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**SARAWAK
LAND CAPABILITY
CLASSIFICATION
AND
EVALUATION FOR
AGRICULTURAL CROPS**

(2ND EDITION)

VOLUME I-TEXT

by

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**DEPT. OF AGRICULTURE
SARAWAK**

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PREFACE

Since the first publication of "Sarawak Land Capability Classification and Evaluation for Agricultural Crops" (Technical Paper No. 5) in 1979, the system has been widely used in the interpretations of soil survey data. Recently, the publication ran out of print. Furthermore, the need for printing a second edition is augmented by the following developments:-

- (a) In 1982, an updated edition of Soil Classification in Sarawak was issued. In this latest version, several changes have been made, some soil families/series have been deleted and some others established. It is felt that these changes should be taken into account in future land-use appraisal.
- (b) All the eight sheets of Agriculture Capability map of Sarawak(1:250,000) have been printed. With the publication of these maps, more accurate estimates of the various classes of land have been obtained. It is therefore timely that this information (Appendix 1) and the maps could be disseminated with a second edition of Technical Paper No. 5. The Land and Survey Department, Sarawak has recently updated their Land-use map of Sarawak(1:250,000). The Soils Division has measured the area of various land-use classes and this information is also included in Appendix 2. It is hoped that comparisons of the information contained in Appendices 1 and 2 will yield a better understanding of the future agricultural potential of Sarawak.

The system presented in this paper is basically a "land capability classification" in its true sense. As such it is most useful in general-purpose appraisal, particularly in reconnaissance soil surveys for the identification of potential areas. However, in the latter portion of this system, various crop requirements are more or less rigidly defined and matched with land capability subclasses to determine crop suitability; this exercise is more akin to "land suitability classification".

It is repeatedly stressed in the scientific literature that no classification scheme can remain static. As new knowledge is gained, so should classifications be modified and improved. With the completion of reconnaissance soil surveys in Sarawak, the Soils Division is now doing more and more semi-detailed and detailed soil

TERMS OF REFERENCE(FIRST EDITION)

As a follow up of the soil surveys conducted under the sponsorship of Canadian International Development Agency from 1974 to 1978, a land capability study of all of Sarawak was undertaken to provide a sound basis for agricultural planning. This project was designed to evaluate each parcel of land designated in the soil surveys in terms of suitability for a wide range of crops and to indicate any limitations that would adversely affect crop production.

Under the terms of reference, the Canadian International Development Agency was to provide a soil evaluator to lead the project while the Sarawak Department of Agriculture was to provide a counterpart evaluator and supporting staff. Operational costs of the project including field work, map preparation and publication of the report were borne by the Government of Sarawak.

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SARAWAK LAND CLASSIFICATION AND EVALUATION
THE AGRICULTURAL CROPS

SUMMARY

Land capability maps for agriculture have been available for only limited areas of Sarawak but with the completion of the reconnaissance soil surveys a comprehensive programme of land evaluation for the entire State was undertaken. Since few figures are available on potential crop yields on different soil types, ratings are based mainly on known soil and land characteristics which are interpreted in terms of limitations to plant growth and the restraints to possible mechanization. Over one hundred soil series or families presently mapped in Sarawak have been evaluated and grouped into five classes ranging from good to poor according to the severity of the limitations. These are further divided into subclasses depending on the kinds of limitations such as depth of soil, wetness, fertility, stoniness and slope that determine their suitability for specific crops and indicate the need for possible improvements.

Soil and terrain requirements have been tabulated for twenty crop groups and matched with the known qualities of these soils. From this information a land capability map for agriculture (comprising eight sheets at 1:250,00) has been prepared which shows the capability of each mapping unit for agricultural utilization in general, the limitations and some of the anticipated management problems. The suitability of a particular mapping unit for a particular crop or crop group can be inferred from Table 5.

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1. INTRODUCTION

The purpose of classifying land according to its capability for agriculture is to provide one of a series of inventories for rational land use planning. This inventory should provide a firm estimate, in the form of maps and statistical tables, of the location, extent and quality of each land class and subclass for the production of the major climatically adapted crops. The land capability class indicates the severity or degree of limitation in land use while the subclass indicates the specific kind of limitation encountered. Complex technical information contained in soil survey maps and reports, as well as crop yields and fertilizer response data gleaned from research station and statistical reports are presented in simple terms of how suitable the land is for agriculture.

The land capability classification for this project is based on those of Andriess (1966), Wong (1974) and the Canada Land Inventory (Report No. 1, 1970 and No. 2, 1972). These have been modified by Eilers and Loi (1982) and Louie and Uyo (in prep.) to suit the soils, terrain and local conditions in Sarawak and takes into account a wide range of both annual and perennial crops suited to the local climate. It applies to all lands whether virgin, abandoned, resting or being currently utilized. The land evaluation concepts have been drawn from many sources of which most of them have been reviewed by Beek (1978).

Since few figures are available on the crop yield potential of the various soils in Sarawak, the main sources of reliable information are the soil surveys. By means of description, classification and mapping, these provide the basic information on which soils can be rated and grouped into broad capability classes from good to poor. The kind of terrain and the observable soil profile characteristics such as soil depth, colour, structure, texture, wetness and parent material are examined and evaluated in agronomic terms of rooting volume, tilth, moisture-holding capacity, drainage, fertility, slope and suitability for mechanization that enhance or limit their potential use. In a land

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capability map for agriculture, these factors will determine the kinds of limitations to be encountered while the severity of limitation will determine the class rating. Matching the class rating and the kinds of limitations expressed as subclass with the stated requirements of each crop can show the user the types of agricultural crops suitable for each area, the problems likely to be encountered and the feasibility of making improvements.

The purpose of the present study is to consolidate existing soil survey and land capability information into a unified land capability map for Sarawak. This will show the location and extent of each land class and subclass and indicate the range of crops that can be grown. The information will be useful to aid the government's programmes of agricultural extension, crop diversification and subsidy schemes or for interested individuals in search of land for farming.

An inventory of the agricultural resources of Sarawak is particularly important because of the extreme scarcity of good agricultural land. Of the 12.3 million hectares in Sarawak only about 28 percent or 3.48 million hectares are suitable for any kind of agricultural use, while the rest consists mainly of steep hilly land in the interior and deep peat swamps along the sea coast. Of the land suitable for agriculture, about 1.64 million hectares are classed as marginal and consist mainly of hilly land suitable only for small-holders using hand tools for rubber or subsistence crops leaving 1.84 million hectares as moderately suitable to suitable for commercial agriculture. Of the latter, only 207,000 hectares are free of some serious limitations to agriculture and are level enough for the employment of modern farm tillage and harvesting machinery. This makes up only 1.7 percent of the total area of Sarawak (see Appendix 1).

2. ASSUMPTIONS AND EXPLANATION

- (a) The system is an interpretive classification based on the combined effects of soil and terrain characteristics and probability of flooding which limit the use of the land for agriculture and on its general productive capacity for crops.
- (b) Good land use practices and a moderate level of management are assumed for commercial farms. This requires that good soil conservation practices be employed to ensure that farming can be permanently

maintained. On-farm drainage and organic matter and fertility enhancement will be standard practices although these may be beyond the financial or managerial capacity of the small-holders. Small-holders, on the other hand, will be able to grow crops such as maize, sorghum, soyabean, vegetables, groundnut and pineapple on steeper or stonier land as most of the work will be done by hand labour and machinery access is not required. Bananas can be grown on land with impeded drainage for local markets where quality and bunch weight requirements are less exacting than for export. Land in this category is indicated as being suitable only for small-holder and subsistence farming.

- (c) Soils within a capability class are similar in amount or degree of limitation hindering agriculture while the subclasses provide information on the kinds of limitations.
- (d) The capability classification may change when major reclamation works such as irrigation, drainage and flood controls are installed.
- (e) Economic factors such as distance to market or cultural characteristics such as skills and resources of the land operators are not criteria for capability groupings.
- (f) Variations in climatic conditions have not been taken into account in separating the different suitability classes. However, due to a cooler climate some of the highland areas should also be suitable for cool season vegetables, flowers and fruits.

3. FACTORS LIMITING CROP PRODUCTION

Specific guidelines have been established to determine land capability classes for all of the soil mapping units in use in Sarawak. The degree of limitation to crop production for each of the fifteen attributes of soil and terrain are separated into five levels of severity ranging from none to very serious. These are shown in Table 1a for mineral soils and Table 1b for organic soils. The number and severity of these limitations as shown in Table 2 determine the capability class ratings and indicate the range of crops that can be grown. This applies to both mineral and organic soils. Tables 3a and 3b show the range of tolerance for each crop group to the main limitations. Some crops are more adversely affected by one limitation than by another, e.g. vegetable crops are intolerant of flooding but can be grown on shallow soils while cocoa and

fruit trees require deep soils but can withstand moderate flooding. A shallow soil that is level but subject to flooding would be unsuitable for either group of crops but could be used for wet-land rice.

The five distinctive levels established for each of the limitations are as follows:

- (a) None : No crop restrictions attributable to soil, water or terrain criteria.
- (b) Minor : Limitations that reduce the productivity of only a few specific crops or that can be easily corrected by proper management.
- (c) Moderate : Soil, water and terrain limitations that restrict the range of crops or require moderate conservation practices.
- (d) Serious : Soil, water and terrain limitations that will seriously inhibit or even preclude the growing of some crops but which may be well suited to others.
- (e) Very Serious : Soil and terrain limitations that will not only hinder but may totally inhibit the use of this land for crop production.

4. CAPABILITY CLASSES

4.1 Capability classes of mineral soils

The mineral soils are grouped into Classes 1 to 5 according to the increasing severity and number of limitation affecting crop production. Classes 1 to 3 decline from suitable to moderately limiting in their agricultural capabilities and in the range of crops that can be grown successfully. Class 4 is marginal for agriculture and suited to only a few specifically adapted crops (such as wet-land rice on undrained sulphidic land). Major improvements are required before a wider range of crops can be grown. Class 5 is for soils and terrain which have little or no value for agriculture in their present condition although an especially well adapted crop might be grown e.g. sago on undrained deep peat or cashew on excessively drained coarse sand.

4.1.1 Class 1

- Land with no limitations or only one minor limitation to crop growth.

Land in Class 1 imposes no significant limitation to plant growth and is suitable for the widest range of

climatically adapted upland crops. The soils are deep with level to very gently sloping topography. They are well to moderately well drained and have good water and nutrient-holding capacities. They are easily maintained in good tilth and productivity. Minimal drainage or soil conservation measures are required. Class 1 lands are of such limited extent in Sarawak that they have usually been combined with Class 2 at the reconnaissance mapping scale. Well to moderately well drained soils however, are not suitable for wet-land crops such as flood-irrigated rice or sago.

4.1.2 Class 2

- Land with two or three minor limitations or one moderate limitation that restricts the range of crops and/or requires moderate drainage or some conservation practices.

Land in Class 2 is incapable of supporting quite as wide a range of annual and perennial crops as that in Class 1. The soils are deep, level to moderately sloping and have good to imperfect drainage. If flooding occurs it is of short duration. The soils can be managed and cropped with little difficulty.

Examples of Class 2 land include the moderately well drained Seduau soils on upper alluvial floodplains. Its only limitation is inundation which may be frequent but of short duration. A wide range of crops can be grown, including rubber, oil palm, cocoa, fruit trees, coconut, forage grasses, vegetables, rain-fed upland rice and wet-land rice under irrigation. Well drained residual soils such as Merit and Bekenu, occurring on slopes of 6 to 12 degrees are also rated Class 2 with minor slope and erosion limitations. In addition to the above mentioned crops these soils, because of their freedom from flooding hazard, are suitable for maize, coffee and pepper but unsuited to root crops or vegetables requiring frequent tillage because of the increased erosion hazard. Clay loams and clays could be terraced for wet-land rice.

4.1.3 Class 3

- Land with two or three moderate limitations or one serious limitation that restricts the range of crops, the degree of possible mechanization, or requires special conservation practice.

Land in Class 3 has more pronounced or more kinds of limitations than that in Class 2 and conservation practices are more difficult to apply and maintain. In this Class, the limitations that restrict the ease of tillage, planting

and harvesting, the choice of crops and the application and maintenance of conservation practices may include moderately severe effects of erosion, low fertility correctable with consistently heavy applications of fertilizers, hilly terrain, frequent over-flow accompanied by crop damage, poor drainage, moderate salinity, restricted rooting zone, low water-holding capacity or stoniness sufficiently severe to hinder cultivation. Examples of Class 3 land include Seduau and Bemang soils with deep, well drained, fine to medium-textured profiles but subject to serious flooding hazard or, well drained hill soils such as Merit, Bekenu, Tarat and Abok on slopes of 12 to 25 degrees. A fairly wide range of crops can be grown on these sites. Class 3 is a common rating in the coastal lowland area and adjoining river valleys. Although few crops are adapted to the poorly drained conditions of the Bijat series, it is one of the best natural soils for wet-land rice in Sarawak. It is rated as Class 3 with wetness as the major limitation to a wider range of crops.

4.1.4 Class 4

- Land with several moderate or two or three serious limitations that severely restrict the range of crops or require special conservation practices, or both.

Land in Class 4 has such limitations that it is only suitable for a few crops, the yield is low or the risk of crop failure is high. The limitations may seriously affect such farm practices as the timing, ease of tillage, planting, harvesting and the application and maintenance of conservation practices. Limitations include very low water-holding capacity, low fertility which is difficult or unfeasible to correct, steep slopes, severe erosion, frequent flooding with severe effects on crops or very restricted rooting zone over bedrock.

Residual Merit and Bekenu soils occurring on slopes of 25 to 33 degrees is a common Class 4 unit in the interior. The management associated with preparing these sites for planting, maintenance and harvesting agricultural crops; the difficult access imposed by the terrain and the serious long term effects of potential soil erosion render these sites suitable for only an infrequent crop of hill rice or for small-holder rubber with a permanent ground cover. Another example of Class 4 land is the humic podzolic Buso series with acute nutrient deficiency and low nutrient- and moisture-holding capacities. It is suitable only for such low-nutrient tolerant crops as coconuts and cashews. The weakly saline and poorly drained Pendam series, although rated as Class 4, is well suited to salt-tolerant rice cultivars and with drainage and dyking to prevent fresh or salt water intrusion could be improved to support a

moderately wide range of crops.

4.1.5 Class 5

- Land with such severe limitations that with a few limited exceptions precludes the use of the area for agriculture.

Limitations include very steep slopes (greater than 33 degrees), very severe erosion hazard, frequent floods of long duration, excessive salinity, shallow soils over bedrock or extremely low nutrient and moisture-retaining capacity. The few crops that can be grown are rice and sago on land subject to severe flooding if the plants are not submerged, and marginally, cashew on droughty coarse sand.

The Miri series found in the coastal area is an example of Class 5 land. It is unamenable to improvements for agricultural use as it has developed on quartzitic sand making it extremely low in fertility and water-holding capacity. It is further impaired by the presence of an impervious humic B horizon at a depth of 60-100cm which creates a perched water-table and poor drainage conditions during much of the year. Another example of Class 5 land in the coastal area is the Rajang series, a saline alluvial clay affected by sulphidic sub-soils and subject to inundation by tidal waters. These soils have moderate agricultural potential when they are dyked, generally drained and well managed.

Much of the interior of Sarawak is rated as Class 5 with excessively steep slopes or shallow actively eroding soils of the Kapit, Tutoh and Meluan families. Settled agricultural development will depend on the better lands of the natural terraces and river valleys while more intensive production may be developed on the Class 4 land in the future by terracing. However unsuitable, considerable areas of Class 5 land are used for shifting cultivation but might be better reserved for forestry and wild life conservation. Lau and Chung (1978) have shown that the gross annual return per unit area from sustained forestry on a 25-year harvesting cycle to be almost four times as great as from shifting rice cultivation. At the same time, it should be realized that some areas of Class 5 land consisting of shallow, poorly drained or extremely infertile soils may also be unsuitable for commercial forestry.

4.2 Capability classes of organic soils

The organic soils are rated on the same capability scale for crop production as the mineral soils but labelled with the prefix 'O' because their management requirements

are quite different and much more exacting. Since this method rates most of the peat soils in Sarawak as unsuitable for agriculture (Class 05) and even the better ones as only marginally suitable (Class 04), it should be noted that after drainage and reclamation most of these soils would be improved by one unit in their class ratings. However, the feasibility of drainage has not been determined and its certainty should not be assumed. Due to their extensive acreage and proximity to the population centres, organic soils constitute an important part of the land resources of Sarawak and must therefore be carefully evaluated.

A moderately wide range of crops can be grown on organic soils under careful management. This includes proper drainage to gradually lower the water-table and enhance surface decomposition, lime added to raise the soil pH and a comprehensive fertilizer programme with particular attention to minor element requirements. Under improved conditions such crops as pineapple, tapioca, coconut, oil palm and vegetables can be grown. However, drainage of an extensive low-lying peat swamp is a difficult undertaking which is complicated by the need to maintain the water-table within a narrow range of crop tolerance. Furthermore, the high degree of shrinkage and decomposition of the peat associated with a lower water-table and increased soil aeration results in a lowering of the land surface that progressively increases the difficulty of drainage and the risk of flooding. Lodging and uprooting is an additional problem with cereals and tree crops due to poor anchorage in the loosely structured organic topsoil.

The sequence of describing the classes of organic soils is from poor (05) to good (02) so that the criteria for upgrading from one class to the next due to reclamation can be more easily shown. Deep peats are greater than 150cm in depth and shallow peats (except KAPOR Family - see Tie, 1982) from 50 to 150cm; those with an organic layer of 20 to 50 cm are classed as a peaty phase of the underlying mineral soil.

4.2.1 Class 05

Land consisting of peat greater than 150cm deep or shallow peat over sand. Class 05 land has four or more serious limitations in its original state that with the exception of sago precludes the use of the area for agriculture without major improvement. Limitations may include low fertility, undecomposed surface peat, high water-table, inundation and deep accumulation of raw peat. Deep peat is considered a serious limitation because of its low bulk density resulting in poor anchorage for roots and upon draining, severe shrinkage and subsidence. The deep basin peats of the Anderson Family are marginally suitable for indigenous sago palm and are rated as Class 05.

Sand underlying a shallow peat is also a serious limitation due to its acute nutrient deficiency and in addition, on disappearance of the peat, its low moisture-holding capacity. Major improvements in drainage and water-table control would enhance decomposition and consolidation and give these soils an improved rating of 04. Under good agronomic practices they would be suitable for vegetables, root crops and pineapple but unsuitable for banana and most of the tree crops due to their sandy subsoil.

4.2.2 Class 04

Land suitable without drainage for only sago and rice. This land has two or three serious limitations that restrict the range of crops and requires special management practices. In its unimproved state Class 04 land may have such serious limitations as salinity, high water-table, low fertility and an undecomposed fibric surface layer. A 50-150cm depth of peat is a moderate limitation as it decreases root anchorage and access to nutrient reserves and increases drainage requirements.

Mukah peat with 50 to 150cm of peat over clay and Gadong muck with a depth of more than 150cm are suitable only for wet-land rice and sago in their natural states. Because of their proximity to the underlying clay or the presence of clay within the profile the soils are generally more responsive to improvements than the Class 05 soils. They are also more accessible because they often occupy an intermediate position between the river levees and the Class 05 deep basin peats although this does not influence their class rating.

Major improvements in flood protection, drainage and water-table control could change the rating of these soils from 04 to 03. With comprehensive fertilizer and production programmes a wide range of crops can be grown but due to the high cost of such a reclamation project, its economic feasibility would have to be carefully assessed.

4.2.3 Class 03 to 02

These are good soils for wet-land rice or sago and dry season crops such as vegetables, maize and soyabeans. They have one serious limitation in the undrained state, i.e. wetness. If already drained they may have two or three moderate limitations or one serious limitation such as very low fertility or muck more than 150cm deep. These limitations restrict the range of crops or require considerable improvement before the range of crops can be extended. Class 03 is represented by the Epai series - a

shallow (50-150cm) muck over clay. Major improvements in flood protection and water-table control could improve the rating of the Epai series to Class 02 and expand its suitability to include most annual and perennial crops. This is the best possible rating for an organic soil in this classification system, its single moderate limitation being the 50 to 150cm organic layer which induces lodging of cereal crops and reduces the stability of tree crops due to poor root anchorage.

5. LAND CAPABILITY SUBCLASS

The land capability subclasses shown in Table 1 are sub-divisions within the capability classes. They are based on the kinds of soil, water and terrain limitations encountered and provide specific guidelines in the choice of suitable alternative crops and the management practices required. Fifteen possible limitations are recognised and described. Seven of these are specific to mineral soils, five are applicable to either organic or mineral soils and three are specific to organic soils. These limitations are designated on the capability map by letter symbols after the class rating (e.g. 4mf). A land capability unit usually consists of one capability class with a maximum of two limitations. It should be noted that a land unit may have more than two limitations. However, due to cartographic reason, only the two most serious and/or important limitations are indicated. In mixed areas two capability classes are often shown each of which may have up to two limitations (e.g. 3iw-4te). Each limitation and its letter symbol is shown below:

| | Limitation | Symbol |
|-----|--------------------------------|--------|
| (a) | Mineral soils | |
| | Depth to massive clay | c |
| | Soil depth to impervious layer | d |
| | Erosion hazard | e |
| | Moisture-holding capacity | m |
| | Stoniness | r |
| | Slope (topography) | t |
| | Wetness | w |

| | | | |
|-----|-----------------------------|--|---|
| (b) | Mineral or Organic soils | Depth to sulphidic layer (potential acid-sulphate) | a |
| | | Fertility | f |
| | | Inundation hazard | i |
| | | Depth of organic layer | o |
| | | Salinity of groundwater | s |
| (c) | Organic soils | Depth to groundwater- table | g |
| | | Degree of humification | h |
| | | Nature(texture) of mineral subsoil | n |

5.1 Subclass limitation applicable only to mineral soils

5.1.1 Depth to massive clay(c)

Massive (usually heavy) clay with very firm to extremely firm moist consistency, although allowing some root penetration, is a moderate limitation if it occurs within 50cm of the surface with cocoa, fruit trees and pepper being most adversely affected. Being plastic and very sticky when wet, and very hard when dry, massive clay also becomes a problem to tillage operations if it occurs within 25cm and is then a serious limitation. Examples of where massive clay may occur are in Bijat, Pendam, Semongok and Kerait soils.

5.1.2 Soil depth to impervious layer(d)

The occurrence of unweathered rock, pan formation, a concentration of lithorelic fragments too great to be penetrated by an Adelman soil auger, or stones occupying more than 50 percent of the soil volume, between 25 and 50cm from the surface is considered a serious limitation as it restricts the growth of all but the shallow rooted crops.

Shallow soils curtail root ramification and limit the volume of soil, adversely affecting the nutrient and moisture reserves. Fruit trees and cocoa are severely affected by shallow soils while special techniques such as ridging may be required for the production of root crops. Shallow soils are often associated with steep slopes and rated Class 4dt suitable only for small scale plantings of

upland rice. Soils with a depth of less than 25cm are unsuitable for agriculture and are rated Class 5d. Where hilly land is to be terraced, a soil depth of at least 75cm is required to produce a terrace of adequate width.

5.1.3 Erosion hazard(e)

The severity of erosion by water is influenced mainly by gradient and length of slope, intensity and duration of rainfall, vegetative cover, surface litter and root mat, stability of the surface soil, and infiltration and percolation rate of the soil. In Sarawak, rainfall intensities of 100 to 150mm(4-6in) per hour are common and in a steep, dissected juvenile landscape, erosion is a serious hazard in land use. Sandy and loamy soils are highly susceptible to erosion on 12- to 25- degree slopes making it a serious limitation in crop management. The heavier-textured soils with stronger aggregation are less susceptible to erosion and on 12- to 25- degree slopes the limitation would be considered moderate. F. Haili Teck (Per. Comm., 1986) reports that the average(1978-85) amount of soil lost by erosion from a clean-weeded traditionally managed pepper garden for a clay soil on a 25- degree slope was computed at 91.24 tonnes per hectare per year compared to 1.99 tonnes for terraced pepper on the same slopes. Primary jungle and traditional hill rice showed a loss of 0.25 and 0.18 tonnes per hectare per year respectively. The recommendations that when pepper is planted on slopes greater than 12 degrees good soil conservation practices must be employed appears to be well substantiated while traditional hill padi is not a cause for concern provided the bush/fallow period is adequate (10-20 years). In the 25- to 33- degree slope range, the erosion hazard would be serious for fine-textured soils which would then be suitable only for an occasional crop of hill rice with minimal disturbance and for small-holder rubber. Coarse-textured soils on this slope would not be recommended even for an occasional crop of hill rice but they are suitable for small-holder rubber under a good ground cover. Slopes greater than 33 degrees are unsuitable for agricultural activities due to insecure footing, difficulty of access and severe erosion hazard.

5.1.4 Moisture-holding capacity(m)

Soils where crops are adversely affected by droughtiness owing to inherent soil characteristics have a limitation "m" in the rating symbol. Fine and medium sands have a low moisture-holding capacity and if they extend to a depth of 100cm constitute a serious limitation to crop production. These soils are also low in fertility and nutrient-retaining capacity giving them a rating of Class

4mf for which the range of crops is restricted to forage, coconut and cashew. However, if a water-table is present at about 75cm they are also well suited to water melon. The coarse sands are rated as Class 5mf as they have a very serious moisture-holding capacity limitation. They are only marginally suitable for cashew and are unsuitable for other agricultural crops. On the other hand, the moisture limitation for the sandy loams is moderate while soils ranging from loams to clays have no moisture limitation.

The presence of excessive amounts of gravel, stone or rock fragments has an equally adverse effect on the effective soil volume and hence on its nutrient- and moisture-holding capacity. Stone occupying 15 to 35 percent of the soil volume in the 25 to 100cm depth is a moderate limitation; while 35 to 50 percent is a serious limitation. The oxisols too may have only a medium moisture-holding capacity and are well drained but due to the absence of an extended dry season and the friable nature of the soil which permits deep rooting, moisture deficiency is not a problem unless the soils are shallow.

5.1.5 Stoniness(r)

Land with stones, rock or concretionary fragments covering from 15 to 50 percent of the surface area or occupying this much of the top 25cm of soil volume would be rated as Class 3r. This amount of stone at or near the surface is a serious limitation as it would be too costly to remove and precludes the use of tillage equipment for arable crops. Stones also impede root development and reduce the effective soil volume for moisture and nutrient retention. Stony land can be used for pasture crops and small scale subsistence planting of upland rice, and for tree crops and maize if the soil depth is not limiting.

5.1.6 Slope(t)

Topography, expressed as steepness of slope, is a dominant factor in agricultural land use. It determines the choice of crop by the degree of mechanization that can be introduced, the ease of movement in the field for site preparation, planting, maintenance, harvesting and removal of the crop or it may preclude mechanization entirely. With increasing slope the land becomes more variable, making uniform cultural and fertility practices less effective and crop maturity uneven. Soil conservation measures such as contour tillage, cover crops, drainage control and terracing may be required which increase production costs and the degree of management employed. In Sarawak where much of the interior terrain is steep and presently utilized under labour intensive small-holder management, steepness is less

restrictive to crops so the upper slope limit for agriculture is locally chosen at 33 degrees. This angle is approximately the lower limit for mass wasting or soil slumping.

The followings are topographic limits for agricultural capability class ratings:

- | | | |
|-----------|---------------------------|---|
| Class 1 | 0-6° slope: (0-10%) | No limitation; no special cultural practices required and all types of agricultural machinery can be used. Flood irrigated crops are limited to 0-2° slopes. |
| Class 2e | 6-12° slope: (10-21%) | Two minor limitations are slope and erosion hazard; majority of cultural machinery can be used without, or with slight difficulty; contour cultivation necessary; not suitable for frequently tilled crops. |
| Class 3te | 12-25° slope: (21-47%) | Moderate slope and erosion hazard limitations; only lighter types of agricultural equipment can be used; too steep for mechanically harvested crops. Suitable with some conservation practices for crops that do not require tillage such as oil palm, cocoa, coconut, fruit trees, rubber and upland rice. |
| Class 4te | 25-33° slope: (47-65%) | Serious slope and erosion hazard limitations; can only be cultivated with the use of hand tools; suitable for rubber that does not need frequent care or for occasional planting to subsistence maize or upland rice with good conservation practices. |
| Class 5te | 33°+ slope: (65%+) | Very serious limitation; too steep for agricultural use. |

5.1.7 Wetness(w)

This may be due to either impeded profile drainage or a high water-table resulting from lateral seepage or poor area drainage which by restricting soil aeration limits the crops that can be grown. Only such wet-land crops as rice and sago will thrive in saturated soils. Most dry-land crops will tolerate some degree of wetness except pepper,

vegetables and root crops which require well to moderately well drained soils. The range of crops decreases with increasing soil wetness and consequently the soil capability rating is downgraded. Poorly drained soils are considered a serious limitation as they are suitable only for the production of rice and sago. Imperfectly drained soils are suitable for maize, soyabean, sugar cane, grasses and most tree crops but since they are not suitable for root crops, water-melon, estate banana, pepper or papaya, imperfect drainage is considered as a moderate limitation.

5.2 Subclass limitation applicable to either mineral or organic soils

5.2.1 Depth to sulphidic layer(a)

Coastal marine alluvial soils require great care in drainage as they may become highly acidic on oxidation if they contain excessive quantities of sulphidic compounds. When a sulphidic soil is drained, oxidation of the sulphidic compounds to sulphuric acid and sulphates takes place and produces an acid condition in the soil. This usually results in severe deterioration of the condition of the soil so that many years of continued aeration and leaching must elapse before it becomes suitable for cultivation of upland crops. Failure of crops growing on these soils when well drained has been attributed to a combination of extreme acidity, aluminum toxicity and phosphorus deficiency. When flooded for rice production they may suffer from hydrogen sulphide or iron toxicity which can best be overcome by delayed planting. When sulphidic soils are to be brought into production the watertable should be lowered gradually so that the sulphides are slowly oxidized without leading to excessive acidification. The acid formed can be removed with the drainage water or neutralized by the addition of lime. Where mudlobster (Thalassima anomela) are present they should be destroyed to prevent them from bringing sulphidic subsoil to the surface.

A sulphidic layer within 50cm of the surface of a mineral soil is a serious limitation as it limits its use to sago and wet-land rice under continuously saturated conditions. A sulphidic layer within 50-75cm would be a moderate limitation where in addition to sago and rice, forage crops, rain-fed rice, coconut and subsistence vegetables can be grown. At 75-100cm it would be a minor limitation and all tree crops except cocoa could also be grown. Virgin organic soils to be developed for similar crops would require an extra 25-50cm depth to the sulphidic layer to compensate for compaction and subsidence of the peat.

increases the need for drainage. The presence of more than 20cm of peat on a mineral soil imposes a moderate limitation to its agricultural capability. A peaty layer of less than 20cm in depth is not considered a limitation as it is readily incorporated and would improve the structure of the mineral soil.

A shallow organic soil, one defined as having 50 to 150cm of organic soil materials is shown by the prefix 'O' in its class rating(e.g. O4). If the organic layer is more than 150cm deep then a small 'o' would also appear as the subclass symbol(e.g. O4o). A deep organic horizon, one defined as being more than 150cm in depth, is considered as a serious limitation to crop production as it provides little anchorage for tree crops and isolates plants from a source of nutrients in the mineral horizon below. Deep peats also have a higher potential for subsidence after drainage than shallow ones and require frequent deepening of the drainage ditches. An organic layer of 50 to 150cm, on the other hand, is considered as only a moderate limitation to crop production and when properly drained and managed is suitable for a fairly wide range of crops.

5.2.5 Salinity of groundwater(s)

Salinity is associated with marine alluvium subjected to tidal flooding by sea or brackish water. Soils with enough salts to adversely affect plant growth cannot be placed in Class 1 or 2. Undrained mineral soils with a groundwater conductivity reading of 1,000-4,000 $\mu\text{S}/\text{cm}$ (S stands for siemen and is the SI unit replacing mho) would be rated as Class 4ws with serious limitations to crop growth due to both wetness and salinity. These soils are only suitable for sago and salt-tolerant rice cultivars and after drainage, to coconuts and salt-tolerant grasses. Where the groundwater salinity exceeds 4,000 $\mu\text{S}/\text{cm}$ agricultural crops cannot be grown and the land is rated Class 5s.

Groundwater salinity is used in Sarawak as a measure of plant growth restriction because of the ease of field sampling and conducting the test. These figures can be converted to saturation extract values by multiplying them by a factor of approximately 2.0 for clay soils. A groundwater salinity readings between 1,000 and 4,000 $\mu\text{S}/\text{cm}$ rated as a serious limitation to plant growth would be equal to a saturation extract range from 2,000 to 8,000 $\mu\text{S}/\text{cm}$ in which yields of many crops would be restricted or salt-tolerant cultivars would be required. Dyking to exclude saline water and adequate drainage are required to reclaim these areas. On the peats and very sandy soils excessive salts are readily removed with the drainage water but this may require several years for the clay soils.

In classifying saline soils of Sarawak, the electrical conductivity of the 1:5 soil: water extract (EC5) is used to define the three classes of salinity (Tie, 1982). Groundwater conductivity readings of <1000, 1000-4,000 and >4,000 uS/cm roughly correspond to the non-saline, weakly saline (EC5 between 300 and 1200 uS/cm) and strongly saline classes respectively.

5.3 Subclass limitations applicable only to organic soils

Forest peat in its natural undrained state is usually an unconsolidated mixture of tree roots, branches, and leaves in various stages of decomposition. Serious limitations for agricultural crops may include groundwater (g) at or near the surface, a predominance of undecomposed plant residues (h), groundwater salinity (s), a depth of peat exceeding 150cm (o), extremely low fertility (f), or the presence of sulphides (a) or nutrient-deficient sandy subsoils (n) making it unsuitable for agriculture without major improvements. Undrained deep peats are rated 05go while undrained shallow peats overlying clays are rated 04gf. Only the two most serious limitations are shown although others may be present.

5.3.1 Depth to groundwater-table (g)

In an organic soil a groundwater-table of less than 30cm below the surface is a serious limitation to crop growth. Although wet-land rice and sago may be grown on undrained peats, some carefully controlled drainage is a continuous requirement in organic soils for other crops. A water-table between 30 to 60cm below the surface is a moderate limitation as it is suited only to shallow-rooted crops such as soyabean, vegetables and grasses while other dry-land crops require a water-table between 60 to 100cm. Even with the water-table controlled within this optimal range recurring problems may be encountered on deep peats in maintaining adequate depth of drainage channels until decomposition, compaction and resulting subsidence become stabilized. On the other hand, overdrainage which allows the water-table to fall below 100cm in a dry season would be a serious limitation to crop growth. Over-drainage would also expose an excessive depth of peat to aeration and shrinkage thus increasing the rate of decomposition and subsidence, and the flooding hazard. The loss of the peat over a sandy subsoil would preclude the growing of vegetables, root crops, sugar cane and pineapple and restrict the range of crops to forage, coconut and cashew. Shallow peats with sulphidic subsoils would best be reserved for wet-land rice or sago so that the high water-table would minimize the settling of the peat and prevent oxidation of the sulphides

to sulphates. Research is presently being undertaken on the use of undrained deep peats for rice and sago which will provide for the long term use and the preservation of this kind of soil.

5.3.2 Degree of humification(h)

The undecomposed surface layer of peat and the abundance of logs and large woody fragments are considered a serious limitation to agricultural crops. It provides both a poor physical and nutritional environment for plant growth and in addition makes field tillage impractical. Initial reclamation entailing drainage, clearing and burning of the surface debris will be costly but subsequent cultivation, liming and fertilizer application will encourage decomposition and consolidation of the surface peat and the production of a mellow soil. The rating of most peat soils can be expected to improve by one class on reclamation, e.g. a soil initially rated as 04gf could become 03f and suitable for both herbaceous and tree crops while one rated 05go could become 04fo which limits it to a narrower range of agricultural crops.

5.3.3. Nature(texture) of the mineral subsoil(n)

A fine-textured mineral soil underlying a shallow peat is not considered to be a limitation to crop production but is an important requirement for rice and the long term suitability of a peat soil for cocoa, oil palm, fruit trees and rubber. A sandy subsoil on the other hand is a serious limitation as it is low in nutrients and following loss of the peat deposit has a low capacity for retaining moisture or added fertilizers.

An undrained shallow peat with a sandy subsoil would be rated 05gn and on reclamation 04fn. With good water-table control and heavy fertilizer applications it can be used for the production of vegetables, root crops, sugar cane and pineapples and for undemanding tree crops such as coconut and cashew. In the undrained state it can be used for rice only if it is well fertilizer and therefore it is unsuitable for subsistence farming.

6. FEASIBILITY OF EVADING OR OVERCOMING LIMITATIONS

A total of fifteen possible limitations to crop production due to soil, terrain or excess water have been recognized. These limitations can be divided into four groups:

- (a) those that can be evaded or easily corrected;

- (b) those that can be overcome by good farming or estate management practices;
- (c) those that require special management practices; and
- (d) those that are hardly or not feasible to overcome.

6.1 Limitations that can be evaded or easily corrected

Limitations such as massive clay(c), shallow soil depth(d), inundation(i), salinity(s), low moisture-holding capacity(m), deep organic layer(o), and steep topography(t) coupled with erosion hazard(e) are most frequently coped with by evading them by the choice of well adapted or undemanding crop. Simple on-farm drainage may be used to overcome minor wetness problems while soils with a serious wetness limitation would be used for rice. Soil with massive clay within 25cm of the surface(e.g. Latang-Class 4fc) is a serious limitation which precludes most crops but is marginally suitable for hill rice and forage. Shallow soils on 12- to 25- degree slopes (e.g. Kapit-Class 4dt) being more fertile can support hill rice and subsistence vegetable crops. Flood-prone areas (e.g. Sedau-Class 3iw) can be utilized by choosing flood-tolerant crops such as rice, oil palm, citrus and coconut or planting maize, soyabean and vegetables during periods when flooding does not occur. Crops such as coconut and sago and salt-tolerant rice cultivars can be grown in weakly saline areas. Soils lacking in both fertility and moisture-holding capacity (e.g. Buso-Class 4fm) are generally unsuitable for most agricultural crops. They can be used for cashew but even such undemanding crops as pineapple, coconut and forage crops are marginal. Deep peats (e.g. Anderson-Class 05go) when improved (Class 04fo) and brought into production can be used for vegetable crops, pineapple, etc. but not for most tree crops which require firm anchorage. Sago can be grown on deep undrained peats but the shallower peats bordering the rivers and streams are preferred.

In Sarawak over 90 percent of the land that is considered suitable for agricultural crops has slopes greater than 12 degrees and is too steep for large scale mechanized farming while three quarters of this has slopes of 25 to 33 degrees and is too steep for mechanization of any kind. However, much of this land has an adequate depth of good-textured soil and is quite well suited to the types of crops that can be grown by small-holders and subsistence farmers. Upland rice, maize and rubber can be grown on slope of 25 to 33 degrees(e.g. Merit-Class 4te) while on 12- to 25- degree slopes (e.g. Merit-Class 3te) most tree crops can be grown also. The effects of limitations imposed by slope and stoniness which are considered serious for

mechanized commercial farming can be minimized by using labour-intensive farming methods while erosion can be controlled by natural vegetative cover and the absence of tillage. Hilly land, however, need not be confined to subsistence farming as it is quite adaptable to remunerative specialized crops (e.g. intensive pepper farming) and the use of modern agricultural technology. As pointed out by Sheng(1971) it constitutes a large proportion of the available agricultural land of the tropics and should be accorded better recognition.

6.2 Limitations that can be overcome by good farming or estate management practices

Good farming or estate management practices can overcome low fertility and ameliorate drainage and salinity problems. The upland soils of Sarawak have been intensively leached and although the limited nutrient reserves are quickly depleted when the land is brought under cultivation, crop yields can be maintained or improved by adequate fertilizer applications. In the lowland areas wetness is an extensive problem while salinity occurs in areas affected by brackish or sea-water. Except where good outlets are unavailable and a high water-table or seepage from a outside source occurs the land capability ratings presuppose that good on-farm drainage practices will be carried out in which the wetness of the soil will be limited only by its internal porosity so that the widest possible range of crops for that kind of land can be grown. Soils with imperfect profile drainage classed as 3iw are suitable for most tree crops and for maize, soyabean and vegetables during the non-flooding season. The installation of dykes to exclude salt-water, farm drainage to reduce the existing salt level and the use of salt-tolerant crops are assumed in determining land capability ratings in saline areas(e.g. Pendam-Class 4ws). Initially these will only support sago, coconut and salt-tolerant rice cultivars but should eventually improve to Class 3iw when they will support standard rice cultivars, tree crops and during flood-free periods maize, soyabean and vegetables.

6.3 Limitations that require special management practices

Limitations that can be ameliorated or overcome by special management practices or an unusually high level of inputs include sulphidic soils(a), steep slopes and erosion hazard(te) and high groundwater-table of the organic soils(g). The economical feasibility of making these improvements will vary widely and have to be carefully evaluated before being initiated.

Sulphidic soils (e.g. Rajang-Class 5sa) when adequately dyked to prevent salt-water flooding can eventually be improved to Class 3wa. This can be achieved by liming and gradual lowering of the water-table to ensure a slow conversion of sulphides to sulphates and their removal in the drainage water provided by rain or controlled fresh-water flooding. This will require a number of years during which only salt-tolerant crops such as wet-land rice and sago can be grown under condition of almost permanent saturation.

The productivity of hilly land (e.g. Merit-Class 3te and 4te) can be increased and the erosion hazard reduced by the construction of dry-bench terraces on slopes up to 33 degrees but to obtain sufficient terrace width a soil depth of at least 75cm is required. Research is presently underway to determine their economic feasibility for hill rice and other crops (Hatch and Tie, 1979). Small terraces for individual pepper vines are widely used on slopes from 12 to 25 degrees but where cover crops are not grown and clean cultivation is practised, soil erosion is often excessive.

The organic soils constitute a large proportion of the level land in Sarawak but their agricultural development has been slow and costly. Kueh (1977) reports that undrained peats may be used for sago and wet-land rice but that sago is usually found on Anderson 1 (150-200cm in depth) or on the shallow organic soils (Mukah-Class 04gf) while on deep peats (Class 05go) rice may fail to set seed. Normal rice yields are claimed to have been obtained in Sumatra on deep peat by covering it with mineral soil (Driessen and Suhardjo, 1976). Siltation by artificial inundation with river water could produce a similar covering of mineral soil which would also reduce the rate of decomposition and subsidence of the peat. Shallow peats when drained, fertilized and well managed (improved rating-Class 03f) can support most of the annual and perennial crops found on the mineral soils. Reclaimed deep peats (improved rating-Class 04fo) when amply fertilized are suited to annual crops, oil palm, dwarf coconut and short term perennials such as tapioca, sweet potato and pineapple but their reclamation may not be economically feasible.

6.4 Limitations that are hardly or not feasible to overcome

Although a large number of the soil, terrain and water limitations can be evaded, overcome or ameliorated sufficiently to allow some kind of crop to be grown, some cannot be changed within the limits of economic feasibility and preclude the use of the land for agriculture. These

and preclude the use of the land for agriculture. These limitations include stones covering more than 50 percent of the land surface (e.g. Tutoh-Class 5r) and slopes greater than 33 degrees, which are usually combined with a soil depth of less than 25cm (e.g. Kapit-Class 5td). A combination of limitations may be equally unimprovable (e.g. Miri-Class 5md) where wetness resulting from a perched water-table on an impervious layer, extremely low fertility and low moisture-holding capacity make it impossible to grow either a wet-tolerant or a drought-tolerant crop.

7. LAND EVALUATION AND CROP REQUIREMENT

Each soil family in Sarawak has been evaluated and assigned a land capability class and subclass rating based on soil and terrain characteristics and modified by their probability of inundation (which will vary with location and is not uniform for a particular soil type). The class ratings are based on the severity and number of limitations that adversely affect crop production according to Table 2 while subclasses are determined by the kinds of limitations shown in Table 1a or 1b. From this information a land capability map can be drawn which is the link between the soil surveyor and the land use planner who requires broad groupings of soils in terms of similarity of management practices (Wong, 1974).

To the agronomist or farmer such a map is still inadequate for decision making with regard to the choice of specific parcels of land for crop production. To meet this need, crop suitability correlations have been prepared in which a crop or a group of crops is shown against each land capability class and subclass. Whereas the land capability classification is based on the principle that land which will support a wider range of crops is placed in a better class than that with a lesser range, a crop suitability map is more specific and soil properties are viewed on their effect on individual crops. Accordingly, the requirements of each crop have been set out in Tables 3a and 3b, and from this knowledge the soils have been grouped according to their properties which influence crop production. A land capability classification based on the kind and severity of limitations shown in Tables 1a and 1b is set out in Tables 4a and 4b to show the class rating and subclass limitations for each soil family or series in Sarawak. By cross tabulating or matching crop requirements in Tables 3a and 3b with the soil ratings the crops that are suitable for each capability class and subclass can be determined as shown in Table 5. By using this table, suitable crops can be assigned to each land class and subclass on the land capability map. Crop suitability evaluations have been confined to five main categories, namely suitable, suitable only for subsistence

farming, marginally suitable, conditionally suitable and unsuitable. Marginal suitability is mainly deemed to reflect the low fertility of the soil thereby restricting productive agriculture. Very large amounts of fertilizers would have to be applied to sustain satisfactory yields. Conditional suitability is indicated where the land becomes suitable through moderate level of management which has originally been assumed for commercial farms(see Section 2). The limitations encountered in such cases can generally be evaded or easily corrected. Some soils are only marginally suitable even after certain conditions have been fulfilled. Such cases are occasionally indicated as "conditionally marginal" in the table.

In the First Edition of this technical paper, some soils on the highlands were rated as unsuitable for certain crop not because of any soil or terrain limitation, but because of the cooler climate. These were indicated as "unsuitable due to climate"("UT"). However, recent findings by the Highland Development Technical Committee(1985) show that our mid-altitude highland areas are not as cool as we had thought; most of the lowland crops can still be cultivated. On the other hand, the slightly cooler and drier climate of the highland enables certain temperate vegetables, fruits and flowers, highland tea, arabica coffee and cardamon to be grown. The potentials of these crops are currently being looked into by the Department.

The present mapping scale of 1:250,000 can indicate where suitable areas exist for the production of specific crops but it cannot provide specific data for individual farms. Good alluvial land exist in many of the narrow river valleys but it is too slender a strip to show on these small scale maps. Nevertheless, it is often the only area of productive land and is an important food source for a small local population. Where detailed, larger scale maps are available specific crops can be recommended for each soil family or series and crop suitability maps can be drawn for planning at the farm level. It should be noted, however, that although certain crops may be suitable agronomically, other factors such as distance from markets, accessibility, and availability of labour have not been considered and their production may not be economically feasible. As a guide to more detailed planning than is possible from the accompanying maps, Tables 3a and 3b also assist the extension agronomist in showing farmers the requirements of the twenty crop groups and their tolerance to possible soil and terrain limitations. These levels of tolerance are much broader than generally recognised and with improved technology, land previously deemed unsuitable is being brought into production.

Throughout the history of the world, agriculture developed most rapidly in areas where good land could be

found while poorer land was often abandoned when better land became available. Up to a century ago only deep, friable, well-drained soils were considered suitable for the production of upland crops on a commercial scale as methods to cope with problem soils were either unknown or not economical to carry out. More recently however, with the ever increasing demand for agricultural products poorer land has had to be utilized which has posed formidable problems to farmers and to soil scientists and agronomists. These problems continue to be resolved or ameliorated in many ways ranging from improved cultural practices including the greatly increased use of fertilizer and better tillage equipment to the breeding of highly adapted cultivars. The tolerance of certain crops to adverse soil conditions is being increasingly recognised and new crops are being tested and introduced. Improvements brought about by drainage of water-logged soils and research into the reclamation of both organic and sulphidic soils by carefully controlled drainage methods are also broadening the range of lands suitable for agricultural crops.

Because of the extreme shortage of good agricultural land in Sarawak, much of the future development will have to occur on Class 3 lands, on presently marginal Class 4 lands and eventually on the Class 05 peatlands. The main soil resources now available are the Red-Yellow Podzolic soils such as the Merit and Bekenu families and to a lesser extent the Grey-White Podzolic soils such as the Kerait family. These occur on rolling to hilly land, 12- to 25- degree slopes for Class 3 and 25- to 33- degree slopes for Class 4 land, and are characterized by clay loam to clay texture, low natural fertility and moderate to high susceptibility to surface erosion under cultivation. This kind of land is not amenable to mechanization but requires a high level of management, sustained fertilizer applications and good soil conservation practices. On the other hand, due to its good physical structure and little risk of rainfall deficiency it has a good potential for high-value labour intensive crops. It is apparent that increased agricultural production in Sarawak will largely depend on the development of land with some rather serious limitations. These will only be overcome by an equally serious application of agricultural research, extension efforts and on-farm management skills.

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Table 1a. LIMITATIONS TO CROP SUITABILITY ON MINERAL SOILS

| Symbol | Type of Limitation | Degree of Limitation | | | | |
|--------|---|----------------------|-------------------|------------------------------|------------------------------------|-----------------------------|
| | | None | Minor | Moderate | Serious | Very Serious |
| a | Depth to sulphidic layer(cm) | >100 | 75-100 | 50-75 | <50 | - |
| c | Depth to massive clay(cm) | >75 | 50-75 | 25-50 | <25 | - |
| d | Soil depth to impervious layer or 50% rock fragments (cm) | >100 | 75-100 | 50-75 | 25-50 | <25 |
| e | Erosion hazard | none | low | medium | high | very high |
| f | Fertility | medium | - | low fertility, low retention | acute deficiency, V. low retention | - |
| i | Inundation hazard(frequency & duration) | none | infrequent, short | frequent, short | infrequent, long | frequent, long or submerged |
| m | Moisture-holding capacity | high(loam to clay) | - | medium(sandy loams) | low(fine and medium sands) | very low (coarse sand) |
| o | Depth of organic layer(cm) | <20 | - | 20-50 | - | - |
| r | Stoniness(% rock fragments or stones within top 25cm) | <0.1 | 0.1-3 | 3-15 | 15-50 | >50 |
| s | Salinity of groundwater (uS/cm) | <1000 | - | - | 1000-4000 | >4000 |
| t | Slope in degree | 0-6 | 6-12 | 12-25 | 25-33 | >33 |
| w | Wetness(drainage class) | well | moderately well | imperfectly | poorly to very poorly | - |

Table 1b. LIMITATIONS TO CROP SUITABILITY ON ORGANIC SOILS

| Symbol | Type of Limitation | Degree of limitation | | | | |
|--------|--|----------------------|-------------------|-----------------|-----------------------|-----------------------------|
| | | None | Minor | Moderate | Serious | Very Serious |
| a | Depth to sulphidic layer*1(cm) | >150 | 100-150 | 50-100 | - | - |
| f | Fertility of the organic layer | medium (high ash) | - | - | very low (low ash) | - |
| g | Depth to groundwater- | - | - | 30-60 | 0-30 | - |
| | table(cm) | | | 30-60 | >100 | |
| h | Degree of humification | hemic-sapric | - | - | fibric | - |
| i | Inundation hazard(frequency & duration) | none | infrequent, short | frequent, short | infrequent, long | frequent, long or submerged |
| n | Nature(texture) of mineral subsoil at 50-150cm | fine loamy to clayey | - | - | sandy to coarse loamy | - |
| o | Depth to organic layer(cm) | - | - | 50-150 | >150 | - |
| s | Salinity of groundwater(uS/cm) | <1000 | - | - | 1000-4000 | >4000 |

*1 Depth after reclamation; allow 25cm more for subsistence of virgin organic soils.

Table 2. NUMBER AND SEVERITY OF LIMITATIONS FOR EACH CAPABILITY CLASS

| Class | Number of Limitations | | | |
|---------|-----------------------|-------------------------|-------------------------|--------------|
| | Minor | Moderate | Serious | Very Serious |
| 1 or 01 | 0-1 | 0 | 0 | 0 |
| 2 or 02 | 2-3 | 1 or its equivalent | 0 | 0 |
| 3 or 03 | >4 | 2-3 or their equivalent | 1 or its equivalent | 0 |
| 4 or 04 | - | 4 | 2-3 or their equivalent | 0 |
| 5 or 05 | - | - | >4 | ≥1 |

Table 3a. SOIL AND OTHER PHYSICAL LIMITS FOR SATISFACTORY CROP GROWTH ON MINERAL SOILS*1

| Crop Group | Crop | Soil Depth (cm) | Soil Texture | Slope (degrees) | Wetness (drainage) | Depth to Sulphidic Layer (cm) | Salinity of Groundwater (umhos/cm) | Flooding (not submerged) #2 |
|------------|--|-------------------------------|--|---|---|-------------------------------|--|------------------------------------|
| ANNUALS | 1. Wet-land rice | >25 | clay loams to clays | 0-2 | imperfectly to very poorly drained | >50 (n.r. if permanently wet) | <2,000, 2,000-4,000 for tolerant cultivars | frequent, long |
| | 2. Upland rice including hill padi | >25 >50 if slope >12 | loams to clays except massive clays | <12 (<25) (up to 33 in forest rotation) | well to poorly | >50 | <2,000, 2,000-4,000 for tolerant cultivars | frequent, long |
| | 3. Maize, sorghum | (>25) >50 >50 if slope >12 | loams to clays except massive clays | <12 (<25) (up to 33 in forest rotation) | well to imperfectly | (>50) >75 | <1,000 | none |
| | 4. Vegetables, chilli, soyabean, tobacco | (>25) >50 | sandy loams to clay except massive clays | <6 (<12) | well to imperfectly | (>50) >75 | <1,000 | none |
| | 5. Ginger, groundnut, sweet potato, tapioca, yam | >50 | sandy loams to clays except massive clays | <6 (<12) | well to moderately well | >75 | <1,000 | none |
| | 6. Water melon | >50 | sands of recent marine origin to sandy loams | <6 | well #3 | >75 | <1,000 | none |
| PERENNIALS | 7. Banana | (>50)>75 | loams to clays except massive clays | <12 (<25) | (well to imperfectly) well to moderately well | (>75)>100 | <1,000 | frequent, short (infrequent, long) |

Table 3a. (contd)

| | | | | | | | | |
|-----|--|----------|--|---|----------------------------|-----------|--|--|
| 8. | Sugar cane, passion fruit | (>50)>75 | sandy loams to clays except massive clays | <12 (<25) | well to imperfectly | (>75)>100 | <1,000 | infrequent, short |
| 9. | Fodder crops, lemon grass | >50 | sandy loams to clays except massive clays | <12 | well to imperfectly | >75 | <1,000 for lemon grass; variable for fodder crops | infrequent, short |
| 10. | Forage crops | >25 | no restriction- podzolic sands doubtful | <12 | well to imperfectly | >50 | variable depending on species | short, infrequent to frequent depending on species |
| 11. | Pineapple | >25 | sandy loams to clay except massive clays *4 | <6 (<12) | well to moderately well | >50 | <1,000 | none |
| 12. | Cocoa | >100 | loams to clays except massive clays | <25 | well to imperfectly | >125 | <1,000 | frequent, short |
| 13. | Oil Palm | >50 | sandy loams to clays except massive clays | <25 | well to imperfectly | >75 | <1,000 | frequent, short |
| 14. | Pepper, papaya | >50 | loams to clays except massive clays | <12, up to 25 with conservation measures | well to moderately well | >75 | <1,000 | none |
| 15. | Annatto, coffee, mulberry | >50 | loams to clays except massive clays | <25 | well to imperfectly | >75 | <1,000 | infrequent, short |
| 16. | Citrus, clove, durian, guava, mango, nutmeg, rambutan*5 | >75 | loams to clays except massive clays | <25 | well to imperfectly | >100 | <1,000 | *6 |

Table 3a (contd)

| | | | | | | | | |
|-----|------------------------|--|----------------------------------|-----------|----------------------------|--------------------------------|--------|-------------------|
| 17. | Coconut | >50 | Except upland and podzolic sands | <25 | well to imperfectly | > 75 | <4,000 | frequent, short |
| 18. | Cashew | >50;>75 if texture coarser than sandy loam | no restriction | <25 | excessively to imperfectly | > 75 | <1,000 | infrequent, short |
| 19. | Sago (metroxyion spp.) | >50 | sandy loams to clays | < 6 | imperfectly to very poorly | > 75 (n.r. if permanently wet) | <4,000 | frequent, long |
| 20. | Rubber, illipenut | >50 | sandy loams to clays | <25 (<33) | well to imperfectly | > 75 | <1,000 | frequent, short |

- NOTES: *1 Parenthesis denotes the limits under the conditions of small-holder and subsistence farming.
- *2 Short-term crops like vegetables with very low flood tolerance can still be grown on land subject to flooding provided that the flooding does not occur during the growing season.
- *3 Water melon is grown on sand, well-drained soils in Sarawak. Under such conditions, a water-table at about 75 cm seems to be required.
- *4 Pineapple can be grown on coarser-textured soils if organic manure is available. This is being done on a small scale around the houses for domestic consumption or for local fruit markets.
- *5 Nutmeg, clove and mango require a dry period for successful flowering and fruiting. Mango has been grown successfully in areas like Miri where the dry period is more distinct. The climatical suitability of these crops is yet to be carefully assessed.
- *6 Frequent, short for clove, nutmeg and rambutan, and infrequent, long for citrus, durian, guava and mango.

Table 3b. SOIL AND OTHER PHYSICAL LIMITS FOR SATISFACTORY CROP GROWTH ON ORGANIC SOILS*1

| Crop Group | Crop | Depth of Waterable Layer (cm) | Degree of Decomposition | Thickness of Organic Layer (cm) | Fertility of Organic layer and Nature of Mineral Subsoil | Depth to Sulphidic Layer (cm) | Salinity of Groundwater (uS/cm) | Flooding (not submerged) |
|------------|--|-------------------------------|-------------------------|---------------------------------|--|-------------------------------|--|--------------------------|
| ANNUALS | | | | | | | | |
| 1. | Wet-land rice | near surface | hemic | <100; n.r. if high ash content | medium if sub-soil sandy and n.r. if subsoil fine loam to clay | >50 | <2,000; 2,000-4,000 for tolerant cultivars | frequent, long |
| 2. | Upland rice | near surface | hemic | <100; n.r. if high ash content | medium if sub-soil sandy and n.r. if subsoil fine loam to clay | >50 | <2,000; 2,000-4,000 for tolerant cultivars | frequent, long |
| 3. | Maize, sorghum | 60-100 | hemic-sapric | <100 | n.r. (i.e. no restriction) | (>50)>75 | <1,000 | none |
| 4. | Vegetables, chilli, soybean, tobacco | 30-60 | hemic-sapric | n.r. | n.r. | (>50)>75 | <1,000 | none |
| 5. | Ginger, ground-nut, sweet potato, tapioca, yam | 60-100 | hemic- | n.r. | n.r. | >75 | <1,000 | none |

*1 Parenthesis denotes the limits under the conditions of small-holder and subsistence farming. Requirements of water melon (Group 6) and pepper (Group 14) are not certain and are therefore not indicated.

Table 3b (contd)

| | | | | | | | | | | | | |
|------------|----------------------------|--------|--------------|-------|--|-------------|--|--|--|--|--|--|
| PERENNIALS | | | | | | | | | | | | |
| 7. | Banana | 60-100 | hemic-sapric | < 150 | medium if sub-soil sandy and n.r. if subsoil fine loam to clay | (>75) > 100 | < 1,000 | frequent, short (infrequent, long) | | | | |
| 8. | Passion fruit, sugar cane | 60-100 | hemic-sapric | n.r. | n.r. | (>75) > 100 | < 1,000 | infrequent, short | | | | |
| 9. | Fodder crops, lemon grass | 30- 60 | hemic-sapric | n.r. | n.r. | > 75 | <1,000 for lemon grass variable for fodder crops | infrequent, short | | | | |
| 10. | Forage crops* ² | 30- 60 | hemic-sapric | n.r. | n.r. | > 50 | variable | short; infrequent to frequent depending on species | | | | |
| 11. | Pineapple | 60-100 | hemic-sapric | n.r. | n.r. | > 50 | < 1,000 | none | | | | |
| 12. | Cocoa | 60-100 | hemic-sapric | < 150 | n.r. but sub-soil must be fine loam to clay | > 100 | < 1,000 | frequent, short | | | | |
| 13. | Oil Palm | 60-100 | hemic-sapric | n.r. | n.r. but sub-soil within 1m must be fine loam to clay | > 75 | < 1,000 | frequent, short | | | | |

*2 Forage Crops - Although pasture grasses can be grown under the conditions stipulated, the trafficability of animals is uncertain. It is noted that lighter animals like goats may not pose a problem and that the trafficability is probably better where the mineral content is higher.

Table 3b (contd)

| PERENNIALS | | | | | | | | | |
|------------|---|----------------|--------------|--------------------------------|--|------------------------------|--------|-------------------|--|
| 15. | Annatto, coffee mulberry | 60-100 | hemic-sapric | n.r. | n.r. but subsoil within 1m must be fine loam to clay | >75 | <1,000 | infrequent, short | |
| 16 | Citrus, clove, durian, guava, mango, nutmeg, rambutan | 60-100 | hemic-sapric | <150 | n.r. but subsoil must be fine loam to clay | >100 | <1,000 | *3 | |
| 17. | Coconut | 60-100 | hemic-sapric | <150; n.r. for dwarf coconut ; | n.r. | >75 | <4,000 | frequent, short | |
| 18. | Cashew | 60-100 | hemic-sapric | <150 | n.r. | >75 | <1,000 | infrequent, short | |
| 19. | Sago(metroxylon spp.) | near*4 surface | hemic*4 | n.r. | n.r. | >75(n.r. if permanently wet) | <4,000 | frequent, long | |
| 20. | Rubber, illipenut | 60-100 | hemic-sapric | <150 | n.r. but subsoil must be fine loam to clay | >75 | <1,000 | frequent, short | |

*3 Frequent, short for clove, nutmeg and rambutan and infrequent, long for citrus, durian, guava and mango.

*4 Recent study indicates that some drainage is required for sago growing on deep peats; where drainage is not provided, the starch content of the palms tends to be very low.

Table 4a. AGRICULTURAL CAPABILITY RATING OF MINERAL SOILS
(Dominant class and subclass underlined>)

| Slope (deg.) Soil series | 0-6 | 6-12 | 12-25 | 25-33 | >33 | Other Possible Limitations |
|--------------------------------|---------|---------|---------|-------|-----|----------------------------------|
| SKELETAL SOILS | | | | | | |
| 1. Meluan | | | 5d, 4dt | 5d | 5td | e, r |
| 2. Tutoh | 3r, 5r | 3r, 5r | 4er, 5r | 5te | 5td | m |
| 3. Lundu | 3r, 5r | 3r, 5r | 4er, 5r | 5te | 5td | m |
| 4. Kapit | | 4dr | 4dt | 5td | 5td | m |
| 5. Buri | | 4dr | 4dt | 5td | 5td | |
| 6. Sedong | | 4dr | 4dt | 5td | 5td | |
| 7. Binatang | 5d | 5d | | | | |
| 8. Kelupu | 5d, 4dw | 5d, 4dw | | | | |
| THIONIC SOILS | | | | | | |
| 9. Belat | 5sa | | | | | w,f,o,i,m |
| 10. Pandak | 5af | | | | | w,o,s,i,m |
| 11. Mersan | 5af | | | | | w,o,i,m |
| 12. Paloh | 5sa | | | | | w,i |
| 13. Nagor | 4aw | | | | | f,s,i,m |
| 14. Nangka | 4aw | | | | | f,i,m |
| 15. Rajang | 5sa | | | | | w,c,i |
| 16. Rampangi | 4aw | | | | | c,i,s |
| 17. Punda | 4aw | | | | | i,c |
| 18. Kluang | 3wa | | | | | i,c,o |
| GLEYSOILS | | | | | | |
| 19. Tatau | 4fw | | | | | o,i,m |
| 20. Telok | 5fs | | | | | o,i,m,w |
| 21. Nonok | 5sf | | | | | w,o,i,m |
| 22. Plan | 4fw | | | | | o,i,m |
| 23. Bokah | 4fw | | | | | o,m |
| 24. Pakan | 3wi | | | | | o |
| 25. Piasau | 4ws | | | | | o,i |

Table 4a. (Cond.)

| Slope (deg.) Soil series | 0-6 | 6-12 | 12-25 | 25-33 | >33 | Other Possible Limitations |
|--------------------------------|-----|------|-------|-------|-----|----------------------------------|
| 26. Sirik | 5sw | | | | | f,o,i,m |
| 27. Gong | 3w | | | | | f,o,m |
| 28. Bijat | 3wi | | | | | o,c |
| 29. Samarahan | 3wi | | | | | o,c |
| 30. Danau | 3wi | | | | | o,c |
| 31. Daro | 3wi | | | | | o,c |
| 32. Pendam | 4ws | | | | | c,i,o |
| 33. Beliong | 5sw | | | | | i,c |
| 34. Buntal | 5sw | | | | | i,c |
| 35. Mundai | 3wi | | | | | c,o |
| 36. Kakai | 3wi | | | | | c,o |
| 37. Jiwan | 3w | | | | | c,i,o |
| 38. Tumau | 3w | | | | | i,t,e |
| 39. Semadoh | 3w | | | | | o,c |
| 40. Embang | 3w | | | | | o,c |
| PODZOLS | | | | | | |
| 41. Grang | 4fm | | | | | o |
| 42. Penian | 4fw | | | | | m |
| 43. Jerijeh | 4fm | | | | | |
| 44. Stoh | 4fm | | | | | |
| 45. Buso | 4fm | | | | | |
| 46. Silantek | | 4fm | | | | |
| 47. Miri | 5md | | | | | w,f |
| 48. Bako | | 5md | | | | w,f |
| ARENACEOUS SOILS | | | | | | |
| 49. Kabong | 4fm | | | | | |
| 50. Chupin | 4mf | | | | | w |
| 51. Siru | 4mf | | | | | |
| 52. Rambungan | 4mf | | | | | |
| 53. Sematan | 4mf | | | | | |
| 54. Kayan | 4fm | | | | | i,e |
| 55. Siar | 4fm | | | | | i,e |
| 56. Tika | 4fm | | | | | |
| 57. Kilong | 4fm | | | | | |
| 58. Peninjau | | 4fm | 4et | | 5te | |
| 59. Sebaya | 4fm | 4fm | | | | |

Table 4a. (Cont.)

| Slope (deg.) Soil series | 0-6 | 6-12 | 12-25 | 25-33 | >33 | Other Possible Limitations |
|--------------------------------|-----------------|------|-------|-------|-----|----------------------------------|
| ALLUVIAL SOILS | | | | | | |
| 60. Semilajau | 3if, 4ei | | | | | m |
| 61. Julan | 2wi, 3iw | | | | | |
| 62. Bemang | 2i, 3ie, 4ie | | | | | |
| 63. Dapoi | 2i, 3ie | | | | | |
| 64. Sebat | 1,2i,2id | | | | | |
| 65. Terbat | 1,2i,2id | | | | | |
| 66. Seduai | 2i,3iw, 4ie | | | | | |
| 67. Malang | 2i,3iw, 4ie | | | | | |
| 68. Paku | 2i,3iw, 4ie | | | | | |
| 69. Sekati | 3iw | | | | | |
| 70. Ramun | 2i,3rm | | | | | |
| ANDISOLS | | | | | | |
| 71. Linau | 2r | 2t | 3te | 4te | 5te | |
| OXISOLS | | | | | | |
| 72. Selio | | 2t | 3te | 4te | | climate, f |
| 73. Nibong | | 2t | 3te | 4te | 5te | climate |
| 74. Mujan | | 2t | 3te | 4te | 5te | climate |
| 75. Ujek | 3fw | 3ft | 4ft | 4tf | | e, climate |
| 76. Tarat | 1, 2w | 2t | 3te | 4te | 5te | d |
| 77. Jebong | 1, 2w | 2t | 3te | 4te | 5te | d |
| 78. Antayan | 1, 2w | 2t | 3te | 4te | 5te | d |
| 79. Serin | | 2t | 3te | 4te | 5te | d |
| 80. Lingga | | 2t | 3te | 4te | 5te | d |
| 81. Rukam | 2f | 3ft | 3ft | 4te | 5te | d |
| 82. Jagoi | | 2t | 3te | 4te | 5te | d |
| 83. Nyaroh | | 2t | 3te | 4te | 5te | d |
| 84. Piring | | 2t | 3te | 4te | 5te | d |
| 85. Gading | | 2t | 3te | 4te | 5te | d |

Table 4a. (Cont.)

| Slope (deg.) Soil series | SLOPE CAPABILITY CLASS | | | | | Other Possible Limitations |
|--------------------------------------|------------------------|------|-------|-------|-----|----------------------------------|
| | 0-6 | 6-12 | 12-25 | 25-33 | >33 | |
| GREY-WHITE PODZOLIC SOILS | | | | | | |
| 86. Triboh | 3fm | 3fe | 4ef | | | m |
| 87. Penipah | 3fm | 3fe | 4ef | | | w |
| 88. Semeba | 3fm | 3fe | 4ef | | | m |
| 89. Saratok | 3fm | 3fe | 4ef | | | m |
| 90. Merang | | 3ft | 3te | 4te | | f |
| 91. Timang | | 3ft | 3te | 4te | | w |
| 92. Bandang | | 3ft | 3te | 4te | | f |
| 93. Durin | | 3ft | 3te | 4te | | f |
| 94. Lubai | 2f | 3ft | 3tf | | | |
| 95. Ajoh | 3wc | 3tf | 3te | 4te | | f,e,w,c |
| 96. Serayan | 3wc | 3ct | 3tc | 4te | | f,e,w,c |
| 97. Kerait | 3wc | 3ct | 3tc | 4te | | f,e,w,c |
| RED-YELLOW PODZOLIC SOILS | | | | | | |
| 98. Matang | | 3ef | 4ef | 4te | 5te | d,m |
| 99. Sabangang | 3fm | 3ef | 4ef | | | m |
| 100. Nyalau | | 3ef | 4ef | 4te | 5te | d,m |
| 101. Bekenu | 1, 2w | 2t | 3te | 4te | 5te | d |
| 102. Sarikei | 1, 2w | 2t | 3te | 4te | 5te | d |
| 103. Takau | 1, 2w | 2t | 3te | 4te | 5te | d |
| 104. Abok | 1, 2w | 2t | 3te | 4te | 5te | d |
| 105. Gumbang | | 2t | 3te | 4te | 5te | d |
| 106. Arip | | 2t | 3te | 4te | 5te | d |
| 107. Kabuloh | 2w | 2t | 3te | | | d |
| 108. Karabungan | | 2t | 3te | 4te | | d |
| 109. Stom | 2w | 2t | 3te | 4te | 5te | d |
| 110. Lupar | 1, 2w | 2t | 3te | | | |
| 111. Merit | 1, 2w | 2t | 3te | 4te | 5te | d |
| 112. Begunan | 1 | 2t | 3te | 4te | 5te | d |
| 113. Bedup | 1, 2w | 2t | 3te | 4te | 5te | d |
| 114. Jakar | 1, 2w | 2t | 3te | 4te | 5te | d |
| 115. Semongok | 2w | 2t | 3te | 4te | 5te | d,c |
| 116. Padawan | 1, 2w | 2t | 3te | 4te | 5te | d,c |
| 117. Stass | 1, 2w | 2t | 3te | 4te | 5te | d,c |
| 118. Melugu | 1, 2w | 2t | 3te | 4te | 5te | d,c |

Table 4b. AGRICULTURAL CAPABILITY RATING OF ORGANIC SOILS*1

| Soil Series | Capability Class | | Other possible limitations |
|--------------|------------------|------------|----------------------------|
| | Unimproved | Improved*2 | |
| 1. Kapor | 05d | 05d | t, e |
| 2. Mulu | 03f | 03f | t, e, climate |
| 3. Umor | 04gf | 03f | climate |
| 4. Bareo | 05go | 04fo | climate |
| 5. Igan | 05gn | 04fn | h, i, s |
| 6. Mukah | 04gf | 03f | i, s |
| 7. Epai | 03g | 02 | i, s |
| 8. Merapok | 04ga | 03a | i, s |
| 9. Patok | 04ga | 04af | i, s |
| 10. Mahat | 04ga | 03a | i, s |
| 11. Anderson | 05go | 04fo | h, i, s |
| 12. Gadong | 04go | 03o | h, i, s |
| 13. Luk | 04go | 03o | i, s |

*1 Most of the organic soils, particularly the shallow ones at the fringes of the peat domes, are subject to flooding. The soils have been rated on the assumption that the flood hazard is either none or minor. Therefore, a soil series may be downgraded and "i" indicated if it occurs in an area subject to moderate, severe or very severe flooding. Similarly, a soil series may be downgraded if salinity is a problem. Where the salinity is very severe, most organic soils would be rated as 05gs.

*2 Reclaimed and with proper water control and management.

*3 d is a soil depth problem as in mineral soils (Table 1a); it is not listed in Table 1b.

Table 5. LAND AND CROP SUITABILITY*1 CORRELATIONS

| Land Suitability Class and Subclass | Crop Groups | | | | | | | | | | | | | | | | | | | |
|-------------------------------------|------------------|----------------|-------------------|------------------------|-----------------------|----------------|-----------|---------------|-----------------|------------------|---------------|-----------|--------------|--------------------|------------|-----------------|-------------|------------|----------|------------|
| | 1. Wet-land rice | 2. Upland rice | 3. Maize, sorghum | 4. Soybean, vegetables | 5. Groundnut, tapioca | 6. Water melon | 7. Banana | 8. Sugar cane | 9. Fodder crops | 10. Forage crops | 11. Pineapple | 12. Cocoa | 13. Oil Palm | 14. Pepper, papaya | 15. Coffee | 16. Fruit trees | 17. Coconut | 18. Cashew | 19. Sago | 20. Rubber |
| 1 | C2 | S | S | S | S | U | S | S | S | S | S | S | S | S | S | S | S | S | U | S |
| 2id | C2 | S | C1 | C1 | C1 | U | S | S | S | U | U | S | U | S | S | S | S | S | U | S |
| 2w | C2 | S | S | S | U | U | (S) | S | S | U | S | S | U | S | S | S | S | S | S | S |
| 2wi | S | S | C1 | C1 | U | U | (S) | S | S | U | S | S | U | S | S | S | S | S | S | S |
| 2t | U | S | S | (S) | (S) | U | S | S | S | (S) | S | S | S | S | S | S | S | S | U | S |
| 2i | C2 | S | C1 | C1 | C1 | U | S | U | U | S | U | S | S | U | U | S | S | U | U | S |
| 2r | U | S | (S) | (S) | (S) | U | S | S | S | S | S | S | S | S | S | S | S | S | U | S |
| 3w | S | S | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | S | U |
| 3ie(m)*2 | U | M | M | (S) | (S) | U | M | M | S | S | (S) | M | S | M | M | M | S | S | U | S |
| 3ef(m) | U | M | M | (S) | (S) | U | M | M | S | S | (S) | M | S | M | M | M | S | S | U | S |
| 3fm | U | U | U | S | S | S | U | M | S | S | S | U | S | U | U | S | S | U | S | S |
| 3te | U | S | (S) | U | U | U | (S) | (S) | U | U | U | S | S | S | S | S | S | S | U | S |
| 3tr | U | S | (S) | U | U | U | (S) | U | U | U | U | S | S | S | S | S | S | S | U | S |
| 3ef | U | M | M | U | U | U | (S) | U | U | U | U | M | S | M | M | M | S | S | U | S |
| 3iw | S | S | C1 | C1 | U | U | (S) | U | U | S | U | S | S | U | U | S | S | U | S | S |
| 3wa | S | S | U | U | U | U | U | U | U | U | U | U | U | U | U | U | C4 | U | S | U |
| 3rv | U | S | (S) | (S) | U | U | (S) | U | S | S | U | S | S | U | S | S | S | S | S | S |
| 3fv | C2 | S | M | M | U | U | U | M | M | S | U | U | M | U | U | S | S | S | S | S |
| 3fw (cool)*3 | C2 | S | M | M | U | U | U | UT | M | S | U | U | UT | U | U | S | UT | UT | UT | UT |
| 3ft | U | M | M | (S) | (S) | U | M | M | S | S | U | M | S | M | M | M | S | S | U | S |
| 3wi | S | S | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | S | U |
| 3ct | U | S | (S) | (S) | U | U | (S) | S | S | S | U | U | S | U | S | U | S | S | U | S |
| 3tc | U | S | (S) | U | U | U | (S) | (S) | U | U | U | U | S | U | S | U | S | S | U | S |
| 3rm(i) | U | M | U | (S) | U | U | (S) | (S) | U | S | U | U | S | U | S | S | S | S | U | S |
| 03g | S | S | C4 | C4 | U | U | U | U | C4 | C4 | C4 | U | U | U | U | U | U | U | S | U |
| 4tm(f) | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | M | S | U | U |
| 4ws | C3 | C3 | U | U | U | U | U | U | U | C4 | U | U | U | U | U | U | C4 | U | S | U |
| 4dt | U | (S) | (U) | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| 4er | U | (S) | (S) | U | U | U | (S) | U | U | U | U | S | U | S | S | S | S | S | U | S |
| 4te | U | (S) | (S) | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | (S) |
| 4av | C5 | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | C5 | U |
| 4et(f) | U | M | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | (S) |
| 4ef(m) | U | M | M | U | U | U | M | U | U | U | M | S | M | M | M | S | S | U | M | |
| 4fv | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | C4 | C4 | U | U | |

Table 5. LAND AND CROP SUITABILITY^{*1} CORRELATIONS (Cont..)

| Land Suitability Class and Subclass | Crop Groups | | | | | | | | | | | | | | | | | | | |
|-------------------------------------|------------------|----------------|-------------------|-------------------------|-----------------------|----------------|-----------|---------------|-----------------|------------------|---------------|-----------|--------------|--------------------|------------|-----------------|-------------|------------|----------|------------|
| | 1. Wet-land rice | 2. Upland rice | 3. Maize, sorghum | 4. Soyabean, vegetables | 5. Groundnut, tepioca | 6. Water melon | 7. Banana | 8. Sugar cane | 9. Fodder crops | 10. Forage crops | 11. Pineapple | 12. Cocos | 13. Oil Palm | 14. Pepper, papaya | 15. Coffee | 16. Fruit trees | 17. Coconut | 18. Cashew | 19. Sago | 20. Rubber |
| 4fm | U | U | U | U | U | U | U | U | U | M | M | U | U | U | U | M | S | U | U | |
| 4mf | U | U | U | U | U | S | U | U | U | M | M | U | U | U | U | M | S | U | U | |
| 4ff (cool) | U | M | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | UT | |
| 4wf (cool) | C2 | C2 | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | UT | U | |
| 4ft (cool) | U | M | M | U | U | U | UT | U | U | U | U | UT | UT | UT | UT | M | UT | UT | U | UT |
| 4fc | U | M | U | U | U | U | U | U | U | S | U | U | U | U | U | U | UT | UT | U | U |
| 04ff | M | M | C4M | C4M | U | U | U | U | C4 | C4 | C4 | U | U | U | U | U | U | U | S | U |
| 04ga | M | C5M | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | S | U |
| 04go | M | M | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | S | U |
| 04ga | C3 | C3 | C4 | C4 | U | U | U | U | C4 | C4 | C4 | U | U | U | U | U | U | U | S | U |
| 5d | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| 5te | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| 5td | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| 5aa | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| 5ad | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| 05gn | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | M | U |
| 05go | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | M | U |
| 05ga | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U |

*1 S - Suitable (Minor and major soil conservation measures are required for slopes ranges of 12-25 degrees and 25-33 degrees respectively).

(S) - Suitable for small-holder and subsistence farming only.

M - Marginally suitable (This is mainly deemed to reflect the very low nutrient availability thereby restricting productive agriculture).

C - Conditional on: 1. non-flood season (e.g. annuals on flood-prone areas);
2. feasibility of flood irrigation;
3. tolerant or suitable cultivars (e.g. padi on weakly saline soils);
4. slightly improved drainage (e.g. shallow rooting crops on shallow peats); or
5. permanently saturated condition (e.g. wet-land rice on sulphidic soils).

C4M - Conditionally marginal, the number in the centre stipulates the condition (See C).

U - Unsuitable.

UT - Unsuitable due to climate.

*2 Other possible limitations are shown in bracket.

*3 The cooler climate on the highland areas does restrict the growth of a few tropical lowland crops. On the other land, it enables the cultivation of certain temperate vegetables, fruits and flowers, highland tea, arabica coffee and cardamon.

APPENDIX 1.

AGRICULTURE CAPABILITY OF SARAWAK (Area in hectares)*1

| District/DIVISION | Class 2 | Class 3 | Class 4 | Class 5 | Class 04 | Class 05 | Total |
|-------------------|---|-------------------------------|-------------------------------|---------------------------------|-----------------------------|-------------------------------|---|
| Kuching | 5,938 | 40,838 | 46,655 | 81,733 | 2,564 | 7,128 | 184,856 |
| Serian | 7,818 | 70,540 | 45,522 | 39,557 | 1,001 | 37,018 | 201,456 |
| Simunjan | 0 | 17,324 | 27,017 | 14,260 | 5,129 | 96,607 | 160,337 |
| Samarahan | 500 | 7,844 | 8,318 | 3,189 | 2,565 | 23,261 | 45,677 |
| Bau | 4,691 | 25,828 | 29,204 | 30,516 | 0 | 0 | 90,239 |
| Lundu | 18,509 | 24,015 | 59,074 | 54,096 | 1,126 | 16,009 | 172,829 |
| FIRST DIVISION | 37,456 ² (4.38) (18.04) ³ | 186,389 (21.78) (12.15) | 215,790 (24.23) (13.16) | 233,351 (26.11) (3.12) | 12,385 (1.45) (12.33) | 180,023 (21.05) (11.27) | 855,394 |
| Sri Aman | 6,380 | 48,226 | 68,966 | 88,548 | 1,314 | 203,659 | 417,093 |
| Betong | 3,023 | 16,039 | 23,418 | 50,423 | 8,192 | 75,895 | 176,990 |
| Saratok | 4,941 | 44,899 | 26,392 | 39,074 | 6,128 | 40,120 | 161,554 |
| Lubok Antu | 12,946 | 34,638 | 22,803 | 160,765 | 0 | 5,066 | 236,218 |
| SECOND DIVISION | 27,290 (2.75) (13.15) | 143,802 (14.50) (9.37) | 141,579 (14.27) (8.63) | 338,810 (34.16) (4.73) | 15,634 (1.58) (15.57) | 324,740 (32.74) (20.33) | 991,855 |
| Sibu | 12,759 | 73,939 | 10,882 | 7,130 | 0 | 217,561 | 322,271 |
| Dalat | 2,251 | 63,783 | 6,379 | 62,215 | 0 | 77,410 | 212,038 |
| Kanowit | 10,703 | 32,205 | 58,220 | 115,369 | 0 | 3,877 | 220,374 |
| Mukah | 3,253 | 103,499 | 53,275 | 144,946 | 5,941 | 197,677 | 508,591 |
| THIRD DIVISION | 28,966 (2.29) (13.95) | 273,426 (21.64) (17.82) | 128,756 (10.20) (7.85) | 329,660 (26.10) (4.60) | 5,941 (0.47) (5.92) | 496,525 (39.30) (31.08) | 1,263,274 |
| Miri | 8,068 | 203,591 | 47,968 | 133,565 | 5,294 | 114,466 | 512,952 |
| Baram | 60,005 | 219,916 | 251,494 | 1,502,844 | 819 | 175,416 | 2,210,494 |
| Bintulu | 7,870 | 218,011 | 326,362 | 463,197 | 33,240 | 124,202 | 1,172,882 |
| FOURTH DIVISION | 75,943 (1.95) (36.58) | 614,518 (16.48) (41.80) | 625,824 (16.06) (38.16) | 2,099,606 (53.89) (29.30) | 39,353 (1.01) (39.19) | 414,084 (10.63) (25.92) | 3,896,328 |
| Limbang | 11,660 | 48,786 | 46,517 | 275,568 | 8,951 | 5,798 | 397,280 |
| Lavasa | 13,929 | 19,604 | 92,907 | 223,571 | 2,332 | 17,649 | 369,992 |
| FIFTH DIVISION | 25,589 (3.34) (12.33) | 68,390 (8.91) (4.46) | 139,424 (18.17) (8.50) | 499,139 (65.05) (6.96) | 11,283 (1.47) (11.24) | 23,447 (3.06) (1.47) | 767,272 |
| Sarikei | 2,439 | 36,959 | 5,378 | 78,728 | 4,440 | 21,261 | 149,205 |
| Julau | 1,189 | 40,025 | 101,992 | 117,964 | 0 | 0 | 261,170 |
| Meradong | 4,128 | 26,764 | 1,564 | 24,328 | 1,564 | 47,149 | 105,497 |
| Matu/Daro | 0 | 5,253 | 2,126 | 10,132 | 9,818 | 88,103 | 115,432 |
| SIXTH DIVISION | 7,756 (1.23) (3.74) | 109,001 (17.27) (7.10) | 111,060 (17.59) (6.77) | 231,152 (36.62) (3.23) | 15,822 (2.50) (15.75) | 156,513 (24.79) (9.80) | 631,304 |
| Kapit | 125 | 25,143 | 76,795 | 1,424,060 | 0 | 0 | 1,526,123 |
| Song | 751 | 11,258 | 41,585 | 334,341 | 0 | 0 | 387,935 |
| Belaga | 3,711 | 75,715 | 159,093 | 1,686,292 | 0 | 2,097 | 1,926,908 |
| SEVENTH DIVISION | 4,587 (0.12) (2.21) | 112,116 (2.92) (7.30) | 277,673 (7.22) (16.93) | 3,444,693 (89.69) (48.06) | 0 (0.00) (0.00) | 2,097 (0.05) (0.13) | 3,840,966 |
| SARAWAK | 207,587 (1.70) | 1,534,642 (12.53) | 1,639,906 (13.39) | 7,166,411 (58.52) | 100,418 (0.82) | 1,597,429 (13.04) | 12,246,393 ₆ (30.27 x 10 ⁶ ac) |

N.B. : *1 Source : Planimetric measurement of 1:250,000 Agriculture Capability Maps, Sarawak. (Dept. of Agriculture, 1980-85). Waterways which appear wider than a single line on the maps are excluded.

*2 Figures in brackets are row percentages (i.e. percentages within the Division).

*3 Figures in the second brackets are column percentages (i.e. percentages within each capability class).

*1
APPENDIX 2. SARAWAK PRESENT LAND USE (in hectares)

| LAND USE CLASSES | FIRST DIVISION | SECOND DIVISION | THIRD DIVISION | FOURTH DIVISION | FIFTH DIVISION | SIXTH DIVISION | SEVENTH DIVISION | SUB-TOTAL |
|-------------------------|----------------------------------|-------------------------------|-------------------------------|---------------------------------|------------------------------|-------------------------------|---------------------------------|----------------------|
| Upland Forests*2 | 249,452 | 139,705 | 309,273 | 2,823,845 | 592,904 | 93,645 | 3,420,256 | 7,629,080 |
| Mangrove | 35,458 | 6,693 | 5,815 | 1,377 | 11,571 | 67,856 | 0 | 128,770 |
| Nipah | 10,568 | 25,829 | 6,629 | 2,444 | 2,253 | 9,884 | 0 | 57,607 |
| Mixed Swamp Forest | 114,308 | 196,668 | 307,019 | 279,674 | 17,763 | 110,350 | 626 | 1,026,408 |
| Alan Forest | 6,379 | 38,119 | 94,709 | 102,457 | 0 | 11,678 | 0 | 253,342 |
| Padang Paya | 0 | 438 | 4,191 | 34,708 | 0 | 0 | 0 | 39,337 |
| FOREST LAND | 416,165*6 (48.45)*7 (4.56) | 407,452 (41.09) (4.46) | 727,636 (57.53) (7.97) | 3,244,505 (83.54) (35.51) | 624,491 (82.61) (6.84) | 293,413 (46.76) (3.21) | 3,420,882 (88.72) (37.45) | 9,134,544 (74.65) |
| SHIFTING CULTIVATION*3 | 318,256 (37.05) (11.90) | 500,228 (50.45) (18.70) | 454,857 (35.97) (17.01) | 583,117 (15.02) (21.80) | 112,233 (14.84) (4.20) | 280,405 (44.69) (10.48) | 425,448 (11.03) (15.91) | 2,674,544 (21.85) |
| Matured Rubber | 20,199 | 21,013 | 44,087 | 9,691 | 2,630 | 23,638 | 4,882 | 126,140 |
| Young Rubber | 30,458 | 7,941 | 250 | 626 | 1,064 | 9,698 | 0 | 50,037 |
| Senile Rubber | 19,512 | 8,256 | 1,251 | 5,818 | 4,009 | 2,502 | 3,692 | 45,040 |
| Padi *4 | 10,881 | 15,826 | 8,409 | 9,691 | 8,380 | 1,939 | 188 | 55,314 |
| Pepper *4 | 8,568 | 9,319 | 3,448 | 3,252 | 188 | 6,691 | 439 | 31,905 |
| Coconut *5 | 25,955 | 11,135 | 1,876 | 3,190 | 1,564 | 5,190 | 0 | 48,910 |
| Oil Palm | 0 | 5,176 | 3,521 | 18,089 | 0 | 0 | 0 | 27,052 |
| Sago | 0 | 3,878 | 14,136 | 626 | 266 | 1,439 | 0 | 20,454 |
| Mixed Horticulture | 3,878 | 333 | 2,717 | 1,815 | 251 | 2,189 | 71 | 11,254 |
| SETTLED AGRICULTURE*8 | 119,451 (13.91) (28.70) | 82,877 (8.36) (19.92) | 79,695 (6.30) (19.15) | 52,798 (1.36) (12.69) | 18,727 (2.48) (4.50) | 53,286 (8.49) (12.81) | 9,272 (0.24) (2.23) | 416,106 (3.40) |
| Mining Area | 0 | 0 | 0 | 125 | 0 | 0 | 0 | 125 |
| Urban & Associated Area | 5,066 | 981 | 2,521 | 2,814 | 500 | 376 | 439 | 12,697 |
| OTHERS | 5,066 (0.59) (39.51) | 981 (0.10) (7.66) | 2,521 (0.20) (19.66) | 2,939 (0.08) (22.92) | 500 (0.07) (3.90) | 376 (0.06) (2.93) | 439 (0.01) (3.42) | 12,822 (0.10) |
| SUB-TOTAL | 858,938 | 991,538 | 1,264,709 | 3,883,359 | 755,951 | 627,480 | 3,856,041 | 12,238,016 |

Footnotes For APPENDIX 2

- *1 Source: Planimetric measurement of 1:250,000 Land-Use maps of Sarawak, Series No. 22, Land & Survey Dept., Sarawak(1978-1983). Reliability diagrams on these maps show that aerial photography was mostly done between 1972 and 1977. Some of interior regions are, however, based on photographs taken in 1963-1968.
- *2 Mainly Mixed Dipterocarp Forest, but also include Kerangas Forest, Riverine Forest and Beach Forest.
- *3 Include the "Grassland" class which is mainly "lallang".
- *4 Departmental latest figure on pepper hectareage for the whole State is 7450 ha; the figures based on planimetric measurement are therefore very high. Since the taking of the aerial photographs(See Note 1 above), many pepper areas have presumably been either abandoned or converted to other crops(e.g. cocoa).
- *5 Oil palm figures were corrected using the acreages of new plantings by SLDB, SALCRA, etc. since the taking of the aerial photographs(see Note 1 above) from which interpretations were made for the Land-Use maps.
- *6 Figures in brackets are column percentages(i.e. percentages for each Division). They are only calculated for the four groups of land-use classes, namely "Forest Land", "Shifting Cultivation", "Settled Agriculture" and "Others".
- *7 Figures in the second brackets are row percentages (i.e. distribution of each group of land uses over Sarawak).
- *8 Cocoa does not appear as a land use on the Land & Survey's Land-Use maps(1978-1983). However, the planting of cocoa has become very popular, and the respective hectareages for the First through to the Seventh Division are as follows(Divisional Annual Reports, 1985):
- | | | | | | | | | |
|-----------|---|----------------------|-------|-------|-------|------|--------|------|
| Monocrop | - | 6883; | 3290; | 1078; | 2157; | 683; | 5560; | 1414 |
| | | (Total = 21,065 ha). | | | | | | |
| Intercrop | - | 7990; | 1039; | 202; | 51; | - | ; 534; | 71 |
| | | (Total = 9,887 ha). | | | | | | |

