crops such as citrus, bananas and coffee and the growing of annual crops on a larger scale than has hitherto been the case. An efficient land use aimed at making the most of the inherent fertility of the soils is a prerequisite for meeting the high expenses needed for land amelioration.

Cultivation on peat deeper than 3 feet is regarded as inadvisable in this particular area.

A Land Use map showing 1963 land use was prepared from air photographs and gives an up-to-date picture of the agriculture activities in the area.

Detailed conclusions and recommendations can be found at the end of this report.

REPORT ON THE SEMI-DETAILED SOIL SURVEY OF NONOK COASTAL AREA (1ST DIVISION) - SOIL SURVEY AREA 60.

by

J.P. Andriesse.

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PART 1

1. Introduction

Since before the last war the Nonok coastal area has been known as the Nonok Peninsula which name gives a wrong impression because the area does not show any of the typical characteristics of a peninsula. It is therefore suggested that the area be known under the name of Nonok Coastal area.

The Nonok coastal area as described in this report comprises all the land situated between the Batang* Samarahan and the Batang Sadong, north of a line drawn east from Muara Tuang meeting the Batang Sadong at Kpg. Nangeh (see location map). Although most of the land which would benefit by the proposed Nonok Development Plan (Dev. Plan 1964/68) is situated near to the coastline, for planning purposes and investigations the whole coastal area as defined in the former paragraph needs to be studied as one entity because it forms the catchment area for most rivers crossing the agricultural land fringing the coast, and drainage problems in this land are intimately connected with the drainage situation of the whole catchment area.

In 1955 a reconnaissance survey of this area was carried out by the Consulting Engineering firm of Sir Bruce White and partners, the object being to investigate the potential of the land for coconut and wet padi and to suggest improvements of the land by reclamation, drainage and irrigation. The recommendations for improving agriculture in the area centred around the constructing of a coastal bund to prevent salt water from entering the area and to provide adequate drainage in areas for which this was required. Mainly because of the high expenses of this scheme these recommendations could not be put into effect at that time. In recent years the scheme was again revived because the agro-economic structure of the area was rapidly deteriorating due largely to the following factors:

a. Salt water infiltration and drainage problems
b. Population pressure
c. Land tenure problems

It was therefore decided to declare the area a Development Area specifically on the recommendations of the Drainage and Irrigation Branch of the Public Works Department, and the development of the area was subsequently included in the 1964/68 Development Programme.

In order to avoid any confusion in interpreting conclusions drawn for the area as a whole or only part of it, the Nonok Coastal area is subdivided in two parts:

Part A: that part which should benefit by the proposed bunding scheme (vide Sir Bruce White Survey).

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* Batang - large river.

Part B: that part situated at the right bank of the Samarahan River falling outside this scheme.

In this report this subdivision has been used throughout.

2. Aim of the Survey

Although the area was previously surveyed at a reconnaissance level (Sir Bruce White survey, 1955, ref.1) a more detailed survey was found desirable for giving more information on the fertility of the soils and on the exact acreage of land suitable for agriculture, especially of that land which would be reclaimed after the coastal bunding, and to give recommendations on the suitability of the soil for crops other than coconut and padi so as to ensure efficient use of potential land resources.

The Drainage and Irrigation Engineer in his Tour Report on the Nonok Peninsula Development Area (ref.2) made a specific request for this survey and for comments on the peat area that could reasonably be cultivated.

3. Itinerary of the survey

The Soil Survey commenced on 1st April, 1964 and was completed by the end of May. Due to persisting bad weather conditions soil sampling proved to be unsatisfactory because of the very high water table and frequent inundations of the area. It was therefore decided to proceed with soil sampling later on in the year when the water table had subsided. Soil sampling in certain areas became the more important after it was found that layers of catclay occurred in the soil. These could become dangerous to crops if drained and exposed to air.

A preliminary report on the uncompleted investigations was issued at the end of May and the writing of a full report was postponed pending the full results of the analytical work carried out on the soil samples.

Soil Survey Assistants Rosli bin Sahari and Michael Chua led the field parties for most of the time.

4. Methods of surveying and accuracy of maps.

Prior to fieldwork air photographs were studied and a Land-Use map prepared. The 1963 photographs taken by Lands and Surveys were extremely useful but unfortunately they did not cover the whole area while the overlap of the two runs was rather small and sometimes absent.

The land-use map presented in this report is based for the greatest part on these 1963 photographs; only for areas opposite Muara Tuang and that between Pendam and Nangeh were boundaries filled in entirely from field observations which are necessarily less accurate because of interpolation between rentises.

The Mangrove and Nipah forest areas fringing the coast and the rivers were mapped mainly from air photographs and rentises were only cut for checking purposes.

The clay soils situated behind the Mangrove and Nipah forest being rather homogeneous in character, were mainly surveyed along existing paths while for the muck and peat areas rentises based on a grid pattern were cut, rentises being approximately 1200 yards apart. This allowed positioning of boundaries of muck and peat soils of varying depth more accurately than given in the report on the reconnaissance survey by Sir Bruce White for which much interpolation was used.

Records of depth of water tables at all observations points were kept but they are unreliable because the water table fluctuates according to rainfall and tidal flow in rivers and drains. For the same reason drainage phases in soil series, although distinguished, could not be delimited.

Salinity was measured with a Portable Conductivity meter in the later part of the survey when samples were collected (July) but salt levels fluctuate and only reflect the situation in that month.

PART 2 - GENERAL DESCRIPTION

1. Topography

The Nonok Coastal area is situated between latitude 1°27' and 1° 35'N. and longitude 110° 29' and 110° 45'E.

The northern boundary is formed by the China Sea while the western and eastern boundaries are formed by the lower stretches of the Batang Samarahan and the Batang Sadong respectively. The southern boundary is an arbitrary line drawn east from Kpg. Muara Tuang at the Batang Samarahan to Kpg. Nangeh at Batang Sadong.

The nearest town is Kuching at a distance of approximately 12 miles by air. Road communications into the area are non-existent, the only access being by sea or river. In the south a large peat swamp has prevented access by road from that side. Chinese launches are operating between the area and the outside world, but no fixed schedules are adhered to, the access from the sea being totally dependend on the tide and weather conditions.

Telecommunications are maintained with the one Police Station in the area, namely Nonok, but reception is generally poor (at least during the time of surveying).

The western part of the area is administrated from Kuching, it being part of the Kuching Rural District, while the eastern part falls under the jurisdication of Simunjan or Lower Sadong District. The boundary of the two districts is shown on the location map. It is mainly because of the difficult approach from the sea in the eastern part of the area that this part is administered from Simunjan, access being easier by way of the Sadong River.

In the past the bad communications have probably played an important role in encouraging neglect of the area. The administration of the area being in the hands of two separate districts has lead to haphazard development and lack of overall planning.

Apart from footpaths, which are unusable during the wet season, internal communications are maintained by small rivers and main drains while at the peak of the wet season when large areas are flooded communications are greatly improved as one can sail freely over the padi- and through the coconut fields.

The main centres of population are Sebandi Ulu, Sebandi Matang, Moyan Laut, Nonok Ulu, Nonok Laut, Semera and Jemukan while there are a further 19 settlements of secondary importance. The only market of any significance is Nonok Ulu bazaar, which is also the administrative centre where the police, health and agricultural offices are situated. A dresser is also posted at Jemukan for the eastern part of the area. The main Chinese school (Chung Hwa primary school) is also situated in Nonok Ulu (Bazaar).

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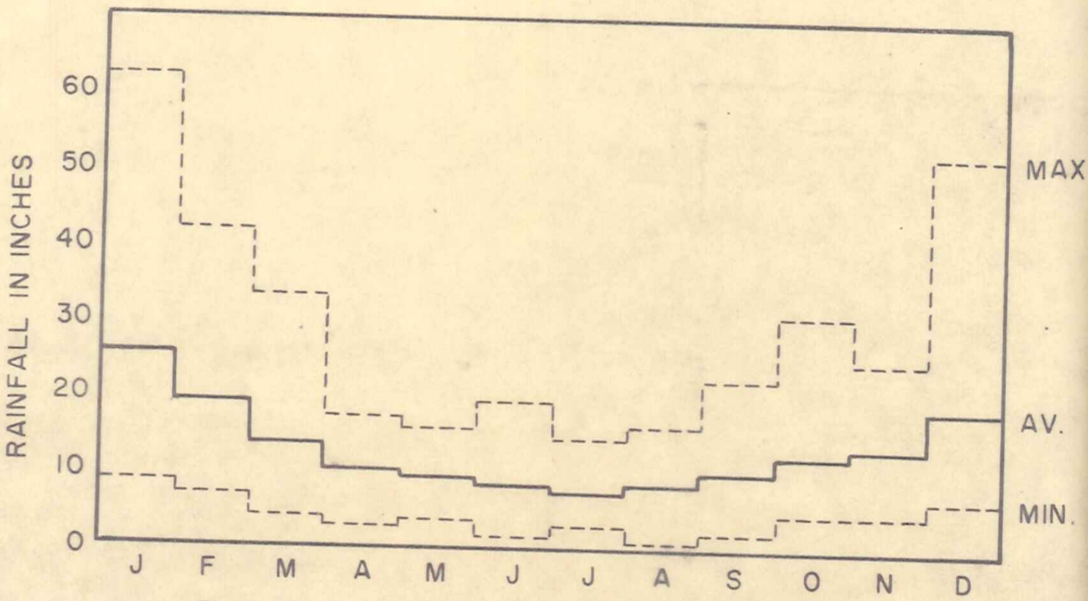

Fig. 1. Average and extreme monthly rainfall at Kuching over 71 years

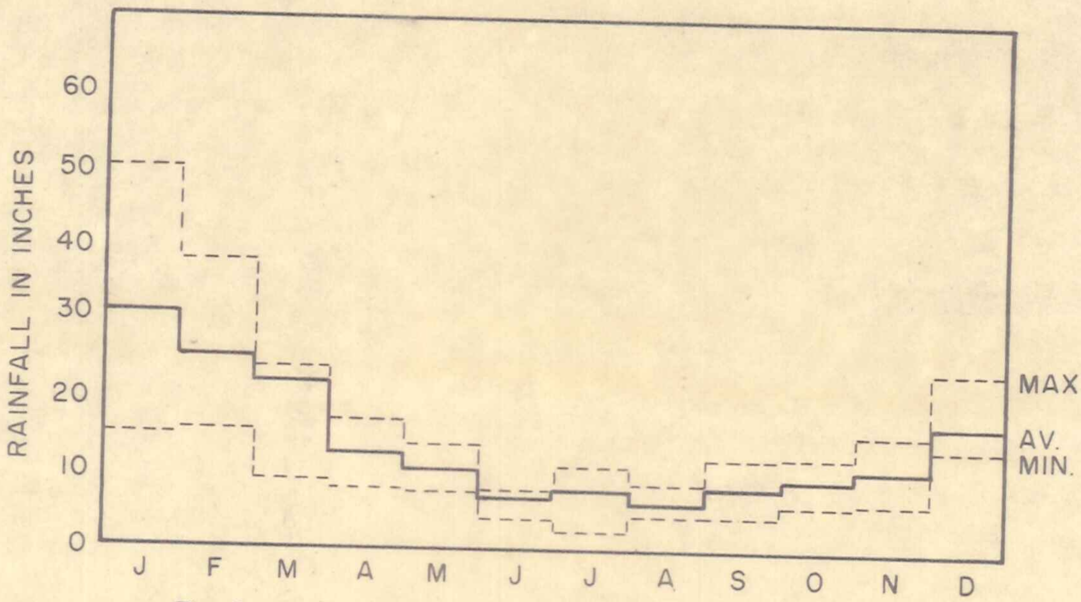

Fig. 2. Average and extreme monthly rainfall at Semongok over $4\frac{1}{2}$ years

2. Climate

There are no climate statistics available for the Nonok area, the nearest climatological station being that of Kuching Airport for which data is available over a period of 71 years. In addition some data is available from Semongok Agricultural Station but over a much shorter period.

The interpretation of this data for the Nonok area is difficult because it is experienced in Sarawak that rainfall in particular varies considerably over short distances. This may not be revealed by average monthly figures but it will undoubtedly be brought to light if e.g. rainfall were reported for periods of 10 days which is nowadays usually done, especially with a view to the agricultural significance of local drought periods or rainstorms.

This may also be the case for Nonok where it was observed during the survey period that many rainstorms bringing heavy rain to the Kuching area and other interior areas by-passed the coastal belt or the storm had rained itself out before reaching the coast. This may be the case in the dry season, but during the landas when the North West Monsoon brings heavy rain, especially in the Kuching area, the Nonok area will most likely receive the same amount of rainfall.

The Kuching rainfall statistics for the landas season can therefore be used for the Nonok area, while the figures given for the period April to November can only be used with reservation.

Figures 1 and 2 were prepared for the report on Semongok Agricultural Station (ref.8) and could be used for the Nonok area with the reservations discussed in the former paragraph. From these figures it can be observed that the yearly totals vary significantly and that it is impossible to make any reliable forecast on rainfall. The average rainfall for the months shows the same trend, and dry years may alternate with very wet years without any apparent cyclic trend. It would be a worthwhile effort however if the available rainfall statistics could be worked out in detail to see whether rainfall cycles are existent.

Rainfall in the area is important with a view to the planting of wet padi for which irrigation appears to be extremely difficult because of the non-availability of nearby sources of water and the awkward location of the scattered padi fields within areas used for coconut.

In Indonesia a rainfall of 60 inches during the growing season appeared to be the normal requirement of a padi crop, but this depends on moisture content of the air, evaporation and wind while soil permeability plays a role as well.

In the absence of any climatological statistics for the Nonok area it is impossible to say what the water requirement of a padi crop in this region will be and as sunshine, moisture content, and wind may vary significantly from Kuching, data from this station cannot be used for that purpose. It is however suggested that the total rainfall is adequate in most years and that rain-dependant sawah cultivation is possible. The biggest problem will probably be more a matter of how to drain surplus water than how to provide irrigation.

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These brief notes on the climate of Nonok area may take it abundantly clear how much is lacking in basic data, especially of this kind, and the impossibility of giving definite advice on agricultural problems if such data is not available. It is suggested that such data is collected for the Nonok area without delay. It is learned that the Drainage and Irrigation Branch of the Public Works Department is attempting to gather such information.

3. Geomorphology

The Nonok Coastal area forms part of a much larger coastal floodplain built up by the sediments of the Sadong, Samarahan and Sarawak rivers. The western part of this floodplain which at present drains the water of the Sarawak river shows deltaic features while the eastern part drained by the Sadong river shows estuarine features. The lower stretch of the Samarahan river draining the middle portion shows both features and probably was part of the Sarawak river delta in former times.

The middle portion of this coastal plain, namely that bordered by the Samarahan in the west and the Sadong in the east, which comprises the survey area, is of a non-complex morphology. Here the coast is formed by an exposed clay topset plain approximately 4 to 5 miles in width which slopes gently towards the sea and which continues as a submarine topset plain for a number of miles into the sea. Beaches are only existent in the eastern part (between Sampun and Jaie) where a cliff shore has developed and erosion is taking place. The remainder of the coastline is formed by a gentle dip towards the sea on which Mangrove and Nipah forest is different stages of development can be found and where deposition is taking place at a rapid rate.

All these features are typical for a coastal mudflat, the only atypical feature being the remnants of an old off-shore sand bar present in the extreme west (in the Sambir-Sebandi area) and the cliff shore in the east. It is suggested that the former part of the plain may have formed a section of the Sarawak-Samarahan river delta because more bars of this nature were found south of the Sambir bar but on the left bank of the Samarahan river. It is quite possible that the Samarahan river at one time drained into the present delta of the Sarawak river but that its mouth has shifted to its present position by cutting through the off-shore bar (further evidence can be found in the sandy deposits at the mouth of the Samarahan river which are supposedly derived from the Sambir ridge.

The presence of a coastal mudflat of this width is atypical for Sarawak where in general more sandy beaches are formed, or peat is found directly behind the coastline. It is suggested that this coastal mudflat may have formed in the quiet water of the bay once existing between the Santubong-Bako peninsula's and the Sebuyau mountains. These formations may have been islands in the past.

This mudflat stretched originally from Serian into the bay and was built up by the deposits from the Samarahan and Sadong rivers. These rivers, building up levees along their courses, deposited material further into the bay and probably because of sea currents and wind action the mudflat deposits accumulated in the present Nonok area so rapidly that the plain rose above high-water level. Because there is no evidence for this part of the world suggesting recent changes in sea level, local up-lift may have been another cause. On this emergent plain Mangrove and Nipah forest developed through which more silt was trapped and sedimentation was increased. Remnants of these organic layers can still be traced in the soil at a depth of 3 to over 5 feet. They occur specifically in the eastern part of the plain.

That part of the coastal plain which was cut off from the sea by riverine levees in the west and east and by the coastal flat in the north became a riverine basin in which freshwater peat could develop because of the subaqueous conditions.

The present coastal area of Nonok displays therefore the following morphological features:

a. A subaqueous mudflat only exposed at low tide in the west.

b. An advancing coastline covered with Mangrove and Nipah also in the west.

c. An eroded and regressing coastline in the east with Mangrove and Nipah forest.

d. A subaerial topset plain extending over the whole length of the area to a depth of approximately 4 to 5 miles inland.

e. The basin peat area backing the subaerial topset plain and covering its subaquous part at the landside.

f. Low incipient clay levees bordering the plain along the Samarahan and Sadong rivers.

g. Remnants of an old off-shore bar in the west.

Other features are layers of leafy and woody material between the clay deposits indicating old mangrove and nipah forest.

Shell layers at a depth of 3 to over 5 feet were found in certain localities and probably represent former beach lines.

The only rock outcrop in the plain is a small hill of approx. 20 feet high, found in Ulu Jemukah. The rock is greenstone (classification confirmed by Geological Department) and of the same origin as that found in the Sematan-Tj. Dato coastal area.

Apart from this small hill which slopes steeply down into the alluvial area surrounding it, the plain is flat with only very gentle slopes towards the east and west.

According to Sir Bruce White levels (ref.1) the height above high tide level is on average not more than 1 feet near the tidal streams and slightly higher in areas between those streams. The peat backing the claybelt is dome shaped and reaches heights of over 20 feet above the average water level in the rivers. At the fringes near the rivers the peat slopes down more steeply than at its boundary with the clay belt, while the centre of the peat-dome is very gentle sloping.

It is suggested that the parent material of the soils are deposits mainly brought down by the Samarahan and Sadong rivers, but deposited in shallow seawater (littoral deposits). They are well sorted and silt and clay fractions are dominant. Only in the western part is more fine sandy material deposited near the mouth of the Batang Samarahan probably derived from the old off-shore bar.

An interesting feature of this coastal area is the rapidly changing coast line. A comparison between the coast line in 1947 (R.A.F. air-photographs) and the coastlinein 1963 (photographs by Lands & Surveys, Sarawak) reveals that accretion is taking place between S. Nonok and Kuala Samarahan while erosion is removing material from the coast between S. Sampun and Jaie. The old coastline is shown on the 1:50,000 topographic series which served as the base map for the soil survey. The new coastline has been used as the northern boundary of the survey area and is shown on all maps accompanying this report.

4. Drainage

a. Natural drainage

Natural drainage of the plain (including the basin peat) is provided by a number of typical consequent streams flowing almost right across the clay belt towards to sea. Most of the existing streams spring from the margins of the basin peat area where surface run-off water is accumulating. It is suggested that these streams may originally have developed in the clay belt as tidal creeks and, after cutting back into the clay, started draining the peat area, which may originally have drained directly into the Sadong- and Samarahan rivers.

At present in the peat basin watertables are almost at the surface even at points higher than 10 feet above the river and drainage occurs only as surface run-off, groundwater being held by the peat as in a sponge. This surface water drains of at all sides of the domeshaped peat area, drainage channels displaying a radial pattern.

Although the watertables in the peat areas may never be low in the dry season, in the clay belt the watertable drops significantly during this period because then no flood water from the peat drains into this area. The natural drainage channels are then sufficient to cope with the surplus rainwater and watertables may drop to 2 feet below the surface. In the wet season much surface run-off water from the large peat swamp reaches the clay belt and a large part of it is inundated. As such times even at low tide the water levels in the rivers do not show any appreciable fall and this situation continues until all surface water from the peat area has been drained.

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Settlers in recent times quickly realised the importance of draining the area so that crops could be established, and the result has been a dense pattern of man-made drainage channels.

b. Man-made drainage

Certain rivers such as Sungei Nonok and Moyan have been straightened out and numerous meander bends cut off. This has allowed quicker drainage during low tide but on the other hand brackish water can penetrate further inland. This situation is aggravated by the numerous drains now intersecting the areas between the rivers. Here freshwater is able to drain quicker during the wet season but in the dry season brackish water can enter during high tides thereby creating a serious salinity problem at the lower ends of main drains near the rivers. The building of floodgates has remedied this problem in certain areas but many are out of order and not maintained properly while in other areas they are non-existent.

The flooding would not have reached such proportions if the peat areas had been left untouched but because of population pressure and land hunger in other places in Sarawak many settlers came into the area and reclaimed the fringes of the peat swamp backing the clay belt. Every drain which was dug into the peat borught more water into the clay belt because groundwater formerly held by the peat was now tapped and allowed to enter the lower lying parts of Nonok. In the wet season much more surface water from the vast catchment area in the peat is now brought to Nonok and flooding is worse than ever.

Flooding is most serious there where peat was reclaimed and where shrinkage and oxidation has resulted in a lowering of the ground surface level. These places are often found where the clay merges into the peat and where the original gentle slope has been converted into a much steeper and almost abrupt fall.

The reclamation of peat in this situation has been a great mistake and should never have been allowed until a proper canal was built to divert drainage water coming from the peat towards the Samarahan and Sadong rivers so that this could not enter the coastal clay belt.

In fact this problem was apparently realised because with this object in mind, the government built, with the help of the local population three drains in the peat area. The largest was located between Sungei Nonok and Sungei Subi, and two smaller ones parallel to these but further to the south. The drains are however much too small and, since cultivation was allowed on both sides, not very effective, as both sides suffer from floods because of the non-existence of a protecting bund along the canal.

It is quite probable that the administration of Nonok being in two hands is reason that the drain did not cross the whole area but stopped almost at the district boundary. It is learned that the stretch between S. Nonok and S. Sampun was built by the people themselves at a later period. Apart from these major efforts numerous drains were dug by the smallholders, the bigger drains as a communal undertaking, the smaller ones being mainly private affairs.

A proper drainage scheme for the whole area was never worked out.

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It is unfortunate to see that this area which offers good prospect for agriculture has been neglected so much in the past, especially on such important matters as drainage. It is a tribute to the local population to see how much they have done through their own efforts although things have been allowed to develop the wrong direction because of lack of guidance.

c. <u>Recommendations</u>

If the area is to be developed, adequate drainage is essential. Proper drainage should be aimed to remedy the following points:

a. Preventing saltwater from entering the area (Sir Bruce White and Drainage and Irrigation Branch suggest coastal bunding and the installation of floodgates).

b. Preventing floodwater from the peat areas entering the coastal clay belt. (Probably by digging a sufficiently large canal to divert water to the main rivers. A protecting bund on the northern side should stop any overflow of the canal. It will be difficult to build such a bund when resting on peat.)

c. A proper layout of main drains and subsidiary drains, the maintenance of which should be controlled by legislation. (At present land-owners allow drains to deteriorate because of lack in funds, time or labour.)

The problem of floodwater entering the clay belt has not been fully realised by Sir Bruce White and should receive as much attention as the saltwater infiltration.

It is however felt that even when these plans are realised it will be impossible to stabalise the watertable in most of the area below 2 feet throughout the year. A definite conclusion can only be drawn when a detailed level survey has been carried out but it is highly probable that there will be insufficient fall to allow quick drainage of rain water below a depth of 2 feet beneath the surface, especially in the rainy season.

This chapter would not be complete without adding a few words on the freshwater resources for domestic use.

The situation is by no means different from most lower stretches of the main rivers in Sarawak where plenty of muddy river water is available in the wet season replaced by brackish water in the dry season. The situation in the Nonok area is however aggrevated by the fact that so many people are concentrated in such a comparatively small area. Most people rely on wells for their domestic water supply, while others obtain their water from the small streams coming from the peat area. Only the upper stretches of these rivers can be used because brackish water comes up these rivers during high tide. In the dry season even these streams are brackish to far inland. The coastal villages like Semera and Jemukan are probably worst off. The overall shortage of freshwater coupled with the unhygenic way in which most of the Malay population dispose of human excrement makes it surprising that many epidemics do not occur, although gastro-intestinal disorders must be very common. (In the survey party 20% were suffering from these disorders after having been in the area for 1 month).

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From the location of the area it can be assumed that it will be unlikely that any large resources of fresh water can be found, unless deep borings are envisaged. Small sources of fresh water may be available in the small sand ridge at Sambir and perhaps near the small outcrop of igneous rock in Ulu Jemukan. To supply the whole area with a reliable and treated water supply will be extremely difficult and costly, the expense probably being unrealistic. From a social and hygenic point of view such costs are probably justified and would stimulate further development.

5. Population

It is impossible to obtain an accurate figure of the population for the whole area. The 1960 Census report (ref.3) although giving quite detailed figures for that part of the area falling in the Simunjan District fails to give a complete population figure for the part falling in the Kuching Rural District and the population for important places such as Nonok and Moyan are not mentioned at all.

The First Divisional Development Plan for the period 1964/68 (ref.4) mentions a total population of between 13,000 and 15,000 but Drainage and Irrigation Engineer in his Tour Report on the area (ref.2) thinks this to be on the conservative side. None of these reports defines the area exactly and it is therefore difficult to see these figures in their right proportions.

In order to arrive at a more accurate figure information was obtained from the Kuching Rural District Council on the number of houses over which rates were paid. These figures could be obtained for each kampong area from the housing rates registers.

From the available figures in the 1960 Census report for part of the area in the Kuching Rural District an average figure for the number of persons per house could be obtained. This figure appeared to be between 6 and 7.

By using this factor and the known number of houses in the area the population of the total area under discussion appears to be in the region of 18,000 (calculated population 18,068). Of this population a number of 16,971 (say 17,000) are living in the area which would benefit from the drainage and bunding scheme (Area A), the remaining portion living between Tambirat and Muara Tuang at the right bank of the Samarahan river (Area BO.

This figure of 17,000 appears to confirm the view of the Drainage and Irrigation Branch and may be the nearest figure to the truth we are able to calculate from the available sources.

Table 1 shows in detail the approximate population per kampong area.

Over a measured area of approximately 40,000 acres (62 sq. miles not including peat over 3 feet deep) the population per sq. miles appears to be approximately 300 which rates amongst the highest population density found in the rural areas of Sarawak.

Table 1

Number of houses and calculated population in Nonok Coastal area

Kampong name or area	Number of houses in area A	area B	Population A	B
Kuching Rural*				
Nonok Ulu	280		1,820	
Nonok Ulu bazaar	24		156	
Nonok Laut	121		786	
Nonok Laut bazaar	3		19	
Moyan Ulu	40		260	
Moyan Laut	152		988	
Moyan Lidong	42		273	
Moyan bazaar	3		19	
Serpan	137		890	
Reba	94		611	
Sampun Gerunggang	83		539	
Sampun Baru	28		182	
Sampun Ebi	35		227	
Sampun Tebung	31		201	
Sebandi Ulu	150		975	
Sebandi Metang	64		421	
Sambir	125		812	
Sambir	4		26	
Tambirat	61		396	
Tambirat bazaar	12		78	
Subi area	77		500	
Tambirat-Sambir	14		91	
Tj. Apong	-	89		578
Tambai Kpg.	-	61		396
Tambai area		19		123
Lower Sadong+				
Semera Kpg.	94		572	
Semera rural	262		1,685	
Iboi/Pelandok	160		920	
Jemukan Kpg.	126		801	
Jemukan rural	96		697	
Pendam	118		779	
Jaie	113		608	
Rangawan	71		393	
S. Bilis	47		246	
Totals	2,669	169	16,971	1,097
			18,068	

* from Kuching Rural District Council
\+ 1960 Census.

It is impossible to arrive at any reliable figure per population group because it is impossible to separate in all cases Chinese, Malay or Dayak houses from the total figures obtained from the mentioned sources. It can, however, be safely assumed that the majority of the population are Malays or Bugis (emigrated from Celebes in the past) followed by Chinese, the minority being Dayak. The latter refer to themselves as being Sebuyau Sea Dayak and they call other Sea Dayak tribes Iban.

The Malays and Dayaks live concentrated in villages and often have their agricultural land at some distance from the village, the Chinese in general live in the middle of their holdings scattered in the Ulu areas. Both Malay and Dayak, although the former much more so, partly depend for their livelihood on fishing which may be one of the reasons why they continue to live in villages located near the mouths of the rivers.

It is beyond the scope of this report to give details on the number of people or households actively engaged in agriculture in the area and the number of holdings and average size of the holdings per population group. It is however realised that for obtaining a proper basis for understanding the agro-economic problems and future planning such figures can be most important and it is therefore suggested that an attempt be made to obtain such information.

6. Land Use and Agriculture

a. Land Use

In order to obtain reliable information on the acreages of crops grown in the area a Land Use map was prepared from the recent 1963 air-photographs.

Total figures for the whole area of land use types were broken down into separate figures for Areas A and B.

Part A was nearly fully covered with 1963 air photography, while area B was only partly covered. Additional information was obtained from rentis observations while land use for areas between rentises was filled in by interpolation between observation points (mainly in Pendam-Nangeh area, Kpg. Baru and Muara Tuang area). Boundaries in such areas are therefore less accurate.

On the land use map 9 units are distinguished:

1. Land at present too salty for cultivation

   a. Mangrove forest
   b. Mangrove mixed with Nipah or Nipah only.

2. Peat forest, at present not used for agriculture.

3. Secondary forest or jerami

   Some small areas of Sago are included in this unit. The land has been used for padi but is either too salty for further cultivation or flooding is too serious. Former areas are mainly along the coast, while the latter areas occur at the fringes of the peat.

4. Village sites - land not used for agriculture.

5. Areas under coconut, subdivided into:

   a. areas with old coconut (more than 15 years old)
   b. diseased old coconut, scattered and without crowns.
   c. young coconut (5 to 15 years old).

The ages of the coconut are arbitrary and only approximate.

6. Mixed, coconut (often 0-5 years old) and annual crops such as soya, groundnuts and wet padi during wet season.

7. Land solely used for wet padi.

8. Old rubber - only a small area (inclusions of small areas of young rubber).

9. Land with mixed old rubber, partly replaced by secondary forest and some sago.

Table 2 gives the acreages of these 9 types of land use for both areas A and B. These figures are probably accurate within a range of 5% more or less.

Table 2

1963 Land Use in Nonok Coastal area

Land Use Type	Area A	Area B	Total
	acreage		acreage
1. Mangrove	1,024	-	1,024
1a. Mangrove and Nipah	7,656	949	8,605
2. Peat forest	31,897	5,153	37,050
3. Secondary forest	3,500	1,224	4,724
4. Village sites	355	68	423
5. Coconut			
a. Old coconut	13,910	2,256	16,166
b. Old, diseased	518	275	793
c. Young	5,093	291	5,384
6. Mixed farming (coconut, annuals)	1,662	159	1,821
7. Wet padi	3,244	1,283	4,527
8. Old rubber mainly	32	984	1,016
9. Mixed, old rubber, secondary forest, sago	183	-	183
Total	69,074	12,642	81,716*

* 1½% error with soil map owing to error of instrument and scale distortion.

An attempt was made to compare 1963 land use with the landuse of 1957 (vide Land Use map prepared by 1st Div. Lands and Surveys Dept. Unfortunately the latter map is more a map showing landownership than land-use and it could not be related to the land use map prepared by this Department.

For certain types of land use, e. g. coconut, the acreage given for 1957 was larger than that revealed by the photographs of 1963. Presumably much of the information was obtained from Land alienation maps showing the purpose for which land was given out. In certain instances cropping may never have taken place.

b. Agriculture

Perennial crops: (i) Coconut.

The cultivation of coconut has by far outgrown the cultivation of any other crop and forms at present the anchor for the economy of Nonok area. So much coconut has been planted in the area that in the next 5 years when the young coconut reaches maturity and mixed cropping becomes impossible virtually all land suitable for agriculture will be in use for coconut only.

Coconut thrives well in Nonok providing it is not planted on deep peat (deeper than 3 feet) and it does not suffer from serious flooding by freshwater in the landas season nor from salinity in the dry season.

In actual fact the area which does not suffer from any of the three mentioned disadvantages is surprisingly small. Large gardens of coconut situated south of the main government drain in the Moyan - Sebandi area show the effect of serious flooding (people say this is due to the blocking of the drain owned by the sawmill situated at Tj. Sabang) and many palms have died. All around the perimeter of the area coconut gardens suffer from the affects of a high salt level in the groundwater, This is particularly severe in the Semara-Jemukan-Jaie area where coastal erosion aggrevates the situation.

In the western part of the area (Sebandi-Subis-Sambir) the salinity problem is caused by deterioration of existing floodgates, this is also the case in the eastern part along the Sadong river.

Despite these disadvantages the planting of coconuts has been very lucrative and in good gardens an income of $400 per year per acre can be obtained. The good price and the low cost for maintenance of the gardens are two good reasons why many land owners favour the growing of this crop. That this policy is unfavourable to the tenants, many of them Chinese, is undoubtedly true. Chinese settlers not able to obtain land for themselves rented land from Malays or Dayaks to plant annual crops such as soya beans and groundnuts, while the land owner planted the land up with coconut. The Chinese tenant maintained the garden, dug the drains and had to leave the place after some years when the coconuts matured.

The situation has become worse with the Coconut Planting Scheme coming into being and land owners who had not done so in the past are now quickly planting up their land with coconut thereby rendering many tenants landless in the near future.

Coconut is planted everywhere, regardless of the possibility of proper drainage. The digging of drains does not necessarily mean that the watertable can be dropped because this depends on other factors such as sufficient natural fall and permeability of soil. Often these factors are not present and the digging of drains is considered merely a prerequisite to become eligible for subsidy under the Coconut Planting Scheme rather than providing an effective drainage for the gardens.

The digging of drains near the coast and along tidal streams has brought the brackish water to the gardens because during high tide in the dry season when not enough surface fresh water is drained, salt water penetrates into these gardens thereby damaging the coconuts.

The urge to plant more and more coconuts combined with the lack of suitable land has led to the reclamation of deep peat soils. Chinese gardeners were only able to obtain land in such areas and because of the critical situation endangering their existence they pressed the point that they could do it. Nobody can say that what they have achieved is not commendable. The miles of drains dug by them are a symbol of their perseverance but this does not alter the fact that in the long run these deep peat areas are unsuitable for coconut. Already the drainage situation is becoming increasingly more difficult because land is subsiding as a result of oxidation and shrinkage of peat and many of the gardens are liable to flooding in the wet season.

This situation will become worse in years to come if this drainage problems is not quickly remedied.

Apart from the flooding, the coconuts cannot root sufficiently in the soft peat and when they reach maturity they lean over because of the top heavy crowns and the roots are exposed.

Between Moyan and Sampun it has been reported that the peat depth there was 2 to 3 feet about 25 years ago. At present there is only 6 inch of muck left and the surface level has gone down approximately 2½ feet. It will be almost impossible to drain such areas adequately if the surface is near flat and natural drainage slow, especially because much flood water from the large peat areas is allowed to enter these coconut gardens.

Considering all these facts the area is regarded as potentially suitable for coconuts providing the salinity problem is remedied and proper drainage can be achieved. From the soils point of view deep peat areas (deeper than 3 feet) should not be planted up with coconuts. The watertable should be kept at a depth of 2 feet and allowed to fluctuate between 2 and 3 feet and kept free of salt. Little or no fertilising is done at present and it is suggested that if the drainage has been improved a proper fertilising programme should be introduced so that crop production can be increased substantially.

(ii) Rubber

Rubber is a very minor crop in the area and is only of some importance in area B along the Samarahan river. Here old rubber gardens can be found, usually on shallow peat and riverine clays. The rubber is poor and badly looked after. It is suffering from flooding and many trees are leaning over because of shrinkage of peat.

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In area A some old rubber gardens occur near Moyan Ledong but much of it has died because of severe flooding. A new rubber garden was seen at Moyan Ulu interplanted with padi! Although the trees looked healthy they already started to lean over (approx. 4 years old). Here also drainage is insufficient.

If the watertable can be lowered to a constant level of minimum depth of 2 feet, rubber could be planted on the clay soils.

(iii) Coffee

Coffee was seen in some gardens, planted mainly for home consumption. At present the crop is of little importance but could prove to become a valuable cash crop if the drainage is improved.

(iv) Bananas

Bananas are growing everywhere and at one time it was a very important crop for supplying the Kuching market. It has only become a crop of secondary importance since coconut planting replaced it. The crop thrives well, especially on muck soils but also here flooding and high watertables are making it at present impossible to develop its cultivation. Some very good stands were observed in freshly reclaimed peat areas where the watertable was low.

Annual crops

The main annual crops are wet padi frequently planted as a monocrop, soya beans, maize and groundnuts. Wet padi is also planted together with soya beans, groundnuts and to a minor extent with maize as in intercrop in young coconut gardens.

(i) Padi

In the past padi was one of the main crops in the area but much of the area planted up with padi had to give way to coconut gardens. Other padi areas near the coast and near the Sadong river had to be abandoned because of salt water infiltration and are now covered with secondary forest. The establishment of padi in the middle of coconut gardens or in the near vicinity is contradictory to the drainage required for the coconuts. It is therefore difficult to understand why the people introduced this form of cultivation. Probably the need for padi land was so great that there was no other alternative. It is obvious that this sort of mixed cropping does not benefit the coconuts which already suffer enough from bad drainage.

In areas where padi was and is grown as a monocrop, salt-water-infiltration has severely affected the yields and only through the building of large bunds to keep the fresh water on the padi fields and the building of tidal gates to keep the saltwater out, is padi-cultivation there possible and good yields can be obtained.

At the time Sir Bruce White carried out their investigations (1955) irrigation of padi was seriously considered and plans were drawn up. These plans have at present little value because much of the land at that time reserved for padi has already been planted up with coconuts or is surrounded by coconut gardens so that it will be extremely difficult to organise a scheme aimed at irrigating one field and draining another. These observations fully confirm the views of the Drainage and Irrigation engineer (ref.2) that if irrigation is envisaged it would be better to make rain-dependent 'sawahs' rather than attempt to bring water through channels to such padi fields. It can be seen from the land use map that the land still available for padi is small and that quick action is needed to ensure that padi as a crop does not vanish from the Nonok scene if it is considered necessary that padi should be grown in Nonok.

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(ii) Soya beans

Soya beans are mainly cultivated in the young coconut gardens and after the harvest of the padi. It was observed that in many places the soya bean suffered from flooding because rainy weather persisted into the month of May (1964). It is reported (ref.5) that the soya bean is an excellent off-season crop for the area and fetches up to $154 per acre/crop. The crop is however labour consuming and much higher incomes per acre could be achieved if cultivation methods were improved and fertilisers used (at present the padi straw is cut down, dried and burned, after which the soya beans are planted; no cultivation is done, weeding only once, and no fertilisers are applied.)

(iii) Groundnuts

Groundnuts are grown in a similar way to soya beans. Good yields can be obtained (12 pikuls per acre with shell, ref.5) but here also with better cultivation methods and fertilisers better results can be achieved.

(iv) Sesami seed

On a small scale also sesami seed is grown for oil extraction. This annual crop takes a full season and is not grown as an after crop. It is estimated that with the present cultivation methods the income per acre is in the region of $240.

(v) Maize

Maize is mainly grown for poultry and pig rearing. It is grown as an off-season crop and on good soils an income of $180 per acre can be realised.

(vi) Pineapples

Pineapples are grown with success on the peat soils. The total acreage is small. Mainly the Sarawak variety suitable only for table consumption is grown intermixed with other crops, frequently young coconuts. The market appears to be too small for increasing the acreage; at present the small supply fetches good prices in the Kuching market although the distance is a disadvantage.

(vii) Melons and vegetables

A variety of vegetables and water-melons is grown in the area mapped as mixed cultivation. They are all grown with success, but the distance from the Kuching market makes competition with vegetable growers near Kuching difficult.

(viii) Food crops such as vassava and sweet potatoes are grown, specifically on freshly reclaimed peat. Yields are good in the first few years but decline rapidly in subsequent years if no fertiliser is applied. Both crops are mainly grown for pig fodder which in some areas provides a good supplementary income to the farmer whose mainstay is the coconut.

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From this chapter it can be concluded that a wide variety of crops can be grown and are grown in the area. The choice in perennial crops is but small although the choice could be enlarged with a proper drainage scheme. There is a much wider choice in annual crops which can at present be grown. Current prices together with the ease with which coconuts can be grown is the reason that this crop has been able to overshadow any other crop in the area.

It is however doubtful whether, with improved drainage and the introduction of rationalised farming using modern cultivation methods and fertilisers, the growing of annual crops would not appear to be more advantageous than the growing of coconuts. The available land resources would be used with more efficiency while the holdings could be smaller.

It will however be very difficult to stop coconuts from taking up most of the available land if no means can be found to implement guided land-use effectively. The present states of affairs may offer the government a'fait accompli', namely that one has to accept the fact that coconuts will not be replaced by any other crops until gardens come out of production.

Diversification of agriculture which is the declared policy of the Government clashes in the Nonok area with another policy namely to plant up more coconuts.

Undoubtedly a switch over to other crops would in the Nonok area be beneficial to both the farmer and the Government.

With the cultivation of off-season crops and padi two crops per year can be grown and the income per acre can thereby be substantially increased. No yields for padi are available so that it is impossible to make an accurate comparison between the income of an acre of coconuts and the income of an acre used for annual cropping if two crops can be obtained. It is however estimated that with proper farming methods 20 pikuls of padi per acre can be obtained, the gross income per acre if e.g. soya bean is to follow padi as an off-season crop would then be in the region of $700 per acre which is substantially more than the reported $400 gross income per acre of coconuts. What the situation will be if drainage is improved and both the cultivation of coconuts and rice with off-season crops is rationalised cannot be overseen because there is no comparative data available. With a view to this, investigations into these different types of land-use aimed at improving cultivation methods and management together with cost price calculations would certainly be justified.

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TABLE 3

SOIL CLASSIFICATION NONOK PENINSULA

Orders	Suborders	Great Soil Groups	Soil Series	Phases	Remarks
INTRAZONAL SOILS	Hydromorphic Soils	Low Humic Gley Soils	Pendam	1) organic	Intergrade to Mukah
				2) saline	Intergrade to Rajang
				3) saline, peat and muck layered	
				4) leached, peat and muck layered	
				5) leached	
			Tatau	1) poorly drained	
				2) very poorly drained	
		Half Bog Soils	Mukah	1) clay surface	Intergrade to Anderson
		Bog Soils	Anderson	1) 3-6 ft. deep	
				2) 6-10 ft. deep	
				3) > 10 ft. deep	
	HALOMORPHIC SOILS	Saline Soils	Rajang	1) sandy loam	
AZONAL SOILS		Lithosols	Bouldery and Rocky land		Intergrade to Sedong Series

PART 3 - SOILS

1. Classification

For this section of the report the reader is constantly referred to Table 3. (p. 20a)

The soil pattern in the area is simple and logical as can be expected in a plain of this nature.

With the exception of Skeletal soils on the one igneous outcrop in Ulu Jemukan all soils belong to the Order of Intrazonal soils indicating that the local environment has been largely responsible for the trend in soil formation rather than the atmospheric climate.

The Intrazonal soils belong to two suborders namely, the Hydromorphic soils and the Halomorphic soils.

The Hydromorphic soils are characterised by strong hydromorphic features such as gleying and the formation of muck and peat indicating a very wet soil environment with high watertables throughout the year.

The Halomorphic soils, although showing hydromorphic features as described above, are still under marine influence being flooded daily with salt- and brackish water during high tides. The saline character of these soils is more important than the hydromorphic nature, hence the separation into the halomorphic soils at such a high level of classification.

At the next lower level of classification the hydromorphic soils are subdivided into:

1. Low Humic Gley soils - a provisional definition according to Thorp Smith (ref.6) is as follows: "An intrazonal group of imperfectly to poorly drained soils with very thin surface horizons, moderately high in organic matter, over mottled gray and brown glei-like mineral horizons with a low degree of textural differentiation." Although according to Thorp and Smith only few soils in this group are neutral to alkaline, due to infrequent flooding or infiltration by brackish water the acidity in these soils in the Nonok area is somewhat lower than usual.

2. Half Bog soils - Half Bog soils are very poorly drained soils with watertables at or near the surface so that bog peat is able to develop. They have mucky to peaty surface horizons ranging from 6-36 inches thick.

The separation of Half Bog soils from Low Humic Gley and Bog soils is somewhat arbitrary. Half Bog soils are typical intergrades between the two other soil groups. In other countries 6 inch of a muck or peat surface horizon may be a sufficient qualification for placing the soil into the Half Bog soils while a peat depth of 2 feet qualifies the soil for a place in the Bog soil class. In Sarawak where deep peat soils are dominant a separation of Half Bog from Bog soils and Low Humic Gley soils is made on depth of the peat or muck layer and on the organic matter content. Half Bog soils by these criteria should have surface horizons with an organic matter content of more than 35% (loss on ignition) and should have a depth ranging from 6 to 36". Where such horizons are deeper than 36", they are placed in the Bog soils and where they are less than 6" deep they are grouped with the Low Humic Gley soils as organic phases of the respective series within the group.

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Such a distinction between the three groups appears to be practical for mapping purposes.

3. Bog Soils

Bog soils are soils in very poorly drained localities with watertables near or at the surface. During part of the year they may be submerged. The depth of the peat or muck horizon is more than 36" and can be as much as 100 feet in Sarawak. This organic horizon is underlain by greyish white gleyed clays or sands. In Nonok the substratum was at all observation points as old marine clay. (see Geomorphology)

4. The Halomorphic soils are only represented by one Great Soil Group namely the Saline soils which occupy areas flooded daily with salt or brackish water during high tides. They are invariably covered with Mangrove and Nipah forest. They are poorly to very poorly drained soils with gley features.

5. Finally, Azonal soils are represented by a small area of Lithosols characterised by very shallow soils of less than 10 inches deep overlying hard rock.

Soil Family classification between the Soil Series and Great World Soil Groups is still incomplete in Sarawak and has therefore been omitted.

The soils are discussed in detail at a series level; only 5 series are present in the area but owing to the presence of certain features in some series over wide areas it has been possible to map them at phase level.

2. Detailed description of the series

a) PENDAM SERIES - 25,983 acres

Although the Pendam Series occurs elsewhere in Sarawak, no detailed descriptions from these locations are available. The description which follows is based on field and laboratory characteristics of the Pendam series soils occurring in the surveyed area.

The Pendam Series are Low Humic Gley soils, generally found in association with Rajang Series (Saline soils).

The general concept of the series is as follows:

Soils recently reclaimed from Mangrove and Nipah forest and converted into agricultural soils through leaching of salts and drainage, or soils which through natural aauses have risen above normal high tide level. They are normally situated in river delta's or found at the mouth of main rivers, and occur as far inland as brackish- or salt water can penetrate during the driest part of the year. Although topsoils and subsoils can contain soluble salts these are easily leached out by rain or fresh water flooding. Groundwater may be salty during parts of the year.

The Pendam soils have developed in a deltaic environment and traces of/former vegetation (Mangrove and Nipah) may still be found in the soils. This is indicated by mucky or peaty layers encountered at depths ranging from 1 to over 4 feet from the surface. The layers are thin and generally not more than 6" thick.

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Apart from this morphological variation, chemical features are variable over a wide range because of their proximity to the sea (salt infiltration through flooding and salty groundwater) and human influence (drainage).

The general concept is therefore taken as a guidance for interpreting field and laboratory data and for mapping the series. If one characteristic of the general concept becomes significantly different from the normal soil, phases have been created to allow these soils still to be classified in the Pendam. Some of these characteristics, particularly organic matter and soluble salt contents of topsoil, appear to change quite rapidly when the soils are drained and bunded - after which the soil resembles the modal concept of the series. It is therefore practical to map such differences as phases so that the soil remains in the same series if and when cultivation through draining or bunding takes place.

Textures

Clay and silt fractions are dominant in the Pendam Series but more sandy textures occur in places, especially near the mouth of Batang Samarahan where topsoils can be a sandy clay loam. Normal textures of topsoils range from clay loam to clays. In the subsoil textures range from silty clays to clays.

Structure

Structure in the Pendam Series is usually absent because of the wet condition in which they are normally found. Topsoils however may display a fine angular blocky structure when dry.

Organic matter content

Typical of the Pendam Series is the high amount of organic material found in the whole profile. Loss on ignition shows an appreciable amount of old, partly decomposed and fresh organic material in all layers. Loss on ignition varies from 5 to 10% in all subsoils while in places soil layers can be found with an organic matter content of as much as 60% (muck and peaty layer of organic debris.) Where possible such soils in the Pendam Series have been mapped as the 'muck and peat layered phase' of the series, because this phase may behave differently upon drainage and subside after the organic material has oxidised.

Loss on ignition in topsoils of the whole series is usually more than 10% and is normally within a range of 10 to 20%. However, where the series grades into more mucky soils the organic matter content measured as loss on ignition may be as much as 60% and over. Soils in the series with loss on ignition of more than 35% in the topsoil (0-6") have therefore been placed in the 'organic phase'.* Where possible this phase has been mapped separately. It is very likely that with continued cultivation the organic matter in the topsoil may fall to a level of 10-20% because of oxidation and mineralization of the organic matter.

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* In practice, soils with loss on ignition approaching 35% are also placed in the organic phase.

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Drainage

a. Internal

The soils are slowly permeable (high clay content) and only where the sand fraction is appreciable higher than the silt and clay fractions is permeability rapid.

b. External

Most soils in the Series are located close to peat areas situated at a higher level. Water draining off the peat tends to keep the watertable high in the adjacent clay soils. Watertables are in general very high (at 6" or at the surface in the wet season while in the drier season the watertable may drop to 18" depending on the presence of drains.) Near the drains the watertable may drop to 3 feet, although a daily fluctuation can be expected because the watertable is affected to a certain extent by the tidal movements of the water in the rivers.

All soils in the Pendam Series are therefore poorly to very poorly drained.

Gley features

Gley features are present throughout the profile. Strong brwon and orange mottles commonly start in the topsoil or immediately below it. They give way to move yellow colour mottles while the matrix colour of the soils changes from brown or greyish brown to grey. The gley horizon is normally met at a depth of 2 to 2½ feet and is coloured greenish grey or bluish grey while if much dispersed organic matter is present the gley layer is coloured dark grey. Yellow and rust- coloured mottles may persist to a considerable depth indicating that air is penetrating through root channels or that oxygen is formed by roots of certain plant species. Near drains the permanently gleyed zone is generally deeper than in the remainder of the area and may be found at a depth of 3 to 4 feet.

Salinity

Because of the location and through human interference (digging of drains) brackish water sometimes floods certain areas or the groundwater becomes slightly salty. This increase in salinity is essentially a seasonal feature in the Pendam Series and the salts are leached out by rainfall especially in the wet season. The salts in the Pendam Series are mostly soluble and the percentage of sodium in the adsorption complex should not be more than 15%. Electric conductivity may vary and depends on the time of the year, location and the depth in the profile. On the content of soluble salts the Series is subdivided into phases, namely:

(a) Pendam Series, saline phase

(b) Pendam Series, leached phase.

It should be understood that mapping of these two phases is extremely difficult because during the wet season the saline phase may revert into the leached phase while in the dry season the opposite may take place. While our studies on these soils were carried out during the transition period of wet to drier weather the boundary between these two phases shown on the map can never be accurate. The occurrence of crab mounds in the saline phase is often a useful indication to salty conditions.

The saline phase is characterised by an electric conductivity of 1,000 - 4,000 micromoho/cm in the surface horizons (0 - 12") while in the subsoil the E.C. is more than 4,000. E.C. of the groundwater is generally much higher than 4,000.

The leached phase has surface horizons depleted of soluble salts and the E.C. should not be more than 500. Subsoils in the dry season are permitted to have an E.C. between 1,000 - 4,000, but this is only the case if the groundwater is affected by salt infiltration through drains. The E.C. of groundwater in the leached phase is usually between 500 and 4,000.

Because the former vegetation was Mangrove and Nipah forest the Pendam Series may have high levels of sulphates, especially in the 'muck and peat layered' phase. The coarse textured organic matter in these layers (peat and muck layers) have been tested for sulphate but in all instances the sulphate content did not rise above danger level. (See Appendix). Nevertheless, Pendam subsoils in other areas of Sarawak have been found to contain high contents of sulphate and probably it is only the layers in which the organic matter occurs in a finely dispersed state where sulphur contents are high and where sulphate becomes toxic after the soils are dried out. It is therefore possible that the electric conductivity values in the Pendam Series, both saline and leached phases, are partly recording the occurrence of sulphates and that high readings do not necessarily refer to sodium salts or chlorides.

Acidity

In the saline phase of the Series the pH ranges from 5 to 7 in both topsoils and subsoils. The pH in the topsoil (0-6") is frequently less than the pH in the subsoil. The pH in the leached phase is generally lower, especially in the topsoil where it varies between 4 and 5. Sometimes the pH of the topsoil may be slightly over 5. The pH in the subsoil is normally between 4 and 5 but depending on the salinity of the groundwater a pH of 6 was frequently recorded. pH may be influenced by the occurrence of 'catclay' which would cause it to be lower.

The pH of the organic topsoil in the organic phase of the Pendam Series is frequently slightly less than 4. All recorded pH values are for oven dry soils.

Base Exchange Capacity

The Base Exchange Capacity of the soils reflects its organic matter content. The topsoils have T. values (Base Exchange in m.e. per 100 gram soil) of more than 20, subsoils slightly less depending on organic matter content. In the organic phase the T. value rises to above 30 in the topsoil.

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Base saturation

For Sarawak conditions the soils are well supplied with exchangeable nutrients. This is due to the young stage in development of these soils, them having been recently reclaimed from sea influence.

Leaching, however, rapidly removes plant nutrients once the soils are drained or ingress of sea water is prevented by bunding.

The leached phase therefore has lower exchangeable bases (plant nutrients) than the saline phase.

In all Pendam soils base saturation in the subsoil is higher than in the topsoil which is an indication of the youthful state of the soils and incipient leaching.

Exchangeable Bases

Exchangeable calcium ranges from 1 to 8 in the topsoil (average-5 meq.). Subsoils deeper than 3 feet have in places an exchangeable calcium content of more tha 20 meq. but values are generally slightly below 10 meq. In the former case the soils are either saline Pendam soils or approaching them.

Exchangeable magnesium varies from below 1 to slightly over 6 in topsoils. Values in the deep subsoils range from 5 to 10 meq.

Exchangeable sodium is generally between 0.3 and 0.5 meq. but in the saline phase values may be between 1 and 2 meq.

Phosphate

The soils are moderately high in total phosphate. Topsoils have generally values of 400 to 1,000 ppm, while subsoils have values between 200 and 300 ppm. The lower subsoils of some profiles show a rise in total phosphate which cannot be explained. Much of the total phosphate is organic phosphate, therefore the availability of the phosphate in the Pendam Series is much better than in the Upland soils of Sarawak.

By comparison the Pendam Series is generally better supplied with plant nutrients than most other series in Sarawak and it is potentially a rich soil. However, if drained and bunded nutrients are easily leached and fertilising will be necessary after some time. With the mineralization of the organic matter in the topsoil combined with oxidation and leaching much of the phosphate and nitrogen will be lost after the first years of reclamation. Probably calcium, magnesium and potassium are for the present form of farming* sufficient but any intensification in landuse aimed at increasing production per surface unit can only be brought about by the application of manure or fertilisers. Detailed chemical data on the series is given in the Appendix.

Present agricultural use of the Pendam Series and suggested improvements.

The Pendam Series although widespread is almost completely in use for crop cultivation.

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* Farmers are generally satisfied with modest returns and no modern methods are employed to raise crop production and hence the standard of living.

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Coconut is the most important crop grown on the Pendam soil. The Pendam Series is regarded as a good coconut-growing soil but where proper drainage cannot be provided the land could be used better for annual crops. This is also the case in the saline phase where salt levels in the dry season prevent the growing of coconut. The latter areas could be bunded, the salts washed out (probably the rainfall is adequate) and further infiltration of salts prevented. The Pendam is used also for mixed cropping (coconut, rice and annuals) and provided flooding is not severe and drainage adequate, good results are obtained.

It has been proved in the Nonok area that that Pendam Series is potentially very suitable for agriculture but that good drainage and prevention of flooding and saltwater infiltration is needed above all to make the most of the potential of this soil.

Some of the organic phase soils of the Pendam Series were previously shallow peat soils, many old coconut gardens can be found there. Shrinkage and oxidation of peat have lowered the surface level and the coconut palms are leaning over, drainage is bad and it would be best to use such land for annual crops only. It is suggested that if improvement in drainage and amelioration of the salinity is taken in hand more attention should be given to proper land use than has hitherto been the case. Experiments with a variety of crops should provide answers as to which crops would be the most economical, especially on the land which cannot be drained adequately for coconut-growing (permanent watertable should be below 2 feet for this crop), and what type and amount of fertiliser to use. It is only by making full use of the potential of the Pendam Series that the high costs for improving the present conditions in the whole area can be justified.

b) <u>TATAU SERIES - 174 acres</u>

The Tatau Series being small in area does not deserve the attention given to the Pendam and is therefore not discussed in such detail.

The Tatau Series forms a small low sandy ridge starting from Pangkalan Sambir and petering out at Sebandi Matang. It has probably been cut by Sungei Sebandi, which stream has eroded part of this ridge. A relic of a still smaller similar ridge can be traced north of the Sambir ridge.

The Tatau Series is formed by a thin, fine sand to sandy loam deposit overlying clays. At the highest point of this ridge the sand layer may be more than 5 feet thick but where the ridge merges into clay deposits surrounding it, the sandy deposit becomes increasingly thinner.

The Tatau Series is characterised by a fine sand to fine sandy loam texture, the top being dark brown to greyish brown, overlying a permanently gleyed, bluish grey, fine sand to fine sandy loam. A mottled zone only exists in the highest part of the ridge where watertables are lower.

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The Tatau Series is subdivided into poorly drained and a very poorly drained phases. The poorly drained phase has a watertable not deeper than 2 feet and shows a pronounced mottled horizon between 6 and 24 inches, while the watertable in the very poorly drained Tatau is within a depth of 6 inches. Watertables during the driest part of the year may be deeper than recorded, the weather being quite wet at the time of observation.

No samples were collected of the Series. The Series is mainly used as village sites because in the wet season it is virtually the only dry land, mainly because of the sandy textured soil. Another factor may be that the Tatau Series (poorly drained phase) forms a source of freshwater stored in the sand deposit. The source is however small and most probably saline in the driest part of the year.

Part of the Tatau is used for coconut and vegetable gardening. Most coconut gardens were in a bad state which probably was due to their location in the middle of kampong areas as much as to neglect by the owners. The soil itself is probably suitable for coconut but the very poorly drained phase needs drainage.

c) <u>Mukah Series - 3,937 acres</u>

The Mukah Series belongs to the Great Soil Group of Half Bog soils and is found in a belt forming the transition between the Pendam Series (the Low Humic Gleys) and the Anderson Series (Bog Soils). The area was probably much larger in former times but since cultivation has started in the Nonok Area much of the Half Bog soils have changed into Low Humic Gleys by loosing the organic top layer through mineralization and oxidation of the organic matter. The organic phase of the Pendam Series is likely to be a relic of recently reclaimed Mukah Series (after approximately 30 years of cultivation).

<u>General Characteristics</u>

The Mukah Series has a 6 to 36" thick organic top layer which can be either peat or muck. In all cases the high loss on ignition of this layer is due mainly to peat (loss on ignition more than 60%). This organic layer rests on a greenish grey to light grey, compact, sticky and plastic clay (probably on old littoral marine clay deposit).

The watertable in the Series is always high and can be encountered at less than 1 foot deep during the dry season; in the wet season the watertables are at the surface. When drained and cultivated watertables near drains are somewhat lower in the dry season but in many areas the drains do not lower the watertable significantly during the wet season.

Where cultivated the organic top layer has subsided and ponded drainage conditions occur during the wet season. The cultivated and drained peat layer looses its fibrous texture and becomes granular (like ground coffee). In this condition the peat is a favourable root medium for many annual crops. The fine textured organic matter becomes more compact with time and tends to consolidate. The top layer forms a compact turf layer on which light buildings can be erected and footpaths constructed.

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It can be observed in all coconut-gardens that the organic layer has shrunk by about two feet in the course of 25 years - slightly over 1 inch per year. This has resulted in a drainage problem because the natural gradient of the land has diminished to virtually nil. Another factor which increases the drainage problem is that much water coming from deep peat areas backing the Mukah Series and situated at a higher level, drains through the Mukah Series. Attempts to remedy this by cutting more drains allows more groundwater from the deep peat areas to enter Mukah Series and only aggravates the situation. In areas fringing river meanders the Mukah series is commonly found covered with a clay top soil of varying depth. Generally the clay deposit is not deeper than 1 foot. This clay top has been deposited by the river when in flood at which times the river is able to flow freely over the meander bends. The total area of the Mukah series with these clay tops is however small; they have only been mapped along the Samarahan river, as the '<u>clay top phase</u>' of the Mukah Series.

<u>Salinity</u>

No salinity problem was studied in the Mukah Series although the likelihood that it exists is great. A soil sample taken at Ulu Nonok approximately 1 mile south of the Government drain (sample S3022) shows an exchangeable sodium content of 7% in the adsorption complex. This is more than twice the amount of calcium and three times that of magnesium. Quite probably water from Sungei Nonok is able to penetrate even as far south as this location. This single indication does not warrant the introduction of a saline phase of the Mukah Series in the Nonok area; more detailed sampling would be needed to obtain information of this kind which would be both time consuming and expensive.

<u>Acidity</u>

The pH of the organic topsoil is invariably low (between 3 and 4). The pH of the mineral clay soil found below organic layer is slightly above 4. Maximum pH recorded was 4.5.

<u>Base Exchange Capacity</u>

Exchange capacity of the organic top layer is high and ranges from 30 to 50 meq/100 gr. of soil.

Exchange capacities of the clay subsoil is in the range 10 to 30 depending on the organic matter content of the clay.

<u>Base Saturation</u>

Base saturation in the organic topsoil is low and is generally below 5%. The clay subsoil is generally better supplied with exchangeable ions but base saturation is this material must still be regarded as low in most cases (between 10 and 25%). Near the larger streams base saturation is higher and can be more than 50% but here the influence of recent saltwater infiltration cannot be ruled out (frequently magnesium or sodium shows a peak in the exchange complex at these places).

<u>Exchangeable Bases</u>

Exchange calcium and magnesium is low (around 1 meq.) in the organic topsoils, while in the clay subsoils a wide range can be noticed from low to moderately high values (2 to more than 7).

Exchangeable sodium is low in all organic topsoils while in the clay subsoil the same trend can be noticed as reported for the Exch. Ca and Mg. contents.

Sample S.3022 shows an unusually high amount of Exch. Na, the reason for this was given under the heading 'Salinity'.

Total nitrogen in the topsoil is extremely high for Sarawak conditions but it is unlikely that this is all available to the plant, much of the material being fixed as lignoproteins.

Total phosphorus content in the topsoil is moderately high (between 600 and 850) much of which is available to plants, it being mainly organic phosphate.

It can be concluded that the Mukah Series as far as fertility is concerned can be rated as a soil of moderate fertility for Sarawak conditions. The soils are generally better supplied with nutrients than most mineral soils occurring in Sarawak. However, drainage-problems make agriculture on the Mukah Series a risky undertaking. Sound land use planning will be needed to make the most of its potential.

Present use of the Series

Most of the Series is used for coconut often mixed with annual crops such as soya bean, groundnut and others. The old coconut gardens all show a bad stand, the palms are leaning over and the root-system is exposed. Drainage conditions and flooding are leaving marked symptoms in the gardesn, such as yellowing of leaves and rot.

In the early years of cultivation the coconut seems to bear heavily when much of the stored plant food of the peat becomes available after drainage and subsequent oxidation. A rapid decline in fertility after some years can be expected.

It is suggested that the Mukah Series should be used for annual crops, especially when the depth of the organic topsoil approaches a thickness of 3 feet. Coffee and citrus may be other crops suitable for this soil type. A switch over to crops with a shallow root system is certainly needed if the organic top layer has subsided to such a level that drainage becomes impossible and the watertables are near the surface.

d) ANDERSON SERIES - 40,616 acres

The Anderson Series is in area by far the most extensive soil in the area surveyed but it is agriculturally of little importance. It is formed by deep peat soils (Great Soil Group - Bog soils) the organic deposits having a thickness ranging from 3 to over 10 feet deep.

On thickness of the organic deposits the series is sub-divided into three depth phases, namely:

Phase 1. organic deposits 3 - 6 feet deep
Phase 2. organic deposits 6 - 10 feet deep
Phase 3. organic deposits over 10 feet deep.

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The Anderson Series forms the nucleus of the area being enclosed by the sea in the north and the Samarahan and Sedong rivers respectively in the west and east. On all sides it is surrounded by clay-deposits although in the west and east it is found very near the rivers where meanders have removed much of the original clay levees. For the greater part it is still covered with Primary Forest (lowland Peat Forest) from which timber is extracted in places.

The mineral soil underneath the Anderson organic deposits is reported to be clay at all observation points. In peat deeper than 12 feet no clay bottom could be struck by poling but it can be safely assumed that in the whole basin clay forms the underlying material. The clay is greenish grey to light grey in colour, sticky and plastic.

Watertables in the Anderson Series are always high. In the dry season it may be 6 inches to 1 foot below the surface but in the wet season the watertable is at the surface or above it.

The Anderson Series is dome shaped, the peat deposits near the rims rising first quite steeply towards the centre of the peat area, whereafter the slope tends to level off.

Chemical analyses of the Anderson Series, phase 2 (S.3105/8) are given in the Appendix. In this particular sample area the calcium content of the topsoil is reasonable, while magnesium and potash are low.

Total phosphate is moderately high. It is mainly organic phosphorus. The pH is low. Total nitrogen appears to be high, but quite possibly not available to plants. It can further be expected that in th se peat soils trace elements will be in short supply, especially, copper, iron, magnesium and probably zinc.

Because of a shortage in other and better land the Anderson Series, especially phase 1 is cultivated in some places, e.g. near the Sadong river and in Ulu Jemukan. As is the case with the Mukah Series, during the first years the peat gives an abundant crop but soon it becomes exhausted.

The coconut on the Anderson 1 although bearing a lot of fruit is heavily leaning over, already before reaching maturity. Because of its original high situation above water level in the main streams the area does not suffer so much from flooding as is the case in the Mukah Series. Reclamation is also recent and the surface level has not gone down very much yet, so that drainage problems are not significant.

Because of the low agricultural value of these deep peat soils and the threatening danger of flooding after long term drainage and subsidence of the surface, the Anderson series could better be left untouched. To allow people to farm on the Anderson Series in order to solve the pressure for land is postponing the problem and eventually increases it. This shortsighted policy has not only spoilt muck peat land in the Nonok area but has resulted in problems for which no easy and cheap remedy can be found. It would be difficult however to urge people to abandon land which forms their only security in life.

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Although the growing of pineapples on this Series may be a sound economic proposition elsewhere, this is not the case in the Nonok area mainly because of inaccessibility and drainage problems. The boundary between Mukah Series and the Anderson Series should be taken as the boundary of permissable cultivation.

RAJANG SERIES - 9,141 acres

The Rejang Series forms a belt of saline soils fringing the area in the north along the coast and in places along the Samarahan and Sadong rivers in the west and east. The Series penetrates into the Nonok coastal areas alongside small tidal streams finding their sources in the freshwater swamp (Anderson Series).

The most important feature in the Rajang Series is its saline character which prevents the growing of crops. The natural vegetation is Mangrove in association with Nipah. In less saline places almost pure stands of Nipah are found.

General Characteristics

The Rajang usually consists of clays deposited in a deltaic environment. The clays are littoral deposits characterised by a high content of soluble salts and a high content of sodium in the exchange complex. The electric conductivity is generally above 4,000 micromho/cm while the Exchangeable Sodium is more than 15% of the total exchange capacity. Although the soils are generally clay throughout, a sandy loam phase was found at the mouth of the Samarahan river where the clay deposits are covered with a thin layer of sandy loam texture from Tambirat to as far north as the sea. It is suggested that the Batang Samarahan has spread this sand over this area after it cut through the coastal ridge (described under Tatau Series). It is possible that this ridge was much larger in former times and that most of the material has been eroded by the Samarahan river, the material being distributed and deposited through the action of tidal water along the banks of the Samarahan river and at sea near its mouth. Further upstream no sandy deposits of the Samarahan river were noticed along the banks and its source must therefore be sought in the coastal ridge.

Apart from being strongly saline (according to the American definition given by the Salinity Bureau Staff, the soils are classified as saline/alkali soils, ref.7) the soils are also strongly hydromorphic and display all the characteristics of the Low Humic Gleys to which they are related.

Once the salts of the Rajang Series are leached out the series is similar to the Pendam Series (probably saline phase). The profile consists of a greyish brown sticky and plastic clay (sandy loam for the sandy phase) top horizon of varying depth, depending on undulations of the surface but normally deeper than 24". There is not a normal A horizon in the sense that humus accumulates in it, but deposition of mineral matter takes place continuously thereby covering any amount of organic debris which may fall on the surface. The topsoils which may be two feet thick are therefore mixed with much organic debris, dead leaves and woody material and many roots, dead and alive, while in places whole trees can be found buried under the sediments.

The only difference between topsoil and subsoil (if one can use these terms) is that at a depth of more than two feet the colour is usually more greenish to bluish grey, while in places even a dark grey colour was observed, where the organic matter is more decomposed.

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Watertables vary with the tide and location. Near streams they drop considerably during low tide, while at high tides the series is submerged with salt water. Further away from the river the tidal change is less noticeable and watertables are more stable although most of the time not falling below a level of two feet.

The chemical features of the Series are dominated by its salty nature. Apart from pH and Conductivity reading no detailed chemical data was available from the area at the time of writing but analytical figures obtained from samples of the same series found in the Sarawak river delta can be used instead.

Base exchange capacity is moderately high in these samples and is over 20 meq/100 gram of soil. Base saturation is 100%, the adsorption complex being dominated by sodium. Calcium and magnesium in the adsorption complex is high for Sarawak conditions (more than 10 meq.). Magnesium may be twice as high as calcium.

The pH in the Rajang Series shows sometimes a remarkable drop after drying. All pH measurements for the Rajang Series were taken in the wet condition and give values of 7 or over indicating its saline character. After drying the pH did not drop very much but in other areas of Sarawak an acidity of as low as 3.5 has been reported for similar soils. Where this is accompanied by a high sulphate content such a fall in pH can be explained easily as sulphur compounds are most of the time present in the fresh samples of the Series. The sulphur becomes oxidised after drying and the resulting sulphates reduce the pH considerably even in the absence of cations like calcium or sodium.

The low pH of the Pendam Series reported upon in the description of that Series was contributed to the rapid leaching of bases after reclamation if the Rajang, but because of the fall in pH after drying in some Rajang samples, the occurrence of sulphates in this Series cannot be ruled out. If the Rajang is reclaimed and salts are leached out its fertility will be much the same as the related Pendam Series and if the large area of Rajang Series existing in the Nonok area could be satisfactorily reclaimed the agricultural potential of the area as a whole could be increased greatly. It would be advisable however to lime the Rajang Series if salts are leached out; this will reduce the acidifying effect of the sulphate which may form after draining and will help to revert the sodium clays into calcium clays thereby improving the structure of the soils. The lime requirement of this series should however be worked out prior to reclamation.

BOULDERY AND ROCKY LAND - 2 acres

This soil-type, although of no significance at all for agriculture is briefly discussed because it is found on the only small hill encountered in this vast area of alluvial deposits. The location is in Ulu Jemukan and it forms a small hill rising steeply out of the surrounding alluvium. The parent material is formed by Greenstone which is of Basic Igneous stock. None or little soil material has developed on this rock; probably the soils were removed by erosion or the time of exposure to air has been insufficiently long to allow any formation of soil to take place.

The two acre plot has been used partly as a building site for a school which has recently been moved to another location. The stone may perhaps be useful for road-making or for defending the coast line between Sampun and Jaie against further erosion although the available supply would not be much more than 10,500 cubic yards.

This chapter is completed with Table 4 which gives in a condensed form the most important features of the Series described. (see page 35).

Information on Soil Series in Nonok Coastal Area

Table 4

Pendam Series	Area A	Area B	Total	Drainage	Salinity	Fertility	Present Use	Agricultural significance	Improvements
Organic phase	3,866	328	4,194	poor	none to weak	moderate	100%	high potential	needs drainage
Saline phase	801	-	801	poor	moderate to weak	high	100% partly abandoned	high potential	leaching of salts & dra.
Muck and peat layered, leached phase	11,209	832	12,041	poor	none to weak	moderate	100%	high potential	needs drainage
Muck and peat layered, saline phase	2,625	760	3,385	poor	moderate to weak	moderate	100%	high potential	leaching of salts & dr.
leached phase	4,377	1,185	5,562	poor	none to weak	moderate	100%	high potential	needs drainage
Tatau series									
Poorly drained phase	114	-	114	poor	none to weak	probably moderate to low	mainly for village site	small	drainage
Very poorly drained phase	60	-	60	poor	weak to moderate			small	drainage
Mukah series	2,900	1,037	3,937	poor	none	moderate	100%	only for annuals & non-tree perennials, moderate	-
clay top phase									drainage
Anderson series									
phase 1 3-6 ft. deep	2,484	1,187	3,671	poor	none	low, moderate first years after reclamation	less than 5%	small. only to be used under guidance. Probably Silviculture more economical	Not relevant
phase 2 6-10 ft.	5,340	1,930	7,270	poor	none				
phase 3 10 ft.									
Rajang series	7,422	826	8,248	poor	strongly saline	high	nil	high after reclamation	leaching of salts & dra.
sandy loam phase	893	-	893	poor					
Bouldery and rocky land	2	-	2	rapid	none	none	building site	none	not relevant
Village sites	355	68	923	-	-	-	-	-	-
	68,799	11,635	80,433*						

* 1½% error with Land Use Map owing to error of instrument and distortion of scale.

PART 4

Conclusions

Under the heading 'Aim of Survey' the immediate objects of the survey were discussed. They were three-fold namely:

A. To give the exact acreage of land suitable for agriculture especially of the land which would become suitable after bunding the coastline.

B. To comment on the fertility aspects of the soils.

C. To give recommendations on the suitability of soils for crops other than coconut and padi.

Re A The exact acreage of land at present suitable for agriculture in Area A (the area for which a bunding scheme was proposed) is:

17,187 - clay soils
2,900 - shallow peat soils.

The total is 20,087 acres.

Soils regarded at present as unsuitable comprise:

Tatau series	-	174 acres
Anderson Series	-	34,175 acres
Rajang Series	-	8,315 acres
Village sites	-	348 acres
Rocky land	-	2 acres
Saline Pendam	-	3,065 acres.

The total acreage of unsuitable is therefore, 46,065, the majority of this being deep peat soils.

After a bunding scheme has been put into effect a maximum acreage of 7,656 acres (Mangrove and Nipah forest area) and 3,065 acres of Saline Pendam Series could be reclaimed. This acreage depends on the siting of the bund and the further this is built inland the less land can be reclaimed. After bunding the total acreage of suitable land would therefore be 30,808 (which figure is on the optimistic side.)

From the Land Use map, it can be learned that in Area A a total of 28,142 acres is used already for agriculture, the difference between this acreage and the 20,087 acres stated as being suitable is made up of 3-6 feet deep peat planted up with young coconut mainly, the remainder being secondary forest (on the Saline Pendam Series.) It follows that all the land at present suitable for cultivation is used and that cultivation is already carried out on land regarded as unsuitable. New land becoming available after bunding would comprise therefore only the saline phase of the Pendam Series (3065 acres) and 7,656 acres of Rejang Series soils).

Re B The majority of the soils at present regarded as suitable for agriculture have a fertility status which is higher than normally found in Sarawak soils (Pendam Series). The Rajang Series, at present not suitable but which is reclaimable after the salts are leached has a fertility status which is not less than that of the Pendam Series.

Apart from the salinity problem which at present is a limitation to cultivation in some coastal areas, the bad drainage in the whole area is a major obstacle to further development.

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Money spent on improving agriculture in the area will for the greater part be wasted if attention is not given first to ameliorating the present drainage conditions. After these have been improved proper land use is then needed to make full use of the potential of the inherent fertility of the soils. If these improvements can be realised effectively a capital expenditure of 150 to 200 Malayan dollars per acre would be justified.

Re C Where it is impossible to lower the watertable in certain areas beyond the marginal limit considered essential for the proper growing of coconut, a switch over to annual crops should form part of a proper land use planning for the area.

The present annual crops such as wet padi, groundnuts and soya beans are suitable crops for all the soils considered suitable for agriculture in the area and improvements in the growing and management of these crops aimed at increased production per acre should follow any land amelioration scheme. (Otherwise the money spent on improving the land will be wasted.) Other crops such as bananas, citrus and coffee should be tried out.

Apart from the land in Area A, a total of 1,345 acres of land suitable for agriculture can be found in the Area B. However, most of this land suffers from bad drainage as well, while 760 acres of this land is too salty for cultivation. It would be too costly to improve this land, the cost per acre being much higher than that for Area A. A possible small bunding scheme could be designed for Tj. Apong area where bunding could bring back into cultivation an estimated acreage of 1,000 acres of land at present very badly drained and in parts too salty for cultivation.

Recommendations

1. The proposed bunding scheme for the Nonok coastal area (part A) is regarded as the answer for stopping further infiltration of saltwater from taking place. Apart from saving valuable existing agricultural land, new land can be reclaimed thereby lowering the cost per acre for the whole area substantially.

2. Together with bunding the coastline, aimed at preventing saltwater from entering the area, a proper drainage scheme should be worked out, the administration and the maintenacne of which should be kept in the hands of a proper board so that such an expensive undertaking does not suffer from mismanagement.

3. Drainage of the area should avoid allowing peat swamp water from entering the coastal belt. It is suggested that a canal aimed at diverting this water to the west (into the Batang Samarahan) and to the east (into the Batand Sadong) could probably prevent this. The writer is not qualified to comment on the technicalities of such an undertaking and the views of the Drainage and Irrigation Branch of the Public Works Department are needed.

4. After amelioration of the land, land use should be guided and improvements in the growing and management of crops are certainly needed if crop-production must be increased in order to meet the high costs of the land-amelioration scheme.

It is suggested that at least one fully qualified junior agricultural officer should be stationed in the area and that serious thought should be given to experiment with the crops suitable for the area in the Nonok area itself. Apart from having experimental value such plots should have a demonstrational value as well. Attention should also be given to introduce double cropping in selected areas with padi in the wet season and off-season cropping in the drier period of the year.

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5. It appears that land on deep peat is already being cultivated and no time should be wasted in preventing further penetration into the deep peat areas. The boundary between the Mukah Series and the Anderson 1 Series shown on the soils map should be taken as the ultimate boundary up to where cultivation should be permitted.

It is quite probable that farmers living in these peat areas will never profit from any drainage scheme if the water coming from the interior peat area cannot be stopped from entering their farms.

6. A possible communication between Muara Tuang and the Nonok coastal area may be possible by providing a small railway of the type used by the timber-companies. It may prove to be more economical than building a road through deep peat. This railway could form a link with the proposed road Kuching-Muara Tuang and only a ferry service is than needed to provide direct communications with Kuching.

7. A small bunding scheme for Tj. Apong is proposed to improve an area of approximately 1,000 acres of potentially good land. Already the local population has expressed its willingness to provide the labour if guidance and the materials could be provided by the Government.

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Appendix

Soil Analyses for Nonok Coastal Area

PENDAM SERIES (Leached phase)

Lab.No.	Depth	pH		P ppm		in Meq/100 gr. soil					N% Tot.	% Loss on Ignition
		Wet	Dry	Tot.	Av.	Ca	Mg	K	Na	C.E.C.		
S.2993	0-11	4.2	3.9	358	23	1.61	0.45	0.17	1.45	12.62	0.25	8.25
S.2994	11-23	4.3	3.9	169	10	3.30	1.80	0.18	0.31	12.73	0.16	6.93
S.2995	22-47	3.3	3.4	150	8	5.89	3.21	0.24	0.31	4.72	0.19	9.35
S.2996	47-50	4.9	6.2	216	37	28.52	5.90	0.50	2.01	18.35	0.13	8.46
S.2997	0-20	4.9	4.8	366	23	8.74	3.64	0.23	0.37	21.65	0.49	15.51
S.2998	20-42	4.4	4.5	152	12	9.07	5.50	0.29	0.47	17.75	0.20	8.73
S.2999	42-52	4.7	4.6	167	16	9.88	7.10	0.33	0.60	16.53	0.17	8.54
S.3000	52-60	7.2	7.0	285	10	43.57	9.65	0.52	1.41	10.60	0.14	8.74
S.3001	0-4	4.3	4.0	435	24	2.80	1.13	0.08	0.34	15.72	0.33	17.36
S.3002	8-13	4.1	4.1	208	8	4.42	3.04	0.32	1.32	13.84	0.18	7.22
S.3003	20-30	4.5	4.0	168	8	6.85	6.8	0.34	0.45	18.76	0.17	8.61
S.3004	50-70	5.2	5.2	283	24	10.41	7.38	0.44	0.43	19.72	0.13	7.48
S.3101	0-4		4.9	480	11	6.89	6.03	0.18	0.57	26.18	0.60	
S.3102	9-12		5.0	184	5	5.43	5.46	0.43	0.52	16.23	0.16	
S.3103	10-20		4.7	207	6	6.16	8.49	0.51	0.87	12.40	0.15	
S.3104	45-50		5.2	253	7	7.50	8.97	0.60	0.84	18.98	0.12	
S.3017	0-2		5.2	695	25	7.74	5.46	1.18	0.45	21.98	0.37	
S.3018	5-10		5.5	199	9	1.79	14.07	0.39	0.35	18.46	0.18	
S.3019	14-18		5.1	206	11	7.25	5.78	0.55	0.57	21.42	0.18	
						PENDAM SERIES (Organic Phase)						
S.3012	0-5		5.2	812	7	13.11	5.58	0.33	0.13	30.15	0.17	29.89
S.3013	8-14		5.1	228	10	10.18	5.90	0.49	0.23	19.05	0.19	8.60
S.3014	20-		5.2	253	26	11.12	8.42	0.40	0.25	20.55	0.15	8.09
S.3020	0-6		5.0	834	26	12.72	3.39	0.48	0.34	36.52	0.84	30.60
S.3021	12-18		3.4	138	10	7.50	6.00	0.46	0.67	26.05	0.25	15.44

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MUKAH SERIES

Lab.No.	Depth	pH		P ppm		in Meq/100 gr. soil					N % Tot.	Loss in ignition
		Wet	Dry	Tot.	Av	Ca	Mg	K	Na	C.E.C.		
S.3022	0-11		3.0	529	25	0.99	0.14	0.26	2.12	34.27	1.82	88.35
S.3023	20-30		4.3	138	4	5.81	6.12	0.28	0.75	22.31	0.27	15.25
S.3009	0-10	3.4	3.3	678	30	1.15	0.54	0.47	1.55	53.08	2.03	93.33
S.3010A	10-37	3.5	3.3	254	11	0.91	0.38	0.20	0.46	53.79	1.03	87.23
S.3010B			3.8		8	2.06	2.55	0.11	0.45	47.35		75.04
S.3011	37-48	4.4	4.5	134	11	3.76	7.0	0.23	0.53	53.08	0.18	9.38
S.3005	0-12		3.2	629	25	1.28	1.22	0.44	0.34	50.35	1.44	65.56
S.3006	17-23		4.0	105	4	0.37	3.15	0.17	0.71	10.60	0.10	6.27
S.3007	27-40		4.4	190	3	0.91	4.71	0.25	1.50	22.05	0.08	4.12
S.3008	40-50		4.3	160	8	1.91	6.47	0.35	1.90	11.41	0.11	5.20
				ANDERSON SERIES								
S.3105	0-2		3.3	535	16	2.86	0.40	0.8	tr.	38.63	1.22	95.91
S.3106	2-7		3.4	328	9	1.45	0.37	0.11	0.17	31.74	1.82	97.54
S.3107	7-16		3.6	165	6	0.60	1.83	0.05	0.22	35.92	1.47	97.56
S.3108	16-42		3.9	123	2	0.36	0.58	0.06	0.35	46.71	1.33	94.71

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Miscellaneous analyses of soil series in Nonok Coastal Area

Soil series	Vegetation	Lab.No.	Depth ins.	pH Wet	pH Dry	SO_4 %	Elec. Con. Soil	Elec. Con. Groundwater
Rajang	Mangrove	S.3172	0-2	7.4	7.5			
		S.3173	46-12	7.5	7.7		5433	
		S.3174	12-24	7.5	7.8		7582	38,364
		S.3175	23-36	7.8	7.8		6900	
		S.3176	36-48	7.7	8.0		5872	
Rajang	Mangrove	S.3185	0-2	7.6	7.8	0.35	5100	
		S.3186	4-12	7.4	7.9	0.44	8050	
		S.3187	12-24	7.6	7.9	0.30	4191	37,808
		S.3188	24-36	7.9	7.6	0.08	7350	
		S.3189	36-48	7.5	8.0	0.28	3730	
Rajang	Dead coconut	S.3195	0-10	7.6	7.7			
		S.3196	12-20	7.2	7.2			
		S.3197	22-38	7.1	6.8	0.08	7350	
		S.3198	42-48	7.0	7.1	0.28	3730	
Rajang	Nipah	S.3239	2-16	7.8	7.9		1350	
		S.3240	20-40	7.8	7.6	0.10		
		S.3241	40-48	7.7	7.7			
Trans. Rajang Saline Pendam	Nipah some coconut	S.3242	0-10	4.5	4.5		3675	
		S.3243	10-18	4.7	5.1		615?	
		S.3244	18-38	6.5	5.5		7500	
		S.3245	40-48	7.3	7.5		1500	
Trans. Rajang Saline Pendam	Unknown	S.3264	0-5	5.8	5.1			
		S.3265	7-19	6.8	4.7			
		S.3266	30-39	7.5	7.3		2678	
		S.3267	40-47	7.2	7.4		3083	
Rajang	Nipah	S.3268	0-9	7.8	7.8		2380	
		S.3269	11-20	7.6	7.7			
		S.3270	21-33	7.6	7.9			
		S.3271	34-45	7.7	7.9			
Rajang	Nipah	S.3272	0-9	7.7	7.8		2350	
		S.3273	11-23	7.2	7.3		3900	
		S.3274	29-46	7.8	7.7			
Rajang	Nipah	S.3275	0-17	5.6	-			
		S.3276	20-32	7.0	-			
		S.3277	35-46	7.1	-			
Rajang	Nipah	S.3300	0-5	6.8	6.2			
		S.3301	5-15	7.0	6.8			
		S.3302	15-26	6.8	6.7		255	
		S.3303	26-36	6.9	6.6			
		S.3304	36-41	6.5	6.5			
		S.3305	41-48	7.6	7.4			
Saline Pendam	Coconut some Nipah	S.3235	0-10	6.4	5.6		1800	
		S.3236	10-20	6.3	5.6		1938	
		S.3237	20-30	6.8	6.8		1101	
		S.3238	32-48	7.4	6.6		109?	
Saline, muck-and peat lay-ered Pendam	Coconut	S.3204	0-12	5.5	5.0		1013	
		S.3205	12-30	5.9	5.9			4,003
		S.3206	30-48	6.4	5.9			

? - doubtful, possible wrong instrument reading.

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Soil Series	Vegetation	Lab.No.	Depth ins.	pH		SO_4	Elec. Con.	
				Wet	Dry		Soil	Groundwater
Saline, muck and peat layered Pendam	Coconut	S.3207	0-4	6.5	6.5		2349	
		S.3208	6-20	6.2	6.2	003	3848	
		S.3209	26-36	7.0	6.1	014	3600	17,792
		S.3210	36-48	7.5	6.9	019	3900	
Saline, muck and peat layered Pendam	Coconut (Flooded)	S.3246	0-10	6.3	6.1	0		
		S.3247	10-24	6.1	5.6	0		
		S.3248	24-36	6.5	5.7	tr.		
		S.3249	36-48	6.8	5.6	016		
Saline, muck and peat layered Pendam	Dead coconut	S.3250	0-10	5.2	4.8			
		S.3251	12-24	6.0	5.5			
		S.3252	24-36	6.9	5.8			
		S.3253	36-48	6.6	6.0			
Leached, muck and peat layered Pendam	Coconut	S.3177	0-2	5.1	4.9		210	
		S.3178	6-12	5.5	5.1		172	1,612
		S.3179	17-25	5.3	5.1		300	
		S.3180	20-45	6.1	6.1		484	
Leached, muck and peat layered Pendam	Coconut	S.3211	0-4	4.8	5.1			
		S.3212	6-10	4.9	5.3			
		S.3213	12-24	5.2	5.3	tr.	226	
		S.3214	24-36	6.7	6.9	015	389	2,001
		S.3215	36-48	6.8	6.9	021	906	
Leached, muck and peat layered Pendam	Jerami	S.3216	0-10	4.5	4.8			
		S.3217	10-15	5.2	5.2			
		S.3218	18-24	5.4	4.8	022		12,323?
		S.3219	24-36	5.9	5.3	033		
		S.3220	36-48	5.5	4.8	031	1056	
Organic Pendam	Coconut, bananas	S.3181	0-10	4.5	4.6		81	
		S.3182	12-24	5.4	4.9		255	1,668
		S.3183	24-36	5.5	5.0		255	
		S.3184	36-48	5.7	6.5		386	
Organic Pendam	Coconut, bananas	S.3190	0-3	4.8	4.6		1425	
		S.3191	4-8	5.2	4.6		1950	
		S.3192	10-24	5.6	5.9		1650	7,228?
		S.3193	24-36	6.2	6.1		1650	
		S.3194	36-48	6.3	6.3		226	
Organic Pendam	Coconut, bananas	S.3199	0-3	4.5	4.4		105	
		S.3200	4-12	5.1	5.1			
		S.3201	12-20	5.4	5.2		240	355
		S.3202	22-36	5.9	5.4		100	
		S.3203	36-48	6.3	6.4		252	
Organic Pendam	Coconut	S.3231	0-3	4.7	4.6		94	
		S.3232	3-8	5.1	4.5		70	
		S.3233	8-30	5.8	4.7	tr.	39	
		S.3234	34-48	6.2	6.6	025	631	

? - doubtful, possible wrong instrument reading.