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Ministry of Overseas Development

Proposals for agricultural development of the Samarahan and Sadong - Krang Padi Project areas, Sarawak: a pre-feasibility study

Volume 3 Appendixes

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VOLUME 3 APPENDIXES

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Project Report
(MALAY-06-2/REP-12/77)

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1977

This study is presented in three volumes. Volume 1, the Executive Summary, is a condensed version of Volume 2, the Main Report. Volume 2 describes the background to the study, records the findings of the LRD/ODM mission and then makes recommendations for agricultural development in the two study areas. Volume 3, Appendixes, comprises more detailed information on specialist aspects of the study.

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APPENDIX 1 SOILS

Following an earlier detailed reconnaissance survey, which covered the whole of the First Division (Andriesse, 1972) the soils of the two study areas were surveyed and mapped at a semi-detailed level (scale 1:25 000) by Lim (1976 a, b). On the basis of the Sarawak soil classification (Lim, 1975), the soils were placed in the groups, families and series recorded in Table 1. The spatial distribution of the soil groups is shown on Separate Maps 1 and 4 and their characteristics are defined in Table 2. A summary of the diagnostic and other features of the soil series is given in Table 3.

The soils of the four groups represented in the study areas - Recent Alluvial, Saline Gley, Gley and Peat - have representatives which are potentially among the most useful agriculturally in the State. The best are capable of growing the major tree crops, such as cacao, citrus, coconuts, coffee, oil palms and rubber and a wide range of annual crops including rice, maize and soya beans. Most of them however are naturally poorly drained and are subject to flooding. A fundamental requirement for their development for agriculture is to achieve good water control. For the tree crops this will mean permanently lowering the watertable to about 1 m. By contrast, for much of the growing period of wet rice, it is necessary to keep the soil totally saturated and preferably with 3-5 cm of water on the soil surface. For other annual crops the soil watertable should be no higher than 30-50 cm but the soil moisture in the rooting zone must be adequate to sustain crop growth - the surface layer must therefore not dry out. There is thus a basic difference in the water requirements of perennial and annual crops and the needs of the two groups can only be satisfactorily met if specific areas are designated for each. In some villages, tree crops have been established on the higher areas of the river levees (*empran* soils) but such areas are of very limited extent and elsewhere there is a need to rationalise land use if satisfactory crop yields are to be achieved.

Agronomic studies, to assess the relative fertility of the different soil series, are not yet sufficiently advanced to draw any firm conclusions. From the soil management aspect the soils can be considered therefore only in their groups - Recent Alluvial, Saline Gley, Gley and Peat.

Recent Alluvial The Recent Alluvial soils are found only in the Sadong-Krang area and are of very limited extent (< 400 ha). They occur as narrow levees in the upper parts of the Batang Sadong; Lim (1976a) notes that they are largely planted with rubber and fruit trees. The management of these soils will be the least difficult of the four groups.

Saline Gley The Saline Gley soils occur in the Samarahan area. They have formed on recent marine deposits. The groundwater is saline (> 500 micromhos/cm at 25^{o}C), particularly in dry periods. The study areas are confined to the weakly saline gley soils of the Pendam Family. These are defined as having a groundwater conductivity of between 500 and 4 000 micromhos/cm at some time of the year. Lim (1975) states that rice has been found to grow "fairly satisfactorily" on saline soils with a groundwater conductivity level exceeding 5 000 micromhos/cm, although soils under nipah (*Nipa fruticans*) vegetation, where groundwater conductivity levels periodically exceed 6 000 micromhos, are seldom reclaimed for rice cultivation. The groundwater salinity in the Pendam soils should not therefore be an inherent constraint on their use for rice cultivation. However their development does depend on amelioration involving drainage and the exclusion of any further saltwater intrusion. Andriesse (1972) has noted that these soils are potentially rich; however their marine origin may result in some of their horizons having an unusually high accumulation of sulphides: such soils on being drained can become extremely acid (pH 2.5-3.0). If this were to occur within the rooting zone of plants their growth would be very poor. The amelioration of such soils, known as acid sulphate soils, is difficult and lengthy. The distribution of potentially acid sulphate soils in the Samarahan area is not known but evidence of their presence is commonly found in the spoil from the bottom of ditches; Wall (1960) recorded them in a rice area on the Samarahan estate, near the southern border of the study area. From the semi-detailed soil survey (Lim, 1976b) it appears unlikely that potentially acid sulphate soils would occur within 50 cm of the soil surface and thus the growth of rice would not be affected, but it should be noted that tree crops such as coconuts require a rooting zone of 75-100 cm. Before high cost land development projects are initiated it would therefore be desirable to examine the area for the presence of potentially acid sulphate soils.

Gley soils The gley soils are non-saline clay soils which are naturally poorly or very poorly drained. They comprise riverine and marine alluvium and their chemical characteristics may vary according to the parent material from which they have derived. In the Samarahan area they may contain potentially acid sulphate horizons (see above) at depths below 50 cm in the Punda and Kluang series.

In both the Saline Gley and Gley soils the maintenance of appropriate levels of soil moisture in the rooting zone will be one of the major problems in the satisfactory production of offseason annual crops such as maize and beans. The poor growth often seen at the present time is frequently attributable to inadequate drainage causing waterlogging or to overdraining resulting in fissuring and cracking, particularly with clays lacking residual plant material. The achievement of suitable soil conditions requires experience and, in the early stages, farmers will need intensive assistance from the extension services.

Peat soils Only one family, Mukah, of the peat soils group of Sarawak is considered to be potentially suitable for rice production. Soils of this family have a surface layer of soil 25-100 cm deep with an organic matter content of 35% and sometimes 65% or more. The organic layer overlies a fertile alluvial clay. The peat deposit is a poor medium for plant growth and the development of these soils for agriculture requires that the peat layer be consolidated and incorporated into the underlying clay as quickly as possible. If the land is under forest, clearing and draining can reduce the depth of a peat layer from 100 cm to 50-70 cm within one year. Subsequent change will depend on the degree of drainage, the quantity of timber in the peat and the type of land use practised. Andriesse (1972) recorded that an area in the Nonok peninsula with a peat layer of 100 cm had been transformed into a muck top layer of 15 cm within 10 years. This period could be reduced if the area is adequately drained, buried timber is removed and the land is cropped twice annually. Burning of the surface of the peat temporarily increases the fertility of the soil as well as hastening the reduction of the peat layer. Cropping should be restricted to rainfed crops, e.g. rice alternating with maize or soya bean. Irrigation should not be introduced until the upper layer of the soil has a substantial mineral content. In the first two to three years following the opening up of these soils it will prove difficult to use machinery for land preparation.

Some of the soil series of this group, e.g. Merapok, may also be affected by salinity problems or the presence of potentially acid sulphate horizons in the clay zone in the same way as saline gley soils.

TABLE 1 Soil groups, families and series of the Samarahan and Sadong-Krang study area

GROUP	FAMILY	SERIES	STUDY AREA	
			Samarahan	Sadong-Krang
RECENT ALLUVIAL				
Silts	Bemang	Bemang		Present
Clays	Seduau	Seduau		Present
SALINE GLEY				
Clays	Pendam	Pendam	Present	
		Jol	Present	
GLEY				
Clays	Bijat	Bijat	Present	Present
		Samarahan	Present	Present
		Kakai	Present	Present
		Danau	Present	
		Sebandi	Present	Present
		Punda	Present	
		Kluang	Present	
PEAT	Mukah	Mukah	Present	Present
		Epai	Present	
		Merapok	Present	

TABLE 2 Diagnostic features of the soil groups of the study area (source: Lim, 1975)

1. RECENT ALLUVIAL soils are mineral soils in which:

   i. An R horizon or C horizon, consisting of rock weathered *in situ*, is not within 25 cm of the base of an O horizon.

   ii. Where the profile consists of bands of coarse and fine earth there is no band of material with more than 80% coarse earth which is more than 50 cm thick and is within 25 cm of the base of an O horizon.

   iii. A gley horizon, if present, is not within 50 cm of the base of an O horizon.

   iv. Neither albic nor spodic nor argillic horizons are present.

2. SALINE GLEY soils are mineral soils in which:

   i. An R or C horizon is not found within 25 cm of the base of an O horizon.

   ii. Groundwater conductivity exceeds 500 micromhos/cm at 25°C at some time of the year.

   iii. A gley horizon occurs within 50 cm of the base of an O horizon.

Andriesse (1972) has noted that the term gley horizon is not defined but that, in practice, a layer in which the matrix colour indicates that reduction is more important than oxidation is taken to be a gley horizon.

3. GLEY soils are mineral soils in which:

   i. An R or C horizon is not within 25 cm of the base of an O horizon.

ii. Any peaty O horizon is not more than 25 cm in thickness.

iii. A gley horizon is present within 50 cm of the base of an O horizon.

iv. Groundwater conductivity does not exceed 500 micromhos/cm at 25^{o} C at any time of the year.

v. There is no spodic horizon.

vi. There is no hardened plinthite.

4. PEAT soils of the Mukah family (the only family of this group represented in the study areas) are soils with 35% or more of organic matter 25-100 cm thick overlying clays.

TABLE 3 Diagnostic and other features of the soil series of the study areas

RECENT ALLUVIAL SOILS

Family	Series	Parent material	Texture	Hue	Physiography	Diagnostic features
Bemang	Bemang	Alluvium from sedimentary rocks, mainly shale	Fine silts	10YR or yellower in upper 50 cm	Levee alluvium	Hue, texture
Seduau	Seduar	Alluvium from non-calcareous sedimentary rocks	Clay	10YR or yellower in upper 50 cm	Levee alluvium	Hue, parent material

SALINE GLEY SOILS

Family	Series	Texture	Hue	Acid sulphate horizon	Conductivity μmhos/cm 25 ^{o}C	Surface peat	Diagnostic features
Pendam	Pendam	Clay	Grey, dark grey or greenish-grey	If present, usually below 50 cm	500-4 000	Absent	Conductivity level, no surface peat
Pendam	Jol	Clay	Grey or dark grey	If present, usually below 50 cm	500-4 000	Present	Conductivity level, surface peat present

TABLE 3 (Continued)

GLEY SOILS

Family	Series	Parent material	Texture	Topography, type locality	Hue	Surface peat	Diagnostic features
Bijat	Bijat	Riverine alluvium, noncalcareous	Clay	Riverine flood plain	Not GY or dark grey	Absent	Hue, parent material
	Samarahan		Clay		Hue GY within 50 cm	Absent	Hue, parent material
	Danau		Clay or sandy clay		Hue, dark grey within 50 cm		Hue, parent material high C% (?)
	Punda	Riverian alluvium over old marine clay	Clay		Dark grey below 50 cm		Hue, acid sulphate horizon below 50 cm
	Sebandi	Riverine alluvium, noncalcareous	Clay or sandy clay	Riverine flood plains	Not GY or dark grey	Present	Surface peat
	Kluang	Riverine and marine alluvium	Clay or sandy clay	Riverine flood plains	Grey or dark grey below 50 cm	Present	Potential acid sulphate horizon below 50 cm surface peat
	Kakai	Riverine alluvium from intermediate basic igneous rock	Clay	Riverine flood plain	Dark grey but not GY below 50 cm		Mn and Fe concretions in B horizon

TABLE 3 (Continued)

PEAT SOILS

Family	Series	Thickness of organic layer	Mineral horizon	Origin of organic layer	Organic matter %	Conductivity umhos/cm 25°C	pH KCl
Mukah	Mukah	25 - 100 cm	Clay	Residual	>65	<500	>3.5
	Epai	25 - 100 cm	Clay	Residual	<65	<500	>3.5
	Merapok	25 - 100 cm	Clay	Residual	<65	>500	>3.5

Source: Lim (1975)

APPENDIX 2 CLIMATE AND HYDROLOGICAL STUDIES

CLIMATE

The pattern of climate is determined by the movement of the equatorial low pressure belt across the country twice a year. Only one season can be readily identified; this is the *landas* which prevails from November to March when low pressure lies to the south of the country drawing in a moist north-easterly airstream off the South China Sea. During the remainder of the year low pressure generally lies to the north of Sarawak giving rise to a southerly air flow with surface winds moving in from Indonesia (Kalimantan). Rainfall during this period is generally greater and more reliable in the First Division than elsewhere in Sarawak.

Within the study areas rainfall records have been kept at Paya Paloh for 12 years, Samarahan Estate (20 years) and Serian (19 years). Paya Paloh also has a well equipped station which regularly monitors important agro-meteorological indicies. There are no recording raingauges in the area from which to obtain intense, short duration rainfall data, although several years ago an instrument was installed at Paya Paloh for a short time and the charts can be examined at the Agricultural Research Centre, Semengok. In general, rainfall data relating to periods of less than one day are not of great interest for the design of agricultural drainage schemes, and particularly for rice. Because the rainfall records are short it was necessary to fit them to statistical distributions for analysis.

Monthly rainfall

Monthly means and the 80% probability range of monthly rainfall were computed for Serian and Paya Paloh. The 80% range on average includes monthly total rainfall, 80 years in a 100 and it is useful measure of rainfall variability. The data were found to fit a gamma distribution quite well. They are plotted in Figure I (Part 3) and listed in Table I.

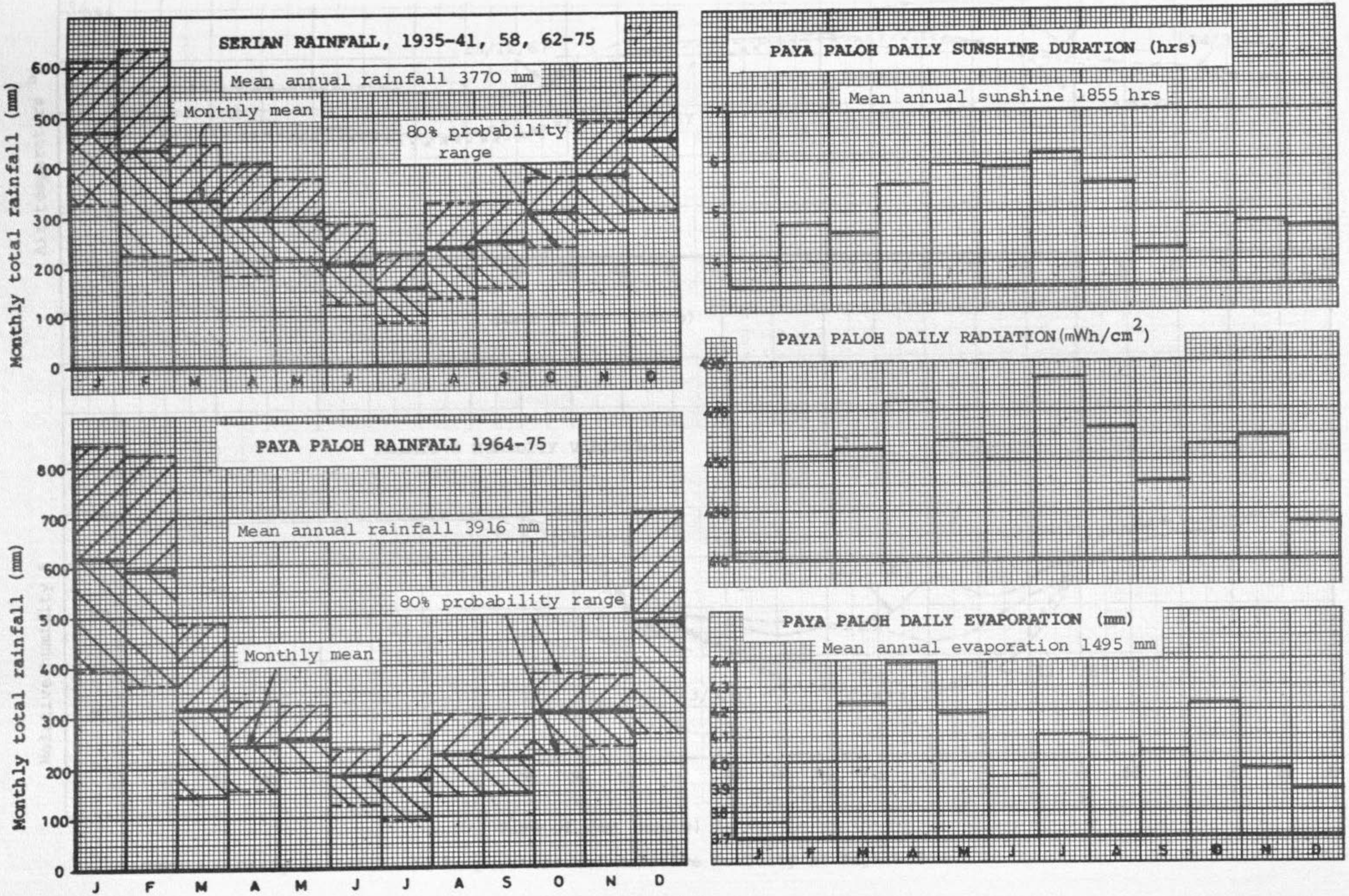

FIGURE 1 Monthly rainfall at Serian and Paya Paloh and sunshine, radiation and evaporation at Paya Paloh

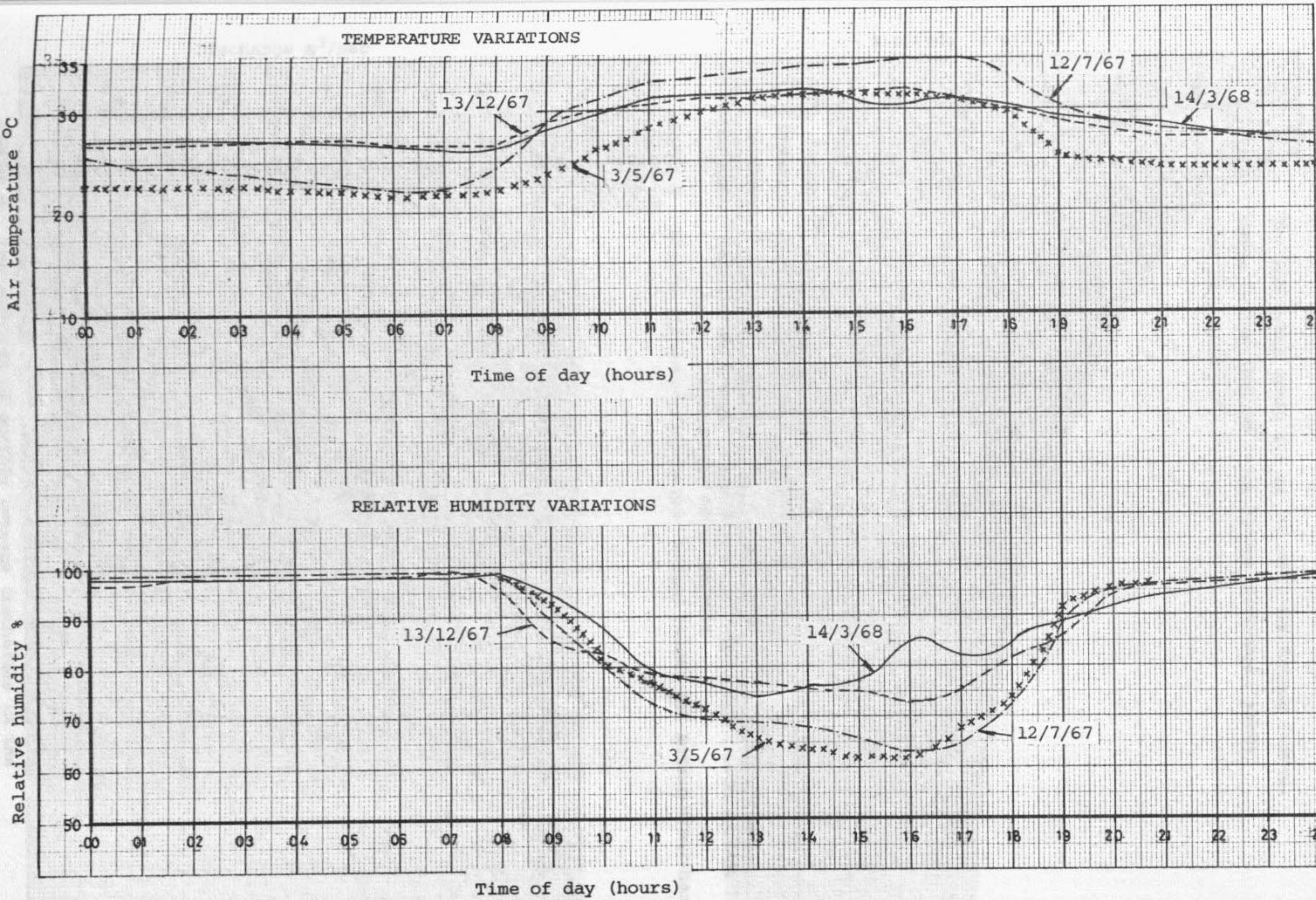

FIGURE 2 Daily variation of temperature and relative humidity at Paya Paloh

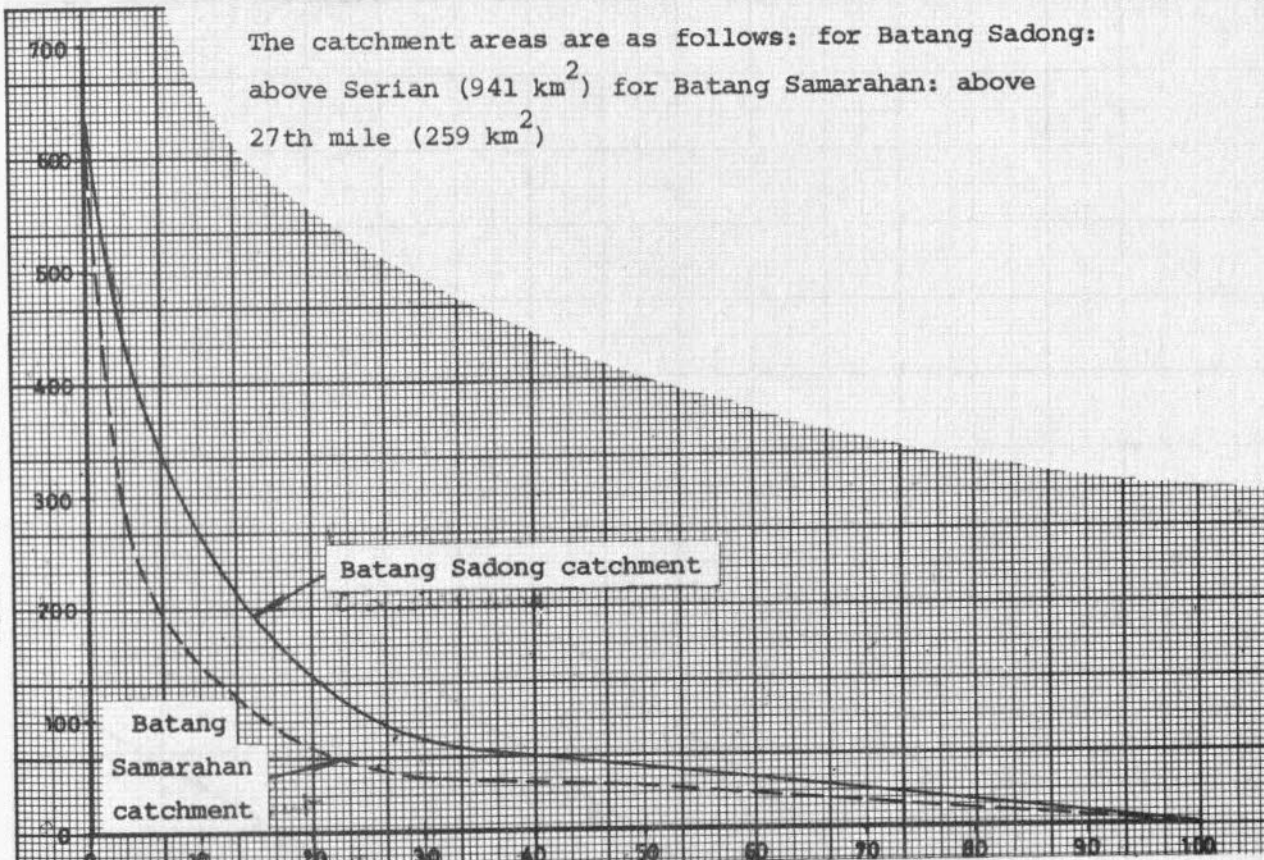

FIGURE 3 Area-altitude relationships: Batang Sadong and Batang Samarahan

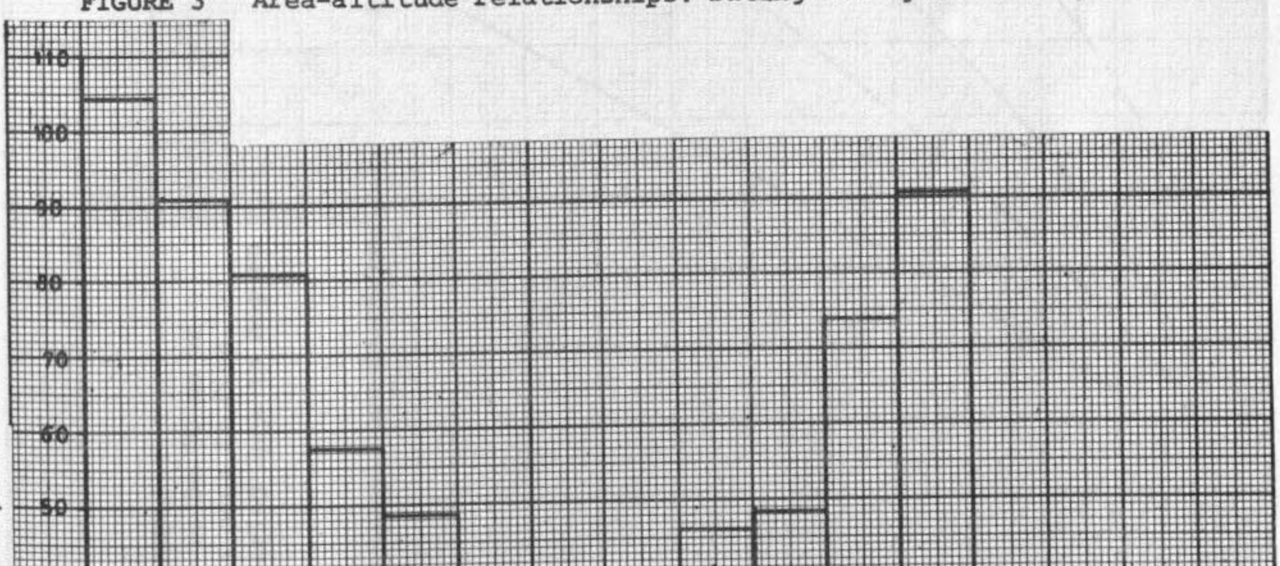

FIGURE 4 Distribution of monthly average discharges in the Batang Sadong at Serian

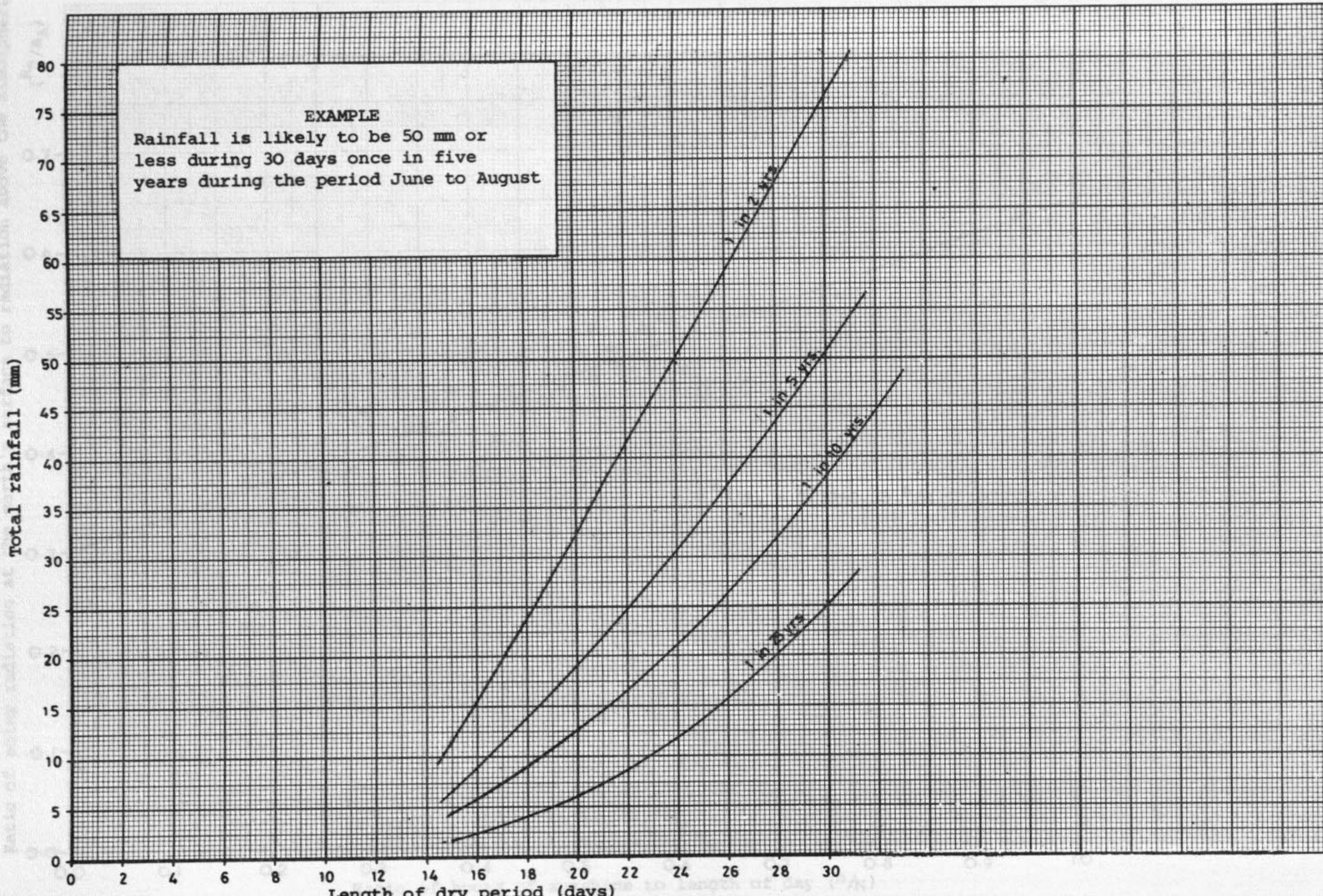

FIGURE 5 Duration and frequency of rainfall during dry periods in June, July and August at Paya Paloh

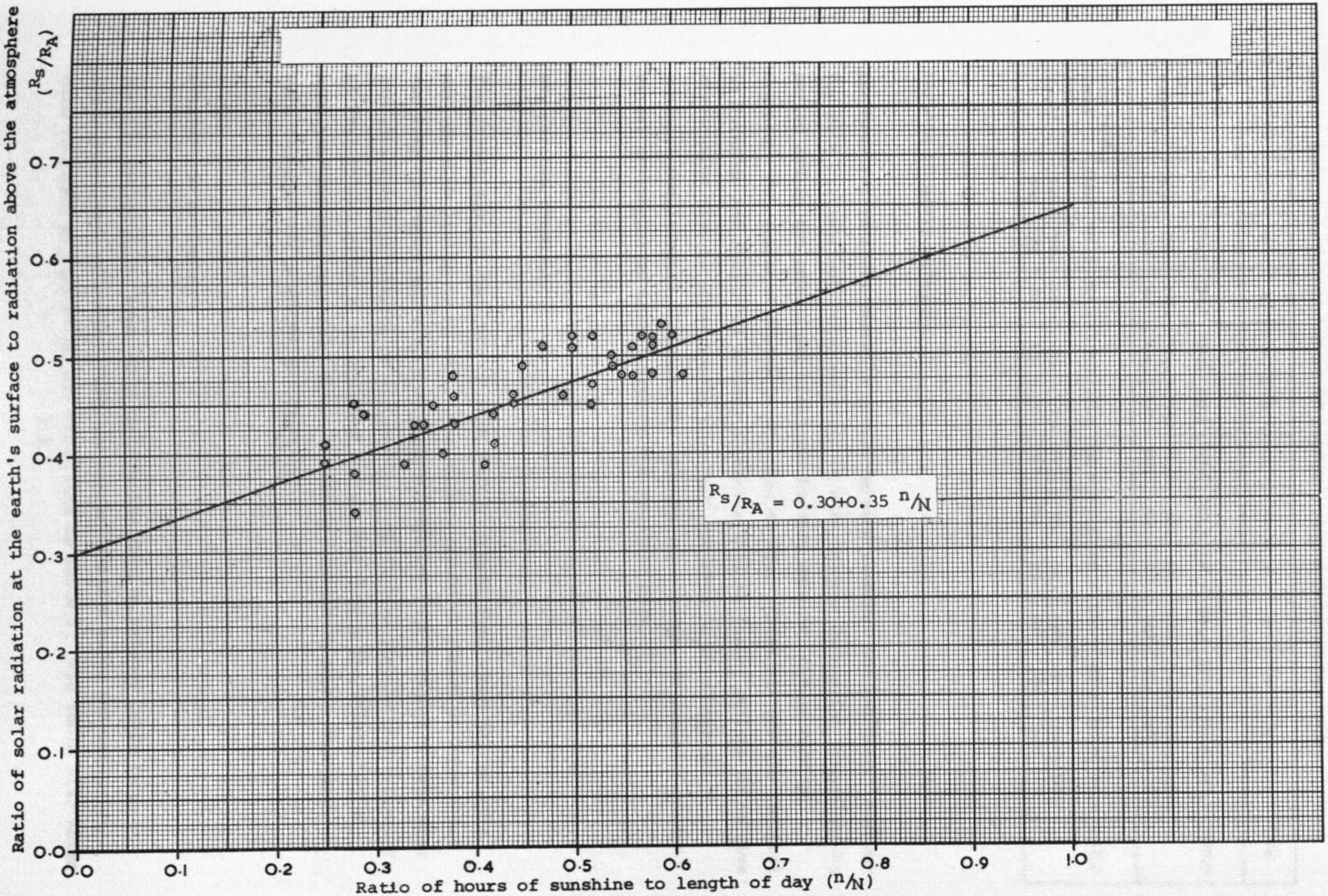

FIGURE 6 Radiation-sunshine relationship at Paya Paloh

TABLE I Monthly mean rainfall (mm) and 80% probability range at Serian and Paya Paloh

Rainfall station	J	F	M	A	M	J	J	A	S	O	N	D	Total
Serian (mean)	469.4	430.5	330.2	294.6	293.6	203.5	153.9	232.4	242.8	302.5	376.7	440.4	3770.5
(80% range)	327-611	224-636	220-441	184-406	215-372	122-285	84-223	136-329	156-329	235-370	267-487	304-577	
Paya Paloh (mean)	618.0	592.6	314.4	242.3	255.8	180.8	177.6	221.7	220.0	302.8	307.8	481.8	3915.6
(80% range)	392-884	360-825	142-487	155-330	191-321	127-234	94-261	143-301	148-292	224-382	238-378	260-704	

Periods of heavy rainfall

The heaviest rainfall normally occurs between December and February. However for rice cultivation, heavy rainfall is most serious during the transplanting period and in the period preceding the harvest when the fields must be drained. For a system of double cropping of rice, these periods are critical in November and April and maximum rainfalls falling during periods up to five consecutive days in these months have been analysed to determine field drainage requirements (Appendix 4). Either log - normal or Gumbel (extreme value) distributions were fitted to the rainfall data.

Dry periods (drought)

The driest time of the year is from June to August when there may be long periods with little or no rain. The driest period on record at Paya Paloh was July 1972 when there were 30 days without any rain. Figure 5 indicates the likelihood of periods of low rainfall, of various lengths and frequency, at Paya Paloh, based on an analysis of rainfall during the driest period each year between June and August, of 10, 15, 20 and 30 days. The data were found to fit a normal distribution.

Evaporation estimates

Monthly estimates of mean daily evaporation from an assumed large body of clear water were calculated with the Penman equation using meteorological data recorded at Paya Paloh and summarised in Table 2. The Table also shows

TABLE 2. Paya Paloh: Meteorological data and evaporation estimates

Year	J	F	M	A	M	J	J	A	S	O	N	D
						Relative humidity %						
1970										81.1	88.5	89.7
1971	89.5	80.6	75.4	72.0	78.5	80.4	79.0	82.0	76.0	76.0	77.8	82.5
1972	88.2	80.9	84.8	82.9	85.7	79.3	76.1	78.8	88.7	88.3	88.7	85.9
1973	89.0	84.5	89.0	89.0	88.5	87.0	87.1	86.5	87.0	81.5	83.0	82.5
1974	85.3	81.4	83.0	85.0	81.2	80.0	83.1	84.3	86.0	83.3	81.1	84.1
1975	82.5	82.0	82.0	82.0	82.0	82.0	81.5	80.5	80.5	80.0	81.5	86.0
1976	88.9	84.8	86.3	82.7	81.8	83.2	80.7					
						Average temperature ^{o}C						
1970										27.5	27.4	26.7
1971	26.7						27.2	26.7	27.2	27.8	27.2	27.2
1972	26.1	26.7	26.1	27.2	27.8	27.8	27.8	27.8	27.2	26.7	27.2	27.8
1973	26.7	26.1	27.2	27.8	27.8	26.1	27.2	26.7	26.7	26.7	26.7	25.6
1974	25.6	26.1	26.1	27.2	27.2	27.2	27.2	27.8	26.7	27.2	27.2	26.7
1975	26.7	26.1	26.7	27.8	27.2	27.2	26.7	27.2	26.7	26.7	26.1	27.8
1976	24.1	24.9	26.5	27.3	27.6	26.8	26.7					
						Wind run (miles/day)						
1970										42.4	7.2	9.3
1971	12.6	10.8	11.9	10.0	8.9	9.5	10.2	11.1	10.3	19.2	9.3	6.3
1972	12.3	13.0	16.6	9.4	9.6	12.0	15.2	14.7	15.2	36.5	46.8	41.4
1973	53.0	46.5	43.8	42.5	47.7	45.8	43.2	36.4	48.0	35.8	17.9	9.6
1974	10.6	13.3	12.6	7.1	5.9	7.1	8.5	9.8	7.8	9.5	11.1	10.0
1975	8.9	6.8	6.6	7.4	9.7	10.6	9.8	10.2	8.6	10.2	11.3	10.4
1976	11.8	9.8	10.5	7.1	8.0	8.7	9.3					
						Sunshine (hrs)						
1970												
1971												
1972						6.86	8.26	5.64	4.06	4.25	4.16	4.94
1973	3.46	4.56	3.83	4.76	5.42	6.31	5.77	5.20	4.24	5.22	4.69	4.46
1974	3.70	3.82	-	5.23	5.25	5.12	5.30	5.36	4.43	4.75	4.98	4.56
1975	4.41	4.16	4.47	5.35	6.07	4.81	5.18	6.06	4.24	5.37	5.31	4.70
1976	4.74	6.30	5.44	6.77	6.88	6.32						
						Evaporation (mm/day)						
1972							4.64	4.30	4.13	4.13	3.96	4.07
1973	3.80	4.12	4.13	4.38	4.28	3.98	4.23	3.94	4.19	4.36	4.02	3.73
1974	3.66	3.86	-	4.23	4.00	3.91	3.96	4.24	4.18	4.25	3.99	3.77
1975	3.91	3.90	4.20	4.31	4.08	3.85	3.95	4.25	4.06	4.21	3.93	3.99
1976	3.65	4.14	4.37	4.63	4.40	4.01						
Mean	3.76	4.00	4.23	4.39	4.19	3.94	4.20	4.18	4.14	4.23	3.97	3.89

the evaporation estimates for July 1972 to June 1976 and the monthly means which are plotted in Figure I (Part 3). Details of the Penman equation and tables for its computation using Paya Paloh data were lodged in the Drainage and Irrigation Department head office. Recent measurements of incoming solar radiation at Paya Paloh using a bi-metallic actinograph have been related to measurements of sunshine hours to be used in the evaporation estimates (Figure 6). Mean daily relative humidity is taken as the average of measurements at 0800 and 1400 hrs and examination of old hygrograph charts stored at Semengok (Figure 2) confirms that this is generally acceptable and the errors when averaged over a month will be very small. Average daily temperature is the mean of maximum and minimum thermometer readings. Average wind run is measured with a cup counter anemometer installed two metres above ground level.

Evaporation from a Class 'A' evaporation pan, is also recorded at Paya Paloh and the mean daily record for each month is compared with the Penman estimates in Table 3.

TABLE 3 Comparison of Penman estimates of mean daily open water evaporation (Eo) with Class 'A' pan evaporation (Epan) at Paya Paloh (mm)

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Mean
Eo	3.76	4.00	4.23	4.39	4.19	3.94	4.20	4.18	4.14	4.23	3.97	3.89	4.09
Epan	4.47	4.37	4.62	4.95	4.31	5.26	4.37	4.37	4.11	3.96	4.44	4.57	4.48
Eo/Epan	0.84	0.91	0.92	0.89	0.97	0.75	0.96	0.96	1.01	1.07	0.89	0.85	0.92

The ratio Eo/Epan is both variable and high. Similar inconsistencies were found at Miri and Bintulu (Hunting Technical Services et al., 1974) and it is concluded that the pan data are unlikely to be reliable because the instrument is not suited to areas, such as Paya Paloh, where intense rainfall causes splashing from the pan. Observation errors are often great with this instrument particularly where observers are changed frequently and inadequately trained in the method of filling and bailing the pan and in reading the vernier of the hook gauge.

Monthly water balance at Paya Paloh

Rainfall at the 80% minimum probability level is compared with evapotranspiration (assumed as 0.85 x Eo) in Table 4.

TABLE 4 Comparison of monthly minimum rainfall and evapo-transpiration at Paya Paloh (mm)

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Rainfall (P_{80})	392	360	142	155	191	127	94	143	148	224	238	260	2474
Evapo-transpiration (Et)	99	95	111	112	110	100	111	110	106	111	110	103	1269
$P_{80} - E_t$	293	265	31	43	81	27	-17	33	42	113	137	157	1205

There is a small chance of evapo-transpiration exceeding rainfall in July. This means that in a few years, offseason crops such as maize and soya beans would benefit from irrigation although, except for rice, it is never likely to be economic. The need for irrigation is discussed in Appendix 4.

HYDROLOGY

Although watersheds are mountainous and frequently over 300 m above sea level (a.s.l.) the catchments upstream of the study areas mostly comprise dissected plains generally lying below 100 m (a.s.l.), while further downstream in the lower courses, the catchments are comprised of alluvial plains and peat swamps nearly at sea level. The rivers here are tidal and riparian land is in danger of periodic flooding. Figure 3 shows the area-altitude relationships of the Sadong and Samarahan upstream of the study areas.

Rainfall on the upper catchments drains rapidly to the middle river courses, where there is a marked change of gradient. Discharge to the lower river courses is hampered by tidal movements which penetrate far up the rivers. Thus, both during times of high flows from up river and during high tides there is a serious flood hazard and when there is a combination of these two factors flooding may be particularly severe. Whereas in the off-season storms tend to be localised and of short duration, in the *landas* rainfall moves in southwards off the sea and periodically an entire catchment may be covered by heavy, continuous rainfall. Maximum river discharge capacity in the middle courses may then be exceeded prior to run-off arriving from upper areas with the result that the middle river valleys are severely and extensively flooded for long periods. This effect may then extend downstream well into the tidal lower courses.

River discharges show a wide annual range corresponding to the rainfall pattern. The high ratio of monthly maximum to minimum discharge of about 3.5 is indicative of the seasonality of rainfall coupled with little storage in the upper catchment. Monthly values of average daily discharge in the Batang Sadong are plotted in Figure 4.

Although there are no records of sediment discharge, amounts must be quite small in relation to the catchment areas. There is little scope for soil erosion and transport to the rivers except on hills cleared for cultivation. Even here, the period between clearing and regrowth is short. Pepper gardens, on the other hand, which are increasing in the middle catchment areas, are a serious erosion hazard as long as farmers continue to leave the soil between vines clear of cover. The chemical quality of the river waters, though generally acid (pH 5.5 - 6.0) is good for irrigation purposes, until well down into the tidal reaches. Here there is a short band where fresh river water mixes with saline water moving up from the sea. The band moves several kilometres up and down the lower river courses during the seasons depending on a balance between the volumes of river discharge and tidal inflow; the latter being dependent to some extent on the tide height.

Sadong-Krang

The Sadong has been continuously gauged at Serian since 1962, and, apart from 1962 and 1963, average daily waterlevels and discharges are published in the DID Hydrological Year books. Within the Krang catchment, on the Sungai Bedup, a similar length of record is also available. Several temporary staff gauges have been installed along the rivers from time to time to determine depths and duration of flooding and two permanent waterlevel recorders with 4 years of record are operated at Gedong and at Kampong Tanah Puteh.

Floods

The Batang Sadong is particularly prone to flooding during the *landas*. Although serious floods occurred in 1974 and 1976, the previous 10 years saw only minor flooding. The worst recorded flood both in terms of depth and duration occurred in January 1962 (see DID file D5/010) when flooding lasted for 10 days. The maximum flood depth was 1.6 m at Serian and this was estimated to represent a discharge of about 1400 m^3/sec. The January 1976 flood reached similar depths although it lasted only 7 days. The maximum river discharge without flooding is 230 m^3/sec. The extent of floods in 1974 and 1976 has been mapped (DID, 1974; DID, 1976a). These show that in the Sadong catchment flooding was serious up-river from Kampong Sebemban to Serian and beyond while along the Krang the area upstream of Sungai Midin was seriously affected. Between Kampong Gumpeh and Gedong, slight flooding occurs, though of short duration and Gedong itself is almost free of this hazard.

For rice cultivation, flood duration as well as flood depth must be considered in order to assess the chance of crop damage or loss in flood prone areas during the *landas*. Figure 7 shows the results of frequency analysis of annual average flood level during consecutive days at Serian; this indicates that at least some flooding can be expected every year and, for example, once in 5 years an average flood depth of more than 1 m is likely for at least 5 days - a period long enough to reduce rice yields seriously. Downstream of Serian, as far as Tanah Puteh, flooding is more severe. At Tanah Puteh, itself, in 1974, the maximum flood depth was 0.25 m higher and lasted half a day longer than at Serian. On the other hand, further downstream, at Sebemban, the flooding was 0.33 m lower and lasted 2 days less than at Serian. No records exist of flooding on the Krang upstream of Sungai Midin, which in 1974 was flooded continuously for 6 days to a maximum depth of 0.50 m.

In view of the frequency and severity of flooding along the Sadong, a preliminary investigation was made of the possibility of constructing dams to store floodwater upstream of the main agricultural areas (Appendix 3).

Low flows

Minimum flows occur in July, August and September which coincides with the irrigation season of a second rice crop. Substantial variations in minimum flow occur from year to year, both in quantity and timing. For example, the lowest recorded flows occurred in 1976 during the latter half of September compared with August in most years. Figure 8 is a log-normal distribution

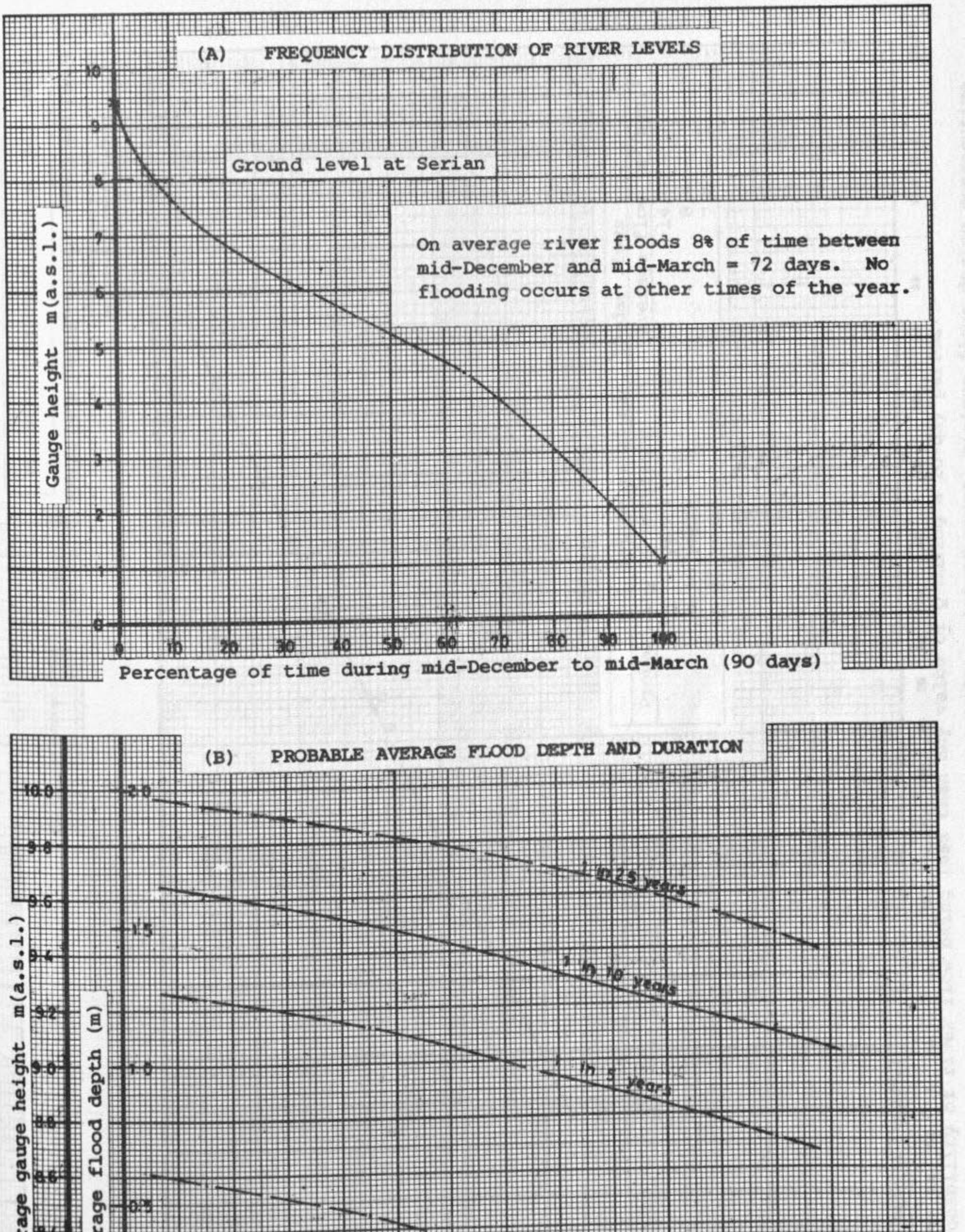

FIGURE 7 Flooding at Serian, mid-December to mid-March

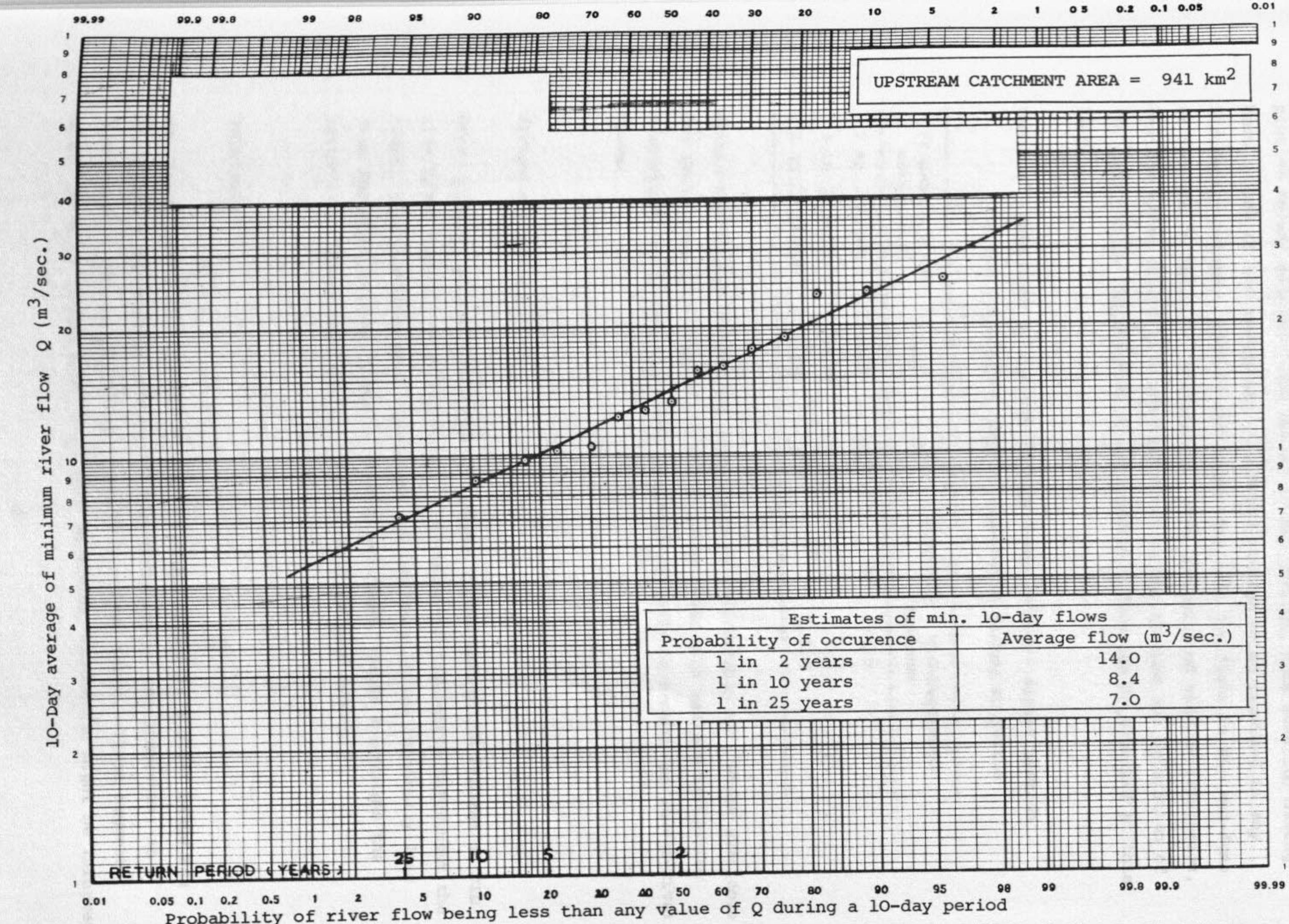

FIGURE 8 Batang Sadong at Serian. Log normal probability plot of annual minimum flows during consecutive 10-day periods during July to September

plot of annual minimum flows during 10 day periods, this duration having been chosen on the assumption of limited storage being provided in any irrigation scheme. Similar estimates were made for flows in May and June as set out in Table 5. Fortunately, from the point of view of irrigation, maximum water demand will normally occur in May or June for saturation of the padi fields (Appendix 4) and a reasonable flow can be expected at this time.

TABLE 5 Estimates of minimum average flows (m^3/sec) during periods of ten consecutive days in the Batang Sadong at Serian

Probability of occurrence	May	June	Mid-July - Mid-September (minimum)
1 in 2 years	27.5	22.5	14.0
1 in 10 years	15.5	10.5	8.4
1 in 25 years	11.0	7.0	7.0

Within the Sadong-Krang study area there is considerably more water available for irrigation than there is suitable land. Even with maximum irrigation development up-river, the water demand is unlikely to exceed the run-of-river flows.

Irrigation water quality

Water quality data collected in the course of the survey and records on DID file 2/86, indicate that the water is suitable for irrigation throughout the season (April-September). Electrical conductivity is low (generally less than 500 µmhos/cm) and there is no sodium hazard. Table 8 contains the results of laboratory analyses of water samples from Gedong.

Samarahan

The Samarahan is not regularly gauged although recently a staff gauge was installed on the Sungai Serin, the main tributory of the Samarahan, at 24th mile; a few discharge measurements have been taken. These suggest that, at least during periods of flow recession, discharges might be inferred from Sadong data in proportion to the catchment sizes. Recently, water level recorders have been installed on the Samarahan at Kampong Reban and on the Sungai Tuang at Kampong Endap, but these record no more than tidal variations and flood levels. During the course of the LRD/ODM survey a short record of river stage and discharge was collected on the Sungai Tuang at Kampong Batu Gong, just upstream of the tidal influence. However, in the Samarahan study area the main hydrological constraint is poor water quality.

Irrigation water quality

Samarahan water is permanently saline downstream of Kampong Mang and from June to September, when the fresh water discharge is low, salt water may extend upstream of the study area. Electrical conductivities of 3 000 µmhos/cm have been recorded at Kampong Reban in August although on average throughout the year, the conductivity is probably less than 500 µmhos/cm. Salinity increases steadily downstream so that a Muara Tuang the conductivity is seldom less than 10 000 µmhos/cm. Likewise in the Sungai Tuang and Sungai Entingan saline water moves upstream towards the tidal limit. Clearly any major abstraction of fresh water from these rivers will substantially reduce the fresh water discharge into the tidal section and thereby extend upstream the limit of salt water intrusion.

Major irrigation proposals have been advanced for irrigated rice production upstream of the study area, along the Sungai Serin and the Sungai Bukar (Text Map 1), and these are likely to ensure that the Samarahan within the study area is permanently saline during the irrigation season. Therefore good quality irrigation water supplies in the area are limited to the seasonal flows of the Sungai Tuang and Sungai Entingan and the development of small peat streams such as the Empila.

Floods

Flooding of a few hours each day at the height of the tides and of depths up to one metre is likely to occur along the Samarahan throughout the project area; this is much less than is known to occur at the proposed irrigated rice areas upstream of 27th mile and in the vicinity of Paya Megok, the former rice research station, where severe flooding (from the river, rather than the tide) will limit the extent of developments. Along the Sungai Tuang, high floods occur at Kampong Endap and along the Sungai Empila and Sungai Entingan flooding occurs at the upper limits of tidal influence. Because the rivers within the study area are saline, even limited flooding may be a serious hazard to rice production.

Estimates of flood discharges for headworks design or other river structures are given in Table 6. These are adapted from a flood peak in the Batang Sadong at Serian of 1 500 m^3/sec (return period of about once in 125 years - Appendix 3) using a modified Greager formula (ECAFE, 1967).

TABLE 6 Design flood peaks (m^3/sec) in the Samarahan, Sungai Tuang and Sungai Entingan

River	Catchment (km^2)	Flood peak (m^3/sec)
Batang Samarahan at 27th mile	260	500
Sungai Tuang at Kpg Endap	87	200
Sungai Entingan at Kpg Nangka	39	80

Low flows

Low flows in the Samarahan and its tributaries are assumed to follow a similar pattern to those in the Sadong. Estimates of minimum flows likely to occur at least once in 10 years during May, June and the period July to September are presented in Table 7 and are derived from Sadong data (Table 5) in proportion to catchment areas.

TABLE 7 Estimates of once in 10 years average minimum flows (m^3/sec) during periods of ten consecutive days in the Samarahan, Sungai Tuang and Sungai Entingan

River	Catchment (km^2)	Average flows		
		May	June	Mid-July to mid-September (minimum)
Batang Samarahan at 27th mile	260	4.28	2.90	2.32
Sungai Tuang at Kpg Endap	87	1.43	0.97	0.78
Sungai Entingan at Kpg Nangka	39	0.64	0.44	0.35

Sungai Ensengei

In view of the limited sources of good quality irrigation water available for use in the Samarahan study area, the prospect of diverting some of the flow from the Sungai Ensengei, via a 4 kilometre canal into the Sungai Sok, a right bank tributory of the Samarahan, has been investigated. No hydrological data are available for the Ensengei, though data collection is proposed for the purpose of flood investigations in the Upper Ensengei. When the river was visited, in the vicinity of Mungu Tengah in September 1976, there appeared to be a moderate flow of perhaps 600 l/sec through substantial weed growth. This was at a time when other rivers in the area were reaching record low levels. On the basis of this single observation, and allowing for an additional contribution from the Sungai Sok, it is likely that at least 1 m^3/sec could be pumped from the Sungai Sok (or Sungai Siniawan) during the maximum irrigation demand period, if a diversion canal and control structure were constructed from the Ensengei. Levels have been taken between the Samarahan and the Ensengei (DID drawings 76/129/1-1; 1-2; 1-3) and these show that it should be possible to divert water by gravity along a canal between the Ensengei and the Sungai Sok. Irrigation water quality in the Ensengei is good.

Peat streams

Rough estimates of the surplus water that might be collected from the interfluvial peat swamps can be determined from the water balance at Paya Paloh (above), assuming that most of the annual water surplus of 1 205 mm drains away in the streams, at any time in proportion to the rainfall.

For example, in June, the month of maximum irrigation demand, rainfall represents 5% of the annual amount and total outflow from the swamp, during the month is therefore assumed to be 5% of 1 205 mm = 60 mm = .06 m = 600 m^3/ha. Average flow during the month = 0.23 litres/sec ha.

Applying this estimate to the Empila catchment area of about 2 000 ha, the outflow in June would be 460 l/sec and the minimum flow during the month might be a third lower (based on data from the Sadong) or 310 l/sec. In July, the month with the lowest reliable rainfall, the flow in the Empila could be down to 230 l/sec.

Analysis of river water samples

A few water samples have been chemically analysed to determine their suitability for irrigation. The results are given in Table 8. No samples from the Samarahan were analysed in view of excessive salinity measured on site.

TABLE 8 Chemical analysis of water samples from rivers in the Sadong and Samarahan catchments

River and location	Date	pH	Conductivity µmhos/cm	Cations (meq/l)			Anions (meq/l)	
				Na^+	Ga^+	Mg^+	Co_3^-	HCO_3^-
Sadong at Gedong	24/ 9/71	5.5	n.a.	0.03	0.16	0.04	n.a.	n.a.
Sadong at Gedong	1/10/71	6.4	n.a.	0.16	0.32	0.12	n.a.	n.a.
Ensengei at Mg. Tengah	16/ 9/76	5.6	12	0.12	0.20	trace	nil	0.09
Siniawan at Siniawan	2/ 9/76	4.5	31	0.17	0.29	0.49	nil	0.02
Tuang at Batu Gong	22/ 9/76	7.4	84	0.23	0.59	0.59	nil	0.94
Serin at 24th Mile	22/ 9/76	7.6	88	0.22	1.08	0.10	nil	0.96

Further analyses of Sadong water are filed in DID 2/86 n.a.= not available

Field measurements of conductivity in the Sadong at Gedong in July and August 1976, were invariably less than 100 μmhos/cm.

The analyses indicate that all the waters tested are of excellent quality for irrigation, with no hazard from salinity or sodicity. Peat streams such as the Sungai Siniawan are moderately acid though this is not considered to be a hazard for rice cultivation.

APPENDIX 3 FLOOD ALLEVIATION IN THE SADONG CATCHMENT

INTRODUCTION

The whole of the Lower Sadong river basin comprising the area of good agricultural soils, particularly those suited to wet rice production, is subject to annual river flooding. This seriously limits their development potential. In addition, occasional very high floods cause severe disruption to social and economic life along the river from Tebedu and Muara Mongkos to nearly as far downstream as Gedong (see for example the flood map-drawing 76/126/1-1 - in the 1976 flood report. DID (1976 a). From Tebakang down as far as Kampong Gumpeh, the flooded area amounted to about 6 000 ha in 1976, and rice yields were considerably less than in a normal year when only minor, short-duration flooding might be expected. In addition to the loss of agricultural production, high floods, as occurred in 1962, 1974 and 1976, lead to considerable loss or damage to property and in some cases the evacuation of whole kampongs (such as Tanah Puteh in 1976) is necessary, involving the emergency services of army and police. Flooding of the Serian-Simanggang and Serian-Tebakang roads causes disruption to traffic (2-day closure in 1962 and 1976) and river traffic is also liable to encounter difficulties. It is apparent therefore that a flood alleviation scheme would not only benefit the 3 200 ha of potential wet rice land within the Sadong study area, which at present are liable to severe flooding, but would also allow all areas from Tebakang downriver to Gedong (perhaps 4 000 to 6 000 ha) to be intensively developed, including new settlements and possibly estates for double cropping rice with irrigation in the off-season.

Severe flooding in the middle and lower reaches of the Sadong results from several days of heavy rainfall throughout the catchment causing run-off which greatly exceeds the channel discharge capacity. In 1976, 4 days of heavy rainfall occurred before the flood reached peak level at Serian. The storms passed up the catchment so that maximum rainfall on the upper area fell over 1-2 days later than that further downstream. Consequently, run-off from heavy rainfall early on in the period rapidly exceeded the river discharge capacity and when maximum flows arrived from up catchment, extensive flooding occurred.

In 1962 the maximum flood resulted from two rain periods separated by only two fairly dry days (see DID file D5/010). Discharge from the first period had just passed its peak before the second storm arrived causing substantially greater flooding. Flood hydrographs for 1962 and 1976 are compared in Figure 13. During floods there is considerable overbank storage, and the dissipation of this takes several days due to restricted discharge during the upper part of the tide cycle. Flood dissipation therefore can occur only when downriver levels are below flood storage levels. Clearly, any scheme that might be proposed for flood alleviation in one part of the catchment will tend to increase the flooding elsewhere, although in the case of bunding of very small areas this effect might be negligible. The only effective solution to the flooding problem therefore is the construction of dams upstream of the flood area and storage of water surplus to the maximum channel discharge capacity (about 200 m^3/sec) until it can be safely released at a rate below full capacity.

A major hydrological constraint to any flood storage scheme results from the splitting of the catchment, near Tebakang, along two major tributaries, the Batang Kayan and the Sungei Kedup. Furthermore, the possible sites for flood storage lie well upriver from Serian. This means that:

1. Flood run-off from roughly one third of the upstream catchment can never be controlled.
2. Run-off from the remainder of the catchment is divided so that storage in one tributary can at the most control only one third of the flood at Serian.

Floods

Flood height

Records of river flows since February 1962 are available at Serian and from these details of flood levels have been extracted. In analysing such a short record it is preferable to use a partial duration rather than an annual series of data to determine the highest flood that can be expected in any year, provided that when selecting two or more floods during a particular season (year it is certain that the events are independent of one another. In a small catchment such as that of the Sadong this is likely to be the case if the floods selected are more than a month apart. In addition to recorded data, use can also be made of historical flood records provided they can be related to the same level datum.

Details of the 1962 flood including the flood profile, are in the DID flood report. This report also refers to the previous highest level in 1957. The 1962 (and 1957) flood levels can be related reasonably accurately to the present datum used by DID for their waterlevel records at Serian, by comparing levels on the Sadong bridge and along the road; these indicate that the 1957 and 1962 levels should be reduced by 1 foot. Altogether, 16 years' data on maximum floods are available (1957, 1962-76) and the levels are listed in Table I in ascending order of magnitude.

TABLE I Maximum flood levels and discharges at Serian selected as a partial duration series for 1957 and 1962-76

Year	Date	Maximum flood level m (a.s.l.)	Maximum discharge m^3/sec	Gumbel plotting position y
1970	22/1	8.24	230	-1.15
1964	3/3	8.36	240	-0.82
1971	8/2	8.38	250	-0.58
1968	17/1	8.84	330	-0.39
1973	31/12	8.84	330	-0.21
1969	22/12	9.06	390	-0.04
1975	27/12	9.06	390	0.13
1974	2/3	9.15	420	0.30
1963	1/3	9.31	610	0.48
1957	Jan	9.36	640	0.67
1962	20/2	9.36	640	0.88
1963	29-30/1	9.38	680	1.12
1975	26/2	9.39	700	1.41
1974	Jan	9.41	740	1.78
1976	14/1	9.75	1 000	2.32
1962	30/1	9.80	1 250	3.35

The flood levels have been related to discharge using a rating curve based on that given by DID (DID 1976a) but drawn to a logarithmic discharge scale with the higher end modified to take better account of the more reliable flood discharge measurements up to about 700 m^3/sec (Figure 12). At higher flows there is likely to be considerable measurement error when estimating overland flow. Both in 1962 and 1976, estimates of the overland flow were made, within the road culverts and along the sections of flooded road. Although considerable variations in flow were found between the two records, despite similar flood depths above the road, the summation of all the constituent measurements (in river, across roads and in culverts) compared very closely. The variation

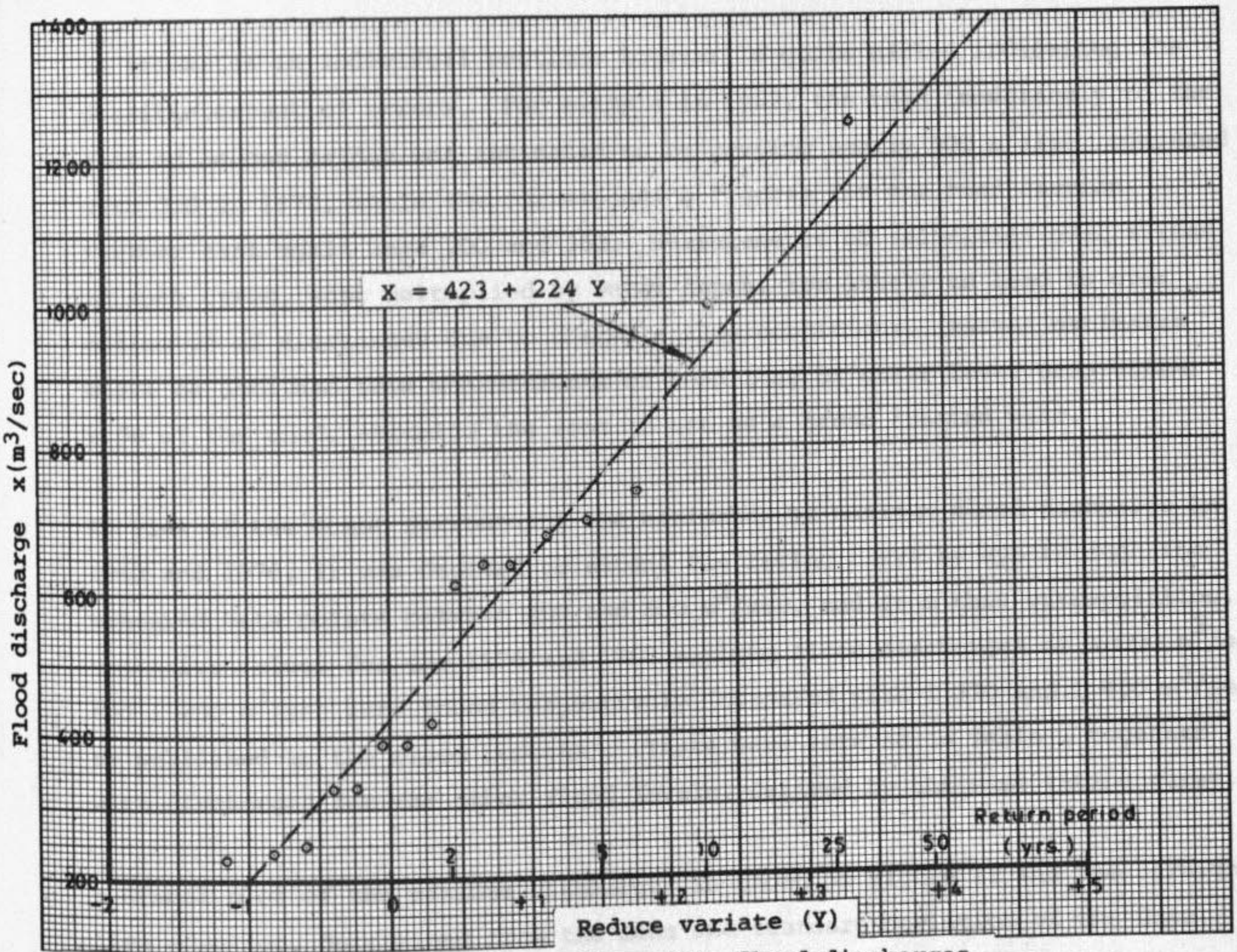

FIGURE 11 Gumbel plot of annual maximum flood discharges

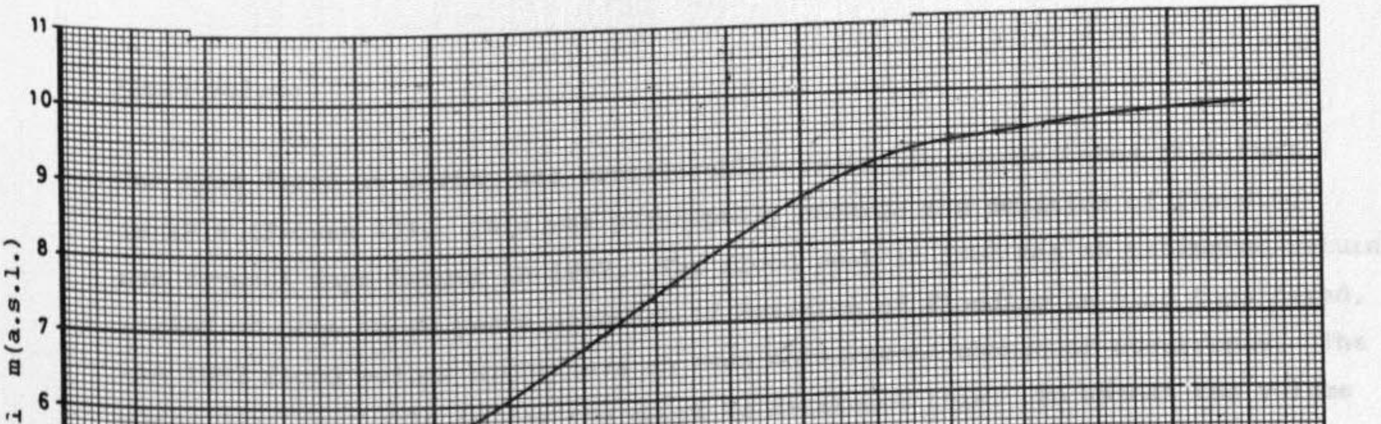

FIGURE 12 Rating curve of Batang Sadong at Serian

in estimates in individual sections however is quite marked indicating the possible extent of errors. For example in 1962, the road immediately to the east of Sadong bridge was estimated to be passing nearly 400 m^3/sec, compared with 310 in 1976, while the corresponding figures for the road section further east again were 200 and 350. Measurements of velocities over a road in such cases, when multiplied by water depth, are likely to lead to over estimates of discharges due to unstable flow conditions. Better estimates might be obtained from measurements of head loss or water level drop either side of the road, assuming the road to act as a broad crested weir.

In view of the doubt surrounding the estimates of maximum flood discharge in 1962 and 1976, it was decided to extend the rating curve by eye through the measured data points between 400 and 600 m^3/sec, and from this extrapolation, tentative values for the 1976 and 1962 maximum flood discharges of 1 000 m^3/sec and 1 250 m^3/sec were found respectively (compared with 1 370 and 1 450 m^3/sec as published in the flood reports). These were entered in Table I together with discharges for the other flood levels, derived by the same rating curve.

A Gumbel plot of the maximum discharges is shown on Figure 11 and the straight line equation, determined from the mean and standard deviation of the data, using the Gumbel equations, is also plotted, indicating a fairly good fit. This would suggest a once in 10 year flood peak of 950 m^3/sec and a once in 50 year flood peak of 1 300 m^3/sec.

Flood volume

The 1962 flood at Serian was considerably greater in volume terms than that in 1976 (Figure 13). This was principally because the duration of flooding was several days longer in 1962. The flood peak in 1962 has an estimated return period of once in 40 years although if duration of flooding is also considered, the 1962 flood volume might have an even more remote chance of occurrence. The flood data available is far too short to determine this. To assess the volume of water that would have to be stored to prevent flooding at Serian, two flood hydrographs have been considered (Figure 13). The first is a hypothetical once in 10 year flood with discharge peaking at 950 m^3/sec and duration of 8.5 days, and the second is a possible once in 50 year flood, based on the 1962 profile with a peak at 1 300 m^3/sec. Possible storage sites in the

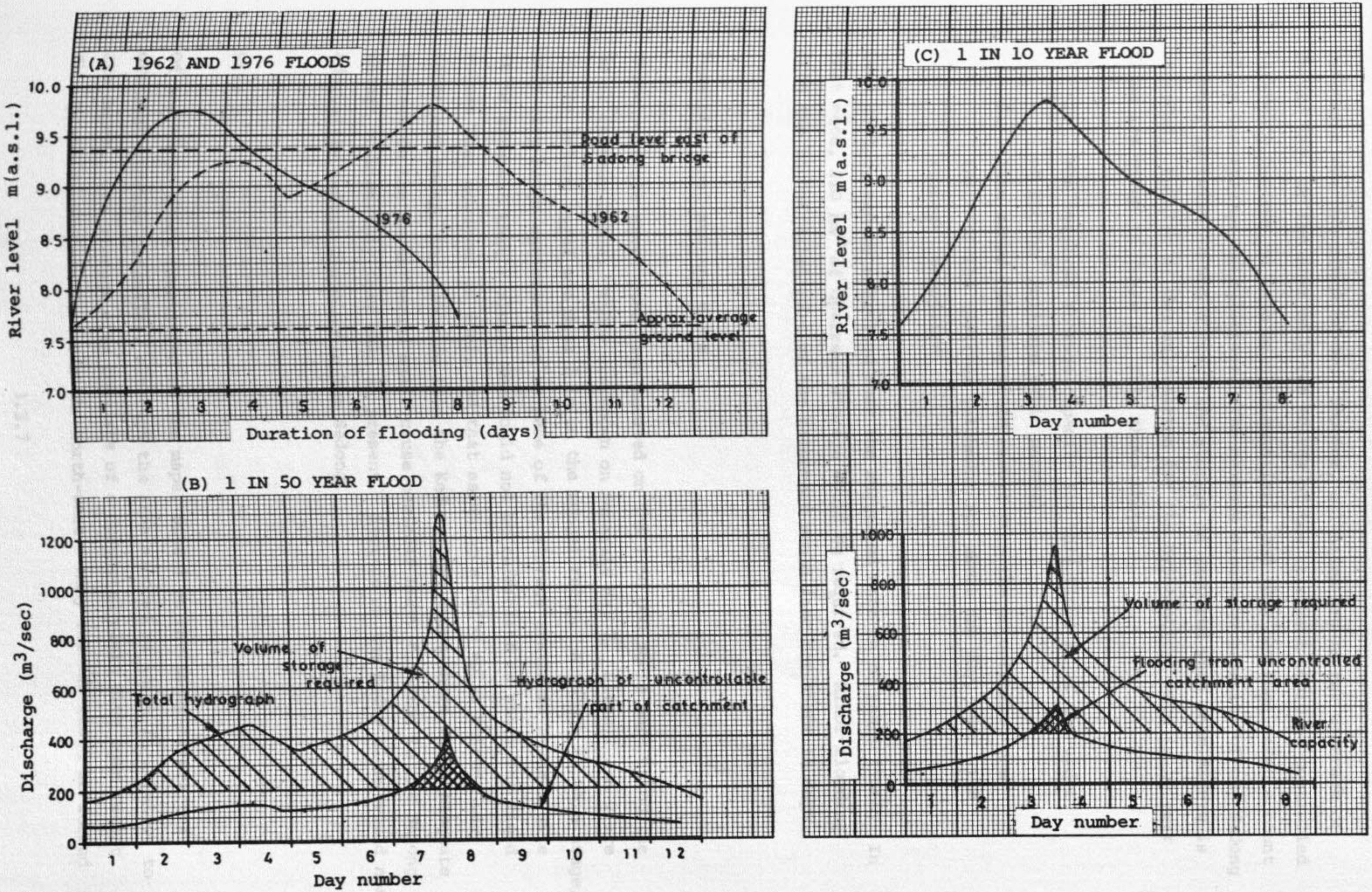

FIGURE 13 Batang Sadong flood hydrographs
(A) Comparison of 1962 and 1976 floods (B) Hypothetical 1 in 50 year flood (C) Hypothetical 1 in 10 year flood

catchment are described below. However, all sites are so far upstream of Serian that at the most only two thirds of the catchment could be controlled (assuming storage on both main tributaries), and this has been taken account of in the storage calculations. The maximum discharge capacity of the Sadong channel is taken as 200 m^3/sec, and storage is required when this figure is exceeded. Details of the calcualtion for the hypothetical once in 10 year flood are given in Table 2. This shows that:

1. The required storage capacity for this flood is of the order of 110 hm^3 (million cubic metres)
2. Some minor flooding would result from the uncontrolled one third of the upstream catchment for about one day, even with storage reservoirs.

Less control can be exercised over the suggested once in 50 years flood. In that case, 210 hm^3 of upstream storage would be required. Minor flooding from the uncontrolled part of the catchment would last for about 1½ days.

Possible flood storage sites

Three possible sites have been located on the 1:50 000 scale maps using the 50 ft contour lines. These are shown on Separate Map 7. Sites 1 and 2 are on the Batang Kayan and Site 3 is on the Sungei Kedup. Although at this stage, only very rough estimates can be made of the storage available at each site it is apparent that a single dam would not be sufficient to store the flood volume that occurred in 1962, and that assuming a 50/50 split between the Kayan and Kedup, the flooding from the Kedup alone (were there to be adequate storage on the Kayan) would still cause periodic heavy flooding in the Sadong though considerably less than at present. Storage on the Kedup alone would not adequately reduce flooding in the Sadong.

Site 1

Of the three sites identified on the maps, Site 1 on the Kedup offers the greatest storage potential, although the area flooded is large in relation to its depth. The storage area consists of a dissected plain with some recent floodplain development towards the north-west. Many islands would be formed

TABLE 2 Computation of Upstream Storage for an assumed once in 10 year flood in the Batang Sadong at Serian

Day no.	Time (hrs)	Discharge (m^3/sec) Total (1)	Uncontrollable (2)=(1)/3	Controllable (3)=2/3 (1)	Release (4)=200 - (2)	Store (5)=(3) -(4)
1	00	180	60	120	140	-
	06	200	67	133	133	-
	12	210	70	140	130	10
	18	240	80	160	120	40
2	00	260	87	173	113	60
	06	290	97	193	103	90
	12	320	107	213	93	120
	18	390	130	260	70	190
3	00	430	143	287	57	230
	06	510	170	340	30	310
	12	600	200	400	-	400
	18	800	267	533	-	533
4	00	950	317	633	-	633
	06	600	200	400	-	400
	12	540	180	360	20	340
	18	490	163	327	37	290
5	00	440	147	293	53	240
	06	400	133	267	67	200
	12	380	127	253	73	180
	18	360	120	240	80	160
6	00	340	113	227	87	140
	06	330	110	220	90	130
	12	320	107	213	93	120
	18	310	103	207	97	110
7	00	300	100	200	100	100
	06	280	93	187	107	80
	12	260	87	173	113	60
	18	240	80	160	120	40
8	00	220	73	147	127	20
	06	200	67	133	133	-
	12	180	60	120	140	-

Storage required = 5226 x 6 x 60 x 60

= 112.9 hm^3

Σ = 5226m^3/sec.

during flood storage periods. Several kampongs farm small parts of the area, generally shifting cultivation from place to place each year. As with the other sites, soils are rather infertile and crop yields poor. The maximum dam height would be in the region of 16-20 m, depending on topography to the south and the extent to which flooding could be tolerated. For example a slightly higher dam might threaten Tebedu with inundation as well as considerable sections of the Tebedu road. The volume of storage would range between a maximum of 160 hm^3 with a 20 m dam to about 120 hm^3 with a 16 m dam.

Geological conditions seem favourable on the left (north) bank at the dam site where sound rock (conglomerate)* outcrops in the river channel. No outcropping is visible on the right bank. The cost of a rockfill dam at this site might be of the order of $6-8 million. This is a very rough estimate in the absence of detailed site plans or cost data. There is an abundance of suitable rock in the area and haul distances would be short. Road access to the dam site would probably be constructed from Tebedu.

Site 2

This is the most favourable site in the catchment for construction of a dam and it is located at a point where the Batang Kayan passes a deep, narrow rock gorge extending well over 100 m above river bed level. However the available storage is limited by a low watershed running south-east towards the Tebakang - Mongkos road (see Map 7). Levels have been taken along the approximate line of the watershed and cross-sections of the dam site (DID drawings 76/130/1-1 and 1-2). These show the lowest point along the watershed to be the Sungei Kais which flows north-east into the Batang Kayan downstream of the dam site, and the maximum dam height without overflowing into the Kais would be only 10 m. The Sungei Kais valley could be used however for construction of the spillway on top of a raised earth or rockfill dam about 10.5 m high (the minimum level of the next lowest points along the watershed), giving a maximum dam height in the Kedup of 20.5 m. The volume of storage with such a dam is likely to be between 50 and 65 hm^3. As with Site 1, farming in the area that would be flooded is limited by poor soils and undulating topography. Yields of hill padi and maize are said to be poor. Parts of Kampong Retoh

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* A description of rock samples appears at the end of this Appendix

might be slightly flooded.

Geological conditions at the site appear to be excellent for dam construction with sound rock (tuff) outcropping on either flank and a rocky riverbed. A mass concrete dam would probably be the cheapest method of construction, particularly if Sarawak cement becomes available. Excellent concrete aggregates could be prepared from stone quarried just to the north-west of the site. The spillway dam in the Sungei Kais would be constructed from rock or earth fill.

The total cost of construction at this site might be of the order of \$2.5 to \$3.5 million, but the storage would be less than half that available at Site 1 and it is likely to be too small to reduce, adequately, the severity of the major floods. Access to the dam sites would be by road from Kampong Krusin via Kampong Siu.

Site 3

This is the only site of any storage magnitude that could be located on the Sungei Kedup. The gradient of the Kedup is generally shallower than the Kayan and a fairly extensive floodplain has developed which is liable to regular flooding during the *landas*. A low dam on the river would create a large storage area. The geological conditions would seem to be more problematical than those on the Kayan. The dam height is determined either by the relatively low left hand (southern) abutment or by the watershed with the Batang Krang (Sungei Kedup) catchment to the north. The 50 ft contours are too broad a measure with which to estimate precisely the volume of storage. On the north side a second very small dam would seem to be necessary but this might be developed at low cost as the flood spillway. On the available evidence, a 10 m high dam is probably the largest that could be constructed at the site with a capacity of the order of 70 - 80 hm^3. However, most of the storage area is already liable to extensive inundation during the major floods (compare the area flooded in 1976 on DID drawing 76/126/1-1 with that of the proposed dam site - Map 7) and it seems unlikely therefore that flood storage at Site 3 would efficiently reduce flooding downstream. To some extent, flooding in the Kedup is probably a backwater effect of heavy flood flows passing rapidly down the Kayan into the area beyond the confluence. Storage at Site 3 would not fully control flooding downstream; high discharges would still have to by-pass the dam via a carefully designed spillway, but if built in conjunction with storage on the Kayan, reasonable downstream flood protection might be achieved. The cost of dam construction at this site might be \$4.5-6 million. If rock is not available in the vicinity, an earth fill dam would have to be built at rather greater cost than construction in rock.

Summary of storage capacity and costs

Details of the three flood storage sites are compared in Table 3 together with the flood estimates.

TABLE 3 Comparison of flood storage sites in the Sadong catchment in relation to severity of flooding

Storage site and river	Estimated storage (hm^3)	Possible cost ($\$x10^6$)	Flood volume at site (hm^3)*	
			1 in 10 yrs	1 in 50 yrs
1 Batang Kayan	120-160	6.0-8.0	55	105
2 Batang Kayan	50-65	2.5-3.5	60	115
3 Sungei Kedup	70-80	4.5-6.0	55	105

* Assuming 50% split between Kayan and Kedup and 10% increase at Site 2 compared with Site 1.

From Table 3 it is clear that any of the storages could eliminate flooding on their respective tributaries in the case of the suggested once in 10 year's flood. Site 2 is at the limit under this condition. The once in 50 year flood can only be controlled in the Batang Kayan at Site 1 and the proposed dam at that site could be reduced slightly and still contain the flood.

It has already been shown that with adequate flood storage on both the Kayan and Kedup, slight flooding will still occur, occasionally, at Serian. This will be considerably worse if only one of the tributaries is dammed and would largely nullify such an investment. It seems, therefore, that the only solution to adequate downstream flood control is by construction of two storages - at

Sites 1 and 3 at a cost probably exceeding $12 million. The total cost including re-location of villages and roads could be considerably greater than this.

It is worth repeating that all the above estimates have been made on extremely limited data and recommendations for further surveys to determine the feasibility of flood alleviation in the Sadong catchment are given later.

Operation of a flood storage dam

A flood storage dam must be operated so that minimum water levels are held during the flood season - mid December to mid March - in anticipation of flood conditions. It is impossible to conceive of an adequate flood warning system which would enable water levels to be regulated more precisely during this time. This is because heavy rainfall in the upper catchment appears as flood flows at Serian within 2 days, and at the proposed storage sites in even less time. There is no way of drawing down a reserviour so rapidly and even moderate rates of drawdown might be a serious hazard to the structural safety of a dam. Therefore it is essential that the waterlevel is drawn right down early in December and maintained close to this level, by careful releases at rates less than channel maximum capacity, until well into March. If a major flood arrives with the reservoir partially filled, overflow could threaten the dam and spillway structure and cause severe flooding downstream as a wave of water passes along the channel. Continuous vigilance in the control of discharges from the dam would be imperative. Without this the dangers are immense.

During the remainder of the year, the reservoir could be maintained at higher levels. Hydroelectric power and fish farming might be developed, during this time, to a limited extent.

Benefits of flood alleviation

Adequate flood alleviation will enable the floodplain to be intensively developed for agriculture, principally rice cultivation. Double cropping with irrigation throughout the present flood prone area will become feasible once the threat of flood damage has been removed.

The floodplain contains some of the best rice soils in Sarawak from which high yields might be expected of the order of 2 500 kg/ha. On a double cropped area of 4 000 ha (very roughly estimated in the absence of land capability data throughout the flood-prone area) this would realise $9 million/annum compared with present yields of around 750 kg/ha realising $1.5 million/annum. During a serious flood such as in 1962 it is unlikely that much rice grew to maturity at all.

In addition to major increases in agriucltural production, flood alleviation would eliminate the need for emergency evacuations and disruptions to the commercial life of the region perhaps once in 5-10 years. During the 1976 flood, emergency measures, damage to vehicles and equipment etc are estimated to have cost about $1 million. No account has been taken of the complete disruption to traffic along the roads of the region.

Conceivably flood storage dams could also serve an additional purpose as reservoirs for hydroelectric power development. However, it has already been mentioned that the waterlevels would have to be drawn down as far as possible from mid-December through to mid-March in anticipation of flooding. The generating head available during this period would be negligible. Power production from the run-of-river flows during this time would require the installation of a different type of turbine, and would not be economic. Therefore, power could only be supplied during 9 months of the year and this is only likely to be beneficial if the output could be supplied to a high tension distribution system, in which diesel power would take over the load during the *landas* season. Operation of the flood storage dams would permanently flood a large area of land which otherwise might be dry and cultivable for much of the year. Although these areas are thinly populated and only farmed spasmodically, some intensification of agriculture might be possible, and loss of this potential must also be added to the cost of flood storage. Finally some benefit might accrue from the development of fish farming.

Geological note on rock samples collected at Sites 1 and 2

Thin sections of rock samples collected at Sites 1 and 2 were prepared and briefly studied by the Geological Survey, Kuching; their report is as follows:

Sample one (Site 1)

Boulder extracted from left river bank

"Sample represents a volcanic component of the conglomerate occuring near Tama, on the Batang Kayan. It is probably a rhyolite (possibly metamorphosed). The conglomerate occurs as lenses at two distinct horizons within thick sandstone beds.

The components of the conglomerate near Tama consist predominantly of intermediate to acid volcanic and plutonic igneous rocks with a few sedimentary and metamorphic rocks and these occur as well-rounded pebbles to 3-foot diameter boulders (Wilford, 1965)".

Sample two (Site 2)

Weathered corner of outcropping boulder in river bed.

"Probably a tuff - greenish grey".

APPENDIX 4 IRRIGATION AND DRAINAGE REQUIREMENTS

IRRIGATION REQUIREMENTS

There is no well established tradition of cultivating irrigated rice in Sarawak; the little that is grown generally suffers from poor water control at field level. Inevitably, few extension staff have any experience with the crop and therefore farmers receive little technical advice on irrigation methods and timing of operations. The water use data on existing schemes such as Tanjung Purun therefore might not be relevant to larger areas which would be provided with good water distribution and control and where detailed extension advice would be available to farmers. Irrigation planning data used in West Malaysia are probably not relevant in Sarawak where the rainfall during the irrigation season is greater and more reliable and where inexperience in irrigation is likely to lead to inefficient water use in the early years. For these reasons, theoretical estimates of irrigation requirements for rice, as well as for other off-season crops have been made.

Irrigation requirements vary according to the cropping system, duration of transplanting and field saturation operations rainfall, evaporation, percolation and drainage, wetting up needs, stage of growth, conveyance and distribution losses between source and field.

Crop calendar

The proposed calendar for double cropping rice or for single cropping of rice followed by an off-season crop of soya or maize is shown in Figure 9. This is based on the need to plant and harvest the main season crop at times when serious flooding and intense rainfall are not likely to occur. The later the main season rice crop is planted the greater the sunshine available for its ripening, but the greater the chance of flood damage during the early stages of growth. Hence it is assumed that traditional 180 day cultivars (30 days in the nursery plus 150 days in the field) will be grown as the main season crop. The off-season rice crop should be a short-term cultivar and this has been assumed to be a 130 day type (20 days nursery + 110 days in the field). Planting of the second crop can start immediately after harvesting

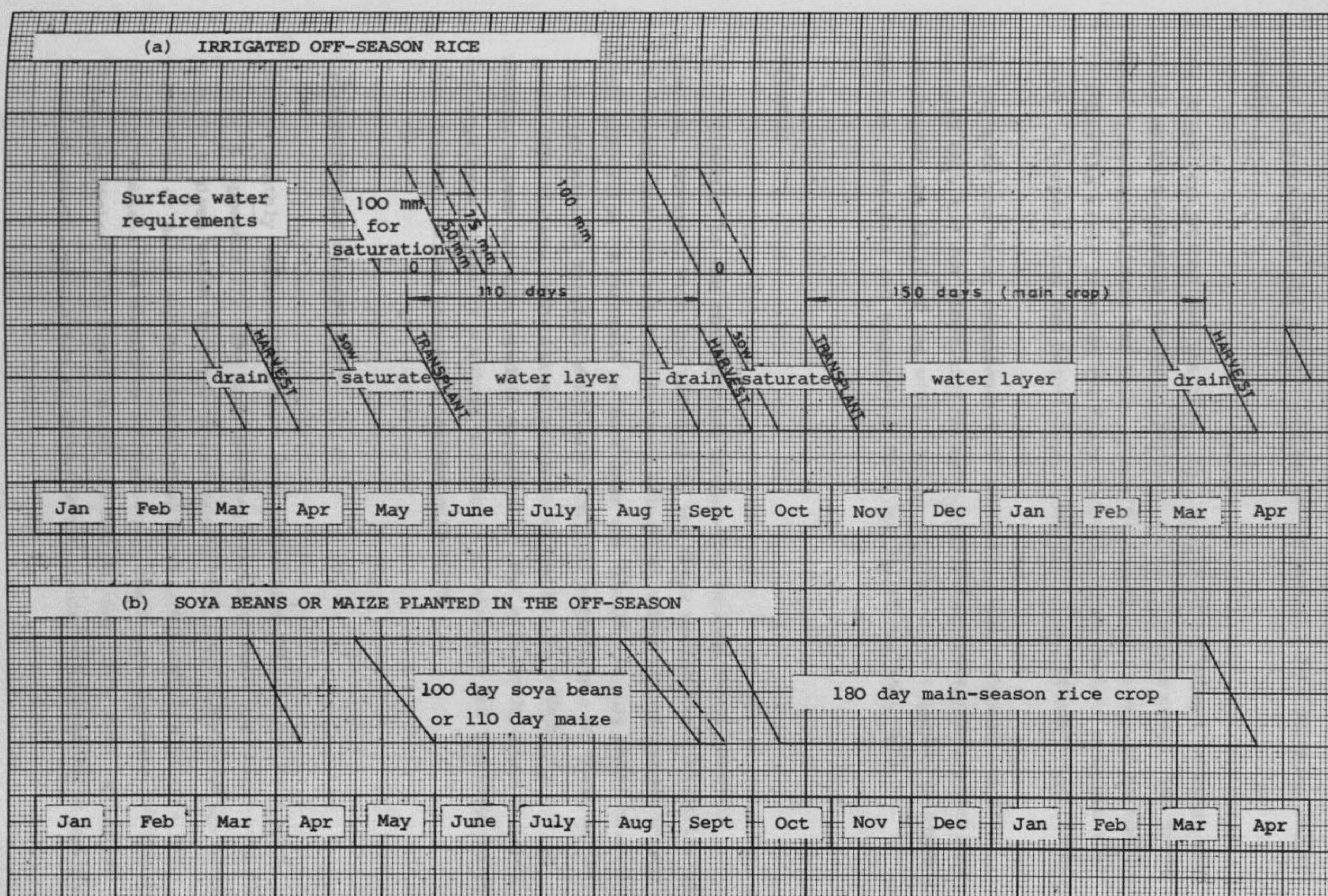

FIGURE 9 Crop calendars for double cropping with off-season rice (irrigated), soya beans or maize

the main season crop in March-April, or be delayed up to 1½ months. Off-season crops of soya beans and maize would be of 100 and 110 days duration respectively.

The first irrigations for the rice crop, should be sufficient to bring the field up to saturation following drainage of the previous crop. 100 mm of water have been allowed for this. Subsequent irrigations should be sufficient to raise the water level on the field (ideally 50 mm) and to maintain that level in compensation for percolation, evaporation and transpiration losses.

To estimate the water requirements of an area, a water balance has been carried out, and for simplicity it was assumed that transplanting would be staggered; one third of the total area in each of three consecutive ten-day periods. Rainfall and evaporation data for Paya Paloh were used.

Rainfall

The estimation of the contribution of rainfall to crop water needs is complex. However, with low rainfall in the drier months there is little chance for runoff and such rainfall is very effective, while in the wetter months a high proportion of rainfall is lost from the fields. In the water balance for rice, the minimum rainfall which might only be experienced 20 times in 100 years (80% minimum probability) has been assumed to be effective, and the monthly values are tabulated in Appendix 2. For off-season crops of maize and soya bean a greater moisture deficit is permissible and for those crops mean rainfall values have been assumed effective.

Evaporation and transpiration

Average monthly values of Penman's open water evaporation have been used (Table 3, Appendix 2). The crop coefficients to convert open-water evaporation in a given month to evapo-transpiration from rice crops grown in saturated conditions or maize and soya beans grown in well drained conditions, are given in Table 1 and should be multiplied by the Penman estimate for the month. These coefficients are based on FAO recommendations (FAO, 1975) and allow for stage of growth, proportion of ground cover, canopy characteristics and plant mechanisms for stomatal control of transpiration; they also account for root development and soil moisture available in the root zone.

TABLE 1 Crop coefficients (f) for various crop stages (length of stage in days in brackets) based on Penman's open water evaporation, Eo

Crop	Duration (days)	Crop stage			
		Initial	Development	Mid-season	Late
Rice	(110) (after transplanting)	1.10 (30)	1.10 (30)	1.25 (30)	0.95 (20)
Soya bean	(100)	0.30 (15)	0.50 (30)	0.75 (40)	0.35 (15)
Maize	(110)	0.30 (15)	0.55 (40)	0.80 (40)	0.40 (15)

Field saturation and initial irrigation

The amount of water required to saturate a rice field at the start of the cropping season depends on how much the soil has dried out since the previous crop. After harvesting the main season crop in April, rainfall is still abundant, and 100 mm might be adequate to replace soil deficits; rather more might be necessary after a non-irrigated off-season crop of maize or soya beans. Once the fields are saturated, transplanting of the rice can take place, and then additional water is required to establish a surface water layer. This has been assumed to be 50 mm during the first ten days after transplanting followed by two additional increments at ten-day periods, to achieve a total water depth of 100 mm. This is a very conservative figure, to allow for poor water control and land levelling. Ideally, a water depth of 50 mm would be adequate.

Field losses

Water in flooded rice fields can be lost by percolation, by seepage through bunds or by runoff. The amount of water lost will vary with soil type and in well puddled heavy textured soils, percolation may be negligible. In the absence of any permeability data and field water balance studies a nominal

TABLE 2 Water balance for three crops of rice planted at 10 day intervals in the off-season at Paya Paloh and estimates of irrigation requirements

Month	10-day period	Open water evaporation E_o (mm)	80% min probable rainfall P_{80} (mm)	Water needs (mm) resulting from staggered planting schedule															Av. Water need = net requirement = 1/3(1+2+3)		Gross diversion requirements (1/sec ha)	
				1					2					3								
				Saturation + water layer	fxE_o	Percol- ation	P_{80}	Water need (1)	Saturation + water layer	fxE_o	Percol- ation	P_{80}	Water need (2)	Saturation + water layer	fxE_o	Percol- ation	P_{80}	Water need (3)	mm	1/sec ha	65%* Efficiency	76.5 + Efficiency
April	III	43.9	27.2	100 +	44 +	20 −	27	137		—					—				45.7	0.53	0.81	0.69
May	I	41.9	46.5		42 +	20 −	46	16	100 +	42 +	20 −	46	116		—				44.0	0.51	0.78	0.67
	II	41.9	49.8		42 +	20 −	50	12		42 +	20 −	50	112	100 +	42 +	20 −	50	112	78.7	0.91	1.40	1.19
	III	41.9	16.0	50 +	46 +	20 −	16	100		42 +	20 −	16	46		42 +	20 −	16	46	64.0	0.74	1.14	0.97
June	I	39.4	19.0	25 +	43 +	20 −	19	69	50 +	43 +	20 −	19	94		39 +	20 −	19	40	67.7	0.78	1.20	1.02
	II	39.4	29.5	25 +	43 +	20 −	29	59	25 +	43 +	20 −	29	59	50 +	43 +	20 −	29	84	67.3	0.78	1.20	1.02
	III	39.4	32.5		43 +	20 −	32	31	25 +	43 +	20 −	32	56	25 +	43 +	20 −	32	56	47.7	0.55	0.85	0.72
July	I	42.0	18.5		46 +	20 −	18	48		46 +	20 −	18	48	25 +	46 +	20 −	18	73	56.3	0.65	1.00	0.85
	II	42.0	13.5		46 +	20 −	13	53		46 +	20 −	13	53		46 +	20 −	13	53	53.0	0.61	0.94	0.80
	III	42.0	19.8		52 +	20 −	20	52		46 +	20 −	20	46		46 +	20 −	20	46	48.0	0.56	0.86	0.73
Aug	I	41.8	21.3		52 +	20 −	21	51		52 +	20 −	21	51		46 +	20 −	21	45	49.0	0.57	0.88	0.74
	II	41.8	20.1		52 +	20 −	20	52		52 +	20 −	20	52		52 +	20 −	21	51	51.7	0.60	0.92	0.78
	III	41.8	41.9		40 +	0 −	42	<0		52 +	20 −	42	30		52 +	20 −	42	30	19.3	0.22	0.34	0.29
Sept	I	41.4	38.6		39 +	0 −	39	0		39 +	0 −	39	0		51 +	20 −	39	32	10.7	0.12	0.18	0.16
	II	41.4	37.1		—					39 +	0 −	37	2		39 +	0 −	37	2	1.3	0.02	0.03	0.04
	III	41.4	44.7		—					—					39 +	0 −	45	<0	0	0	0	0

* 85% conveyancy efficiency x 75% field application efficiency
+ 85% conveyancy efficiency x 90 % field application efficiency

field loss of 2 mm a day has been assumed. Some runoff can be expected during periods of heavy rainfall if a system of field to field irrigation is employed. This is a wasteful technique which can be minimised by rotational delivery for set periods every one or two days depending on the rate of water loss in the field. An allowance for water use efficiency has been made in determining gross irrigation requirements (below).

Water balance and net irrigation requirements

The irrigation season was divided into 10-day periods (numbered I to III within each month) and the water required for saturation or establishment of the water layer on the fields was listed for each period for each of three crops which were transplanted at intervals of 10 days (Table 2). Open water evaporation multiplied by the relevant crop coefficient (f) from Table 1 was listed next then the field loss from percolation. Figures in the three columns were added together and the available rainfall deducted from the sum to give the water need. The rainfall was assumed to be the 80% probability minimum rainfall in the case of rice and mean rainfall in the case of off-season crops. The result was the net irrigation requirement on the field for each crop. For off-season crops it was found that irrigation would not be required except during very occasional dry years, although adequate drainage would be required to avoid saturation of the root zone for long periods. The water balance for off-season rice is shown in Table 2, and Table 3 gives the water balance for soya beans and maize planted in the off-season.

Gross irrigation requirements

The net requirements were increased to allow for conveyance losses in the distribution system and for poor field application efficiency. Conveyancy was assumed to be 85% efficient and field efficiency either 65% which might be expected in the early years of a project, or 90% which is an achievable target. The combined efficiencies would be 65% and 76.5% respectively and net irrigation requirements have been adjusted accordingly.

TABLE 3 Water balance for soya beans (two planting dates) and maize grown in the off-season at Paya Paloh

Month	10-day period	Soya beans Planted early May				Soya beans Planted early June				Maize Planted early May			
		Open water evaporation Eo (mm)	Crop factor (f)	Crop water need f x Eo (mm)	Mean rainfall (mm)	Open water evaporation Eo (mm)	Crop factor (f)	Crop water need f x Eo (mm)	Mean rainfall (mm)	Open water evaporation Eo (mm)	Crop factor (f)	Crop water need f x Eo (mm)	Mean rainfall (mm)
May	I	42	0.3	12.6	83.3					42	0.3	12.6	83.3
	II	42	0.3/0.5	16.8	103.1					42	0.3/0.55	17.8	103.1
	III	42	0.5	21.0	56.1					42	0.55	23.1	56.1
June	I	39	0.5	19.5	54.6	39	0.3	11.7	54.6	39	0.55	21.4	54.6
	II	39	0.5/0.75	24.4	66.5	39	0.3/0.5	15.6	66.5	39	0.55	21.4	66.5
	III	39	0.75	29.2	67.8	39	0.5	19.5	67.8	39	0.55/0.80	26.3	67.8
July	I	42	0.75	31.5	53.1	42	0.5	21.0	53.1	42	0.80	33.6	53.1
	II	42	0.75	31.5	40.6	42	0.5/0.75	26.2	40.6	42	0.80	33.6	40.6
	III	42	0.75/0.35	23.1	82.6	42	0.75	31.5	82.6	42	0.80	33.6	82.6
Aug.	I	42	0.35	14.7	61.2	42	0.75	31.5	61.2	42	0.80/0.40	25.2	61.2
	II					42	0.75	31.5	49.8	42	0.40	16.8	49.8
	III					42	0.75/0.35	23.1	97.5				
Sept.	I					41	0.35	14.7	78.0				
	II												
	III												

Maximum irrigation demand and available run-of-river supplies

Maximum irrigation demand for rice occurs in the early stages when water is required for saturation of the fields and establishment of the water layer. For the crop calendar chosen for an off-season crop, this occurs in the middle of May when 1.4 l/sec ha are required. High rates of demand may also continue in June (1.2 l/sec in Table 2), and the maximum area that can be irrigated from a given source depends on the water available in May or June. (Tables 5 and 7 Appendix 2). For example the maximum area that might be developed using the Sungai Entingan (Table 7) would be $0.64 \times 10^3/1.4 =$ 456 ha in May or $0.44 \times 10^3/1.2 = 366$ ha in June. During mid-July to mid-September, the period of minimum river flows, the maximum irrigation demand is lower and is not a constraint on the maximum area that could be developed. Hence with the chosen cropping pattern, water is a critical constraint in June when a maximum of 366 ha could be developed. However, this would use the total fresh water available in the river, and abstraction would normally be less than this.

DRAINAGE REQUIREMENTS

The requirements of a rice field drainage system are:

i. The control of water depth during land preparation and the period immediately after transplanting

ii. The removal of excess rainwater and river floods which could demage the crops by flooding or erosion

iii. The removal of water from the fields before harvesting and the maintenance of the fields in as dry a condition as possible during the harvest

In general either requirement 1 or 3 will determine the necessary maximum field drainage rate (module). A wide range of critical waterlogging conditions are given in the literature, but for most lowland wet rice fields in the tropics the necessary rate of drainage lies in the range 30 to 60 mm/day (3.5 to 6.8 l/sec ha) (van de Goor, 1974). In Sumatra, requirement i is assumed to be critical, and drainage systems should ensure that during the first month after transplanting, the total water depth on the fields does not exceed 150 mm for 5 days or longer and that the maximum water depth during this period does not increase above the normal water level (assumed to be 50 mm) by more than 150 mm. On the Mekong Delta on the other hand, requirement iii is assumed to be critical and this is interpreted as the need to remove 3 day total rainfalls in no more than 5 days during the harvest period, and preferably in less time (3 days). Both criteria can be tested using local rainfall data to determine an acceptable field drainage rate. For the chosen cropping calendar (Figure 9), transplanting occurs in June and November and drainage in November is likely to be more difficult than in June. Drainage for harvesting occurs in March - April and August - September, and the former period is likely to be the more difficult. Therefore estimates have been made of maximum rainfalls expected during periods of one to five days for November and April - Figure 10. They are based on rainfall records at Samarahan Estate which are assumed to be applicable to both study areas.

The need for water control in November after transplanting is considered first. Assuming 75 mm of water already on the field, the maximum permissible rise in level is 75 mm (total water depth 150 mm). No allowance is made for seepage losses or surface runoff. Therefore the slope of line on Figure 10 drawn from the 75 mm rainfall mark tangential to the curves, gives the required drainage rate and the rate can be determined by transferring the sloping line to the origin. For a rainfall return period of once in twenty-five years this is 25 mm/day (2.9 l/sec ha). Maximum water on the field can be expected between 1½ and 2½ days from the start of the rainy period.

Considering drainage of the fields for harvesting in April, the criterion is removal of 3 days rainfall in no more than 5 days, and this is shown by the sloping line on the April graph. The slope of the line is 40 mm/day (4.6 l/sec ha). A less severe flooding condition than once in 25 years might be acceptable in which case a slightly lower drainage rate could be considered. It is clear that drainage capacity for harvesting should be greater than for water control after transplanting and it is suggested that field drains (tertiaries) be designed for 5.0 l/sec ha and primaries for about 40% lower values, say 3.0 l/sec ha, thereby allowing for some storage in the system.

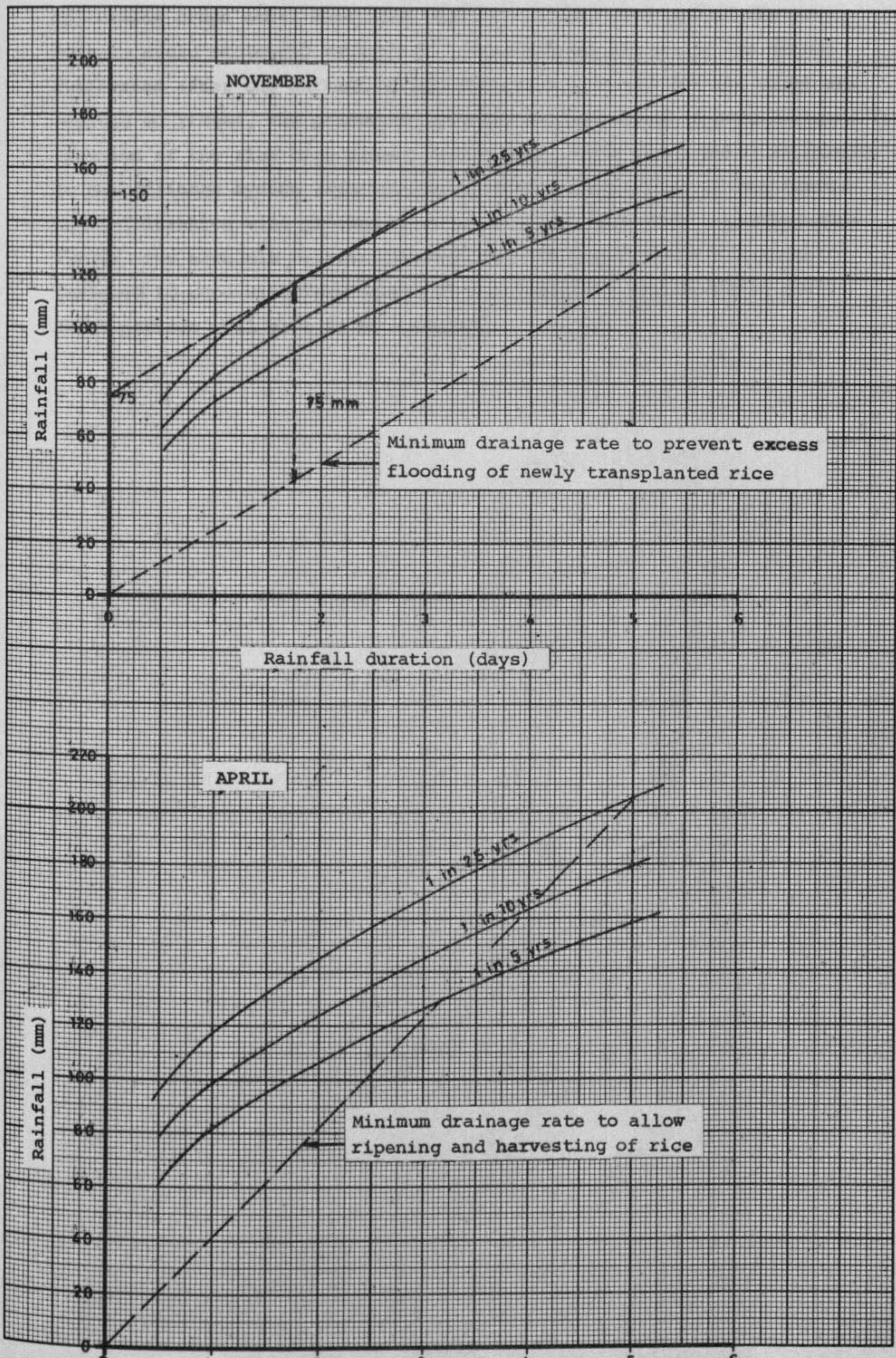

FIGURE 10 Expected maximum rainfalls during 1-5 days at Samarahan Estate during November and April

Off-season crops other than rice require adequate drainage of the root zone to avoid prolonged saturation. Provided (a) the soils are deeply cultivated after the harvest of the main rice crop and (b) the crops are planted on ridges, the permanent (primary and secondary) system designed for drainage of the rice crop should be adequate. Thus water which is surplus to the drainage system capacity can be stored temporarily in the furrows and infiltration will proceed at a greater rate than from a puddled rice field. For economic reasons drainage for off-season crops cannot be designed to cope with very severe floods and occasional flooding for short periods will have to be accepted.

APPENDIX 5 THE FARMING SYSTEM*

INTRODUCTION

Agriculture in the two study areas is undertaken entirely by smallholders who live in villages or longhouses with populations (1970) of from 12 to 1 290 people. There are no estates, development schemes or cooperative farms. A number of the communities also farm areas of hill land adjacent to the riverain land of the areas. In the Sadong-Krang area these include Kampongs Ampungan, Kuala, Munggu Kupi, Nyabah and Sebenkoi. In the Samarahan area, Kampongs Entingan, Mapar, Nangka, Pla'i and Pinang have such land.

Most of the land in the vicinity of the villages is available for cultivation by local farmers but not all of it. The land available is adequate for local needs in terms of production of rice and other crops. Estimated land availability is shown in Table 1 (interpreted from data provided by Soil Survey Division, Department of Agriculture).

TABLE 1 Land available in the study areas and adjacent hill areas (ha)

	Samarahan	Sadong-Krang
Land with soil suitable for rice production	11 635	7 025
Other cultivated land (excluding cultivable but unused land)	3 007	1 517
Total land available	14 642	8 542
Number of households	1 793	1 089
Land available per household	8.2	7.8

Much of the land which is available for cultivation is either seldom cultivated or lies under fallow. Furthermore within the study areas there are areas of primary forest which have never been cleared and which belong to the State. The most extensive of these are situated along the Sungai Empila and at Kampong Kuala.

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*The information in this appendix is based on published and unpublished material of the Departments of Agriculture and Statistics and on field work undertaken by the LRD/ODM mission. The latter included a number of interviews with farmers in the study areas. These took place with 27 Iban farmers in six villages, four Malay farmers in eight villages and one Chinese.

Crop production is dominated by the subsistence crop, wet rice, and the cash crops, coconuts and rubber: all other crops are of minor importance. Livestock play only a limited role. Poultry, goats and, in non-Muslim communities, pigs are kept in very small numbers for home consumption. A limited exception to this general picture is found in the area near Gedong where herds of cattle comprising up to 12 beasts each are maintained by grazing natural fodder. They are of the Kedah-Kelantan type with some degree of crossing to Red Sindhi. In total they may number 100-200 head.

LABOUR IN THE FARM HOUSEHOLD

In the 1976 LRD/ODM field survey, data on residents and migrants were obtained from interviews with heads of households. The results are summarised in Table 2.

TABLE 2 Residents and migrants from households in the study areas

	Samarahan	Sadong-Krang
Households in the sample	57	18
Full residents in the household	343	122
Seasonal migrants	18	6
Total resident population	361	128
Mean household size		
(fully resident members only)	6.0	6.7
(including seasonal migrants)	6.3	7.1
Semipermanent or permanent migrants	35	6
Mean number of migrants per household		
(permanent migrants only)	0.6	0.3
(including seasonal migrants)	0.9	0.6

The data suggest that households are larger in the Sadong-Krang than in the Samarahan. The reason for this may be that in the Sadong-Krang a substantial amount of land is readily available to both Iban and Malay communities. In addition young men can find employment locally in the sawmills of Gedong, so the level of outward migration, both seasonal and permanent, from both communities could be expected to be lower. Again, the attraction of Kuching would be relatively less than in the Samarahan area.

The difference in household size on an ethnic basis was not significant in the sample (see Table 3).

TABLE 3 Residents and migrants in sampled households in the study areas according to ethnic group

	Iban	Malay
Households in sample	27	47
Full residents in household	168	297
Seasonal migrants	7	17
Total resident population	175	314
Mean household size		
(fully resident members only)	6.2	6.3
(including seasonal migrants)	6.5	6.7
Semipermanent and permanent migrants	19	22
Mean number of migrants per household		
(permanent migrants only)	0.7	0.5
(including seasonal migrants)	1.0	0.8

The relationship between migration, household size and land available per household is discussed further in Appendix 7.

The household size and pattern of migration is important for estimating the numbers of people who would be available as labour if development were to increase the amount of land cultivated in the study areas. Development strategies must therefore take account of seasonal migration or the availability of other employment opportunities in the locality. While migration seems to be generally low for both the study areas it can be of greater importance in certain villages e.g. Baru, Empila, and Rembus.

On the other hand the indications of the field survey are that migration from the study areas might be checked as development provided alternative employment opportunities on the land for the potential migrants. The potential growth of population in the proposed schemes has to be considered before the introduction of new settlers is contemplated.

Seasonal and permanent migration is rational in the context of the present farming system, which requires abundant land. Labour shortages at certain times in the agricultural cycle can be overcome in a number of ways. First, seasonal migrants return for planting and harvest. Second, extra labour can be obtained on an exchange basis (*gotong royong* for Malays, *bedurok* for Ibans) or by hire. This latter method is usually on the basis of a contract in which it is agreed that a certain amount of land (usually 0.25 ha) will be cultivated for an agreed sum (in cash). Both the contract and the area of land is known as *pajak*.

RICE

Rice is fundamentally a subsistence crop and is usually only sold in times necessity or when yields are unusually good. Most of such sales take plac within the local community. There are a few exceptions to this rule, for example, some households in Kampongs Melayu and Niup in the Samarahan area and in Kampong Gumpeh and Rumah Tanjong Paoh in the Sadong-Krang area regar rice as a cash crop.

Wet rice areas per household

In the 1974/5 Padi Production Survey (PPS) heads of households were asked t estimate the area they had planted with wet rice: the area was then measure by the PPS staff. The results are shown in Table 4.

TABLE 4 Wet rice areas (ha) by household, 1974/5 Padi Production Survey (Source: Department of Statistics)

District	Mean of farmer estimates	Measurements		No. of households surveyed
		Range	Mean	
Kuching	0.58	0.07 - 1.51	0.40	56
Serian	0.42	0.11 - 1.61	0.36	40
Lower Sadong	0.68	0.10 - 1.08	0.46	18

It will be noted that the tendency was to overestimate the area planted; the difference between the mean of the estimated area and that of the measured area was statistically significant in Kuching ($p = 0.01$) and Lower Sadong ($p = 0.05$) but not in Serian. The measured mean area per household varied between the three districts in which the study areas lie from 0.36 ha to 0.46 ha, with an overall range of 0.07 - 1.61 ha. The 1976 survey, using recall data, indicated that in 1975/6 the range of area cultivated went up to 4.86 ha in the Samarahan area and 3.24 ha in the Sadong-Krang with the mean areas for the two being 0.85 ha and 1.13 ha respectively.

The principal wet rice experiment station of the Department of Agriculture is sited at Paya Paloh in the Samarahan study area. This station, which bears soils typical of the area, has shown that, with irrigation (pumped), it is feasible to grow two crops of rice per year. This practice however is not followed by any members of the farming community by whom rice is grown as a rainfed crop in the *landas*. The practice of alternating growing a crop of rice with periods of fallow is widespread throughout both study areas; the period of fallow varies from 1 to 4 or 5 years. Annual cropping is undertaken by only a minority of farmers and even they may include periodic fallow breaks in their programme. Planters believe that with the methods of production they use it is not possible to grow a crop of rice annually on the same piece of land and maintain satisfactory yields. The Department of Agriculture has attempted, through, its Assistance to Padi Planters Scheme (APPS) to demonstrate how annual cropping can be achieved. Such schemes have been established in many of the villages in the two study areas e.g. Kampongs Gumpeh, Kuala Ilir and Nyabah in the Sadong-Krang and Kampongs Empila, Entingan, Pinang and Pla-i in the Samarahan. All these schemes have shown that rice planters are prepared to work together to build the principal structures required to achieve good water control. The rather limited success of the APPS, indicated by the reversion of the areas in most cases to traditional methods of usage on the conclusion of the scheme, is probably attributable principally to the only partial success gained in water control and the fact that the labour requirements for land levelling and cultivation are beyond the capabilities of the participants.

Land cultivation

An earlier scheme to introduce buffaloes as draught animals to plough the ricefields was not successful and, apart from a small area prepared with chemicals, land cultivation is undertaken by hand. (Elsewhere in First Division - at Kampong Pueh and Tanjong Purun - the Department of Agriculture has successfully introduced the use of pedestrian tractors. These rotovate the ricefields which have been previously destumped and levelled, at a rate of 1 ha per 20 hours). In the Sadong-Krang area land preparation begins in July/August; in the Samarahan about a month later. The fallow growth is slashed and, after drying, burned. The land is then cultivated by hand to a depth of 5-7 cm with a machete (*parang bengkok*) or a form of hoe (*peto, tajak, changkol*). Simultaneously with the slashing of the fallow, the seed is sown in a dry nursery either within the rice area or on adjacent hill soils. Seedlings may be transplanted once before being planted in the field usually when over 4 weeks old - that is, after the optimum stage. The limited effectiveness of land preparation results in weed growth often being abundant. Most of the major weed species can be controlled with the chemica 2, 4-D, MCPA or butachlor but in practice weeding is achieved by hand.

Cultivars (varieties)

The rice cultivars grown in the study areas may be divided into three main groups.

1. Traditional, unimproved
2. Traditional, selected
3. Short term, high yielding

The cultivars of Group 1 are tall and normally take 6-7 months from sowing to harvest. They are well suited to present methods of cultivation but are probably not capable of yielding more than 3 000 kg/ha even in optimum conditions. The group includes such cultivars as Biansu, Bukit, Empawah, Jambi, Jijak and Puteh. Over the last 20 years the Department of Agriculture has collected, described and tested a wide range of these and similar cultivar and, on the basis of this work, recommended four for general adoption - Acheh 62, Baru 3, Lasak and Serendah Kuning. The first three mature in about 180 days, Serendah Kuning in about 165. A fifth cultivar, Kara 1, which matures in about 145 days, is recommended for areas which may suffer from periodic brackish water flooding. All five have a yield potential of 3 000-4 000 kg/ha. The third group are selected from cultivars bred either in Peninsular Malaysia or at the International Rice Research Institute (IRRI) for their high yield. However they require optimum growing conditions if they are to achieve their potential, otherwise they may yield no more (or even less than the traditional cultivars. The cultivars of this group recommended for use in Sarawak are Bahagia, Mahsuri line 17 and Sri Sarawak. They come to harvest in 120-140 days, respond to fertiliser and are said to have a yield potential of 4 500 kg/ha. In 1975/6 the Padi Production Survey (PPS) in Kuching district recorded 10 out of 25 respondents planting at least part of their area with one of the selected traditional cultivars and four using the high yielding short term cultivars.

Fertilisers

In the PPS of 1975/6 undertaken in Kuching and Lower Sadong districts, only five out of 53 farmers were recorded as using fertilisers. In 1974/5 in the Serian district the figure was three out of 18. The use of fertilisers is largely confined to areas under the APPS and, in as much as it is these areas which are annually cultivated, this is probably appropriate. In other areas, where land has been freshly cleared from fallow and traditional cultivars sown, it can be expected that there would be little or no response to fertilisers. Indeed in some instances, the application of nitrogen could have a deleterious effect through increased disease or lodging. In the second or third year of annual cropping, response to fertiliser could be expected. Experiments undertaken under a wide range of conditions by the Department of Agriculture have shown that application rates for basal (preplanting) application should be 22 kg/ha of nitrogen (= 50 kg/ha urea) and 13 kg/ha of phosphorus (= 90 kg/ha of Christmas Island Rock Phosphate, CIRP). A further application of nitrogen after 2-3 weeks may be beneficial for plants showing signs of nitrogen deficiency (Dunsmore, 1968). High yielding cultivars would probably respond to rates of N application up to 60-80 kg/ha but detailed experimental evidence for this is not yet available.

Pests and diseases

A range of insect pests has been recorded on wet rice including stemborers, sucking bugs, leaf-eating caterpillars and mole crickets. Of these, stemborers and black padi bugs were most commonly mentioned by planters. Quantitative data on crop losses is not available but they are not likely to be serious under the present methods of production. Loss due to attack by rats and birds on the other hand could be severe locally where small areas of rice are surrounded by areas of fallow. Under the more intensive system of rice production with high yielding cultivars employed at Paya Paloh Experiment Station, the neck rot form of the disease blast (*Pyricularia oryzae*) and sheath blight (*Corticium oryzae*) have become common. On farmers fields, diseases are not yet recognised as a serious factor although, where standards of cultivation are poor in the nursery, brown spot *(Cochliobolus miyabeanus)* is common. Blast, in the leafspotting stage, is also found.

Yields

Data on rice yields obtained specifically in the two study areas are not available but the PPS has obtained estimates of mean yields by districts since 1968 on the basis of crop cutting tests. These may be taken as a fair estimate of yields obtained in the two study areas. The results of the PPS in the three districts of the study areas are therefore given in Table 5 for the years 1968-75. These data apply to district means: yields from individual farms will have a much greater range. On the Sadong in 1976, for instance, floods completely destroyed some fields and they common cause yields to fall to 540-600 kg/ha in the more vulnerable areas. Furthe more the plots of the PPS would have been carefully harvested, threshed and winnowed. On larger areas harvesting losses could be expected to be 5-15%. The crop actually garnered by the farmer might therefore be some 10% less than the PPS estimate.

TABLE 5 Mean yields (in kg/ha of clean, dry padi) of wet rice by district, 1968-75 (Source: Department of Statistics, 1976)

Year	National mean	Kuching	Serian	Lower Sadong
1967/8	2 042	2 719	1 817	2 823
1968/9	2 196	2 372	2 151	2 870
1969/70	2 201	2 985	2 493	2 605
1970/1	2 039	2 429	2 176	2 551
1971/2	2 079	2 330	2 268	2 365
1972/3	1 714	2 209	1 905	856
1973/4	2 199	3 009	2 215	3 167
1974/5	n.a.	2 629	1 971	n.a.

n.a.: not available

The range of mean yields and overall means for the 7 years 1968-74 are shown in Table 6.

TABLE 6 Range of mean yields and overall means (in kg/ha of clean, dry padi) by district 1968-74

District	Range		Overall mean
	Minimum	Maximum	
Kuching	2 209	3 009	2 579
Serian	1 817	2 493	2 147
Lower Sadong	856	3 167	2 463
National	1 714	2 201	2 067

MINOR ANNUAL CROPS

Annual crops other than rice are grown only on a very limited scale. The expansion of the cultivation of maize, soya bean and groundnuts as off-season crops in rice areas is encouraged by the Department of Agriculture under the Agricultural Diversification Scheme both as a means of raising annual returns per unit area and as a help in improving the standards of rice cultivation, but so far the practice has been adopted only on a very limited scale in the two study areas.

Legumes

A number of leguminous food crops is planted on a small scale in the off-season. Of these, soya beans have the most potential. Their limited adoption so far may be attributed to the lack of an established seed supply and market and the unfamiliarity of farming families with the methods of cooking the beans. However, good stands of the crop were seen at the Mid-Sadong Scheme (MSS) where conditions are similar to those in the study areas. Agricultural staff report yields of 1 500 kg/ha of shelled beans. In 1969 four farms in the Nonok Peninsula were recorded as having an average yield of 1 156 kg/ha (Best and Wong, 1973). On the clay soils of the study area the crop would be susceptible to any extended dry periods unless standards of management were satisfactory; the drying out of the soil could seriously reduce yields. In 1973 conditions reduced the yield at Paya Paloh Experiment Station to 685 kg/ha. The crop is also subject to pests (leaf-folders, hoppers and beanfly) and fungal disease attack: means of controlling these are known. Experiments have so far failed to identify any cultivar superior to the locally used Nonok. This takes 100 - 110 days to maturity and has a yield potential up to 1 700 kg/ha under the conditions of the study areas.

A few small plots of groundnuts were noted in the Samarahan area: the vegetative growth was good. On the basis of a "very small number of observations" Best and Wong (1973) quote yields of only 600 kg/ha of undecorticated nuts. In contrast, experiments undertaken in First Division on recent alluvial and gley soils by the Research Branch of the Department of Agriculture recorded yields of 1 700 - 2 000 kg/ha. One could expect that farmers growing the cultivar China (110 days) on unfertilised land would obtain a yield in the region of 1 000 kg/ha of unshelled nuts. Pests do not appear to be a problem. Leafspotting disease (*Cercospora* spp.) is common but the economics of fungicidal spraying have yet to be established. On the heavier clay soils, pegging (that is the descent of the rootlike growth from the flower into the soil which precedes the development of the pod) could be affected if the soils capped in dry weather; this would reduce yields. The crop would also be difficult to lift from dry, heavy soils.

Other legumes are grown only on a very small scale (a few square metres) and are used in the household. The commonest of these is the long bean - a subspecies of cowpea (*Vigna unguiculata*). In cultivar trials on other species of cowpea the Department of Agriculture has recorded yields of 4 500 kg/ha of fresh pods and 1 100 kg/ha of dry seed. Other beans noted included green gram (*Phaseolus aureus*), the red bean (*P. calcaratus*) and the winged bean (*Psophocarpus tetragonolobus*). The market for these species would be only limited but they could be important components of the household diet.

Maize

In the study areas maize is grown in the off-season following the rice crop. It is the only such crop grown to any extent at the present time. When the land has been carefully prepared the growth and yield are good. Best and Wong (1973) state that yields of well over 1 500 kg/ha of dried seed have been recorded from various sites in Sarawak. Agricultural staff at the Mid-Sadong Scheme report that yields of 1 800-2 000 kg/ha are achieved by farmers on the scheme. This would include production from local unselected cultivars. The recommended cultivar, Metro, which has a maturation period of 110-120 days, is capable of producing yields in excess of 2 500 kg/ha. In contrast, maize growing on unconsolidated, ill-drained peat was producing no crop at all. Definite recommendations on fertiliser requirements cannot yet be made. Farmers currently use little or none. The Department of Agriculture has made a tentative recommendation to apply 65 kg/ha of nitrogen, 40 kg/ha of phosphorus and 35 kg/ha of potassium but the effect of this on yields has not been quantified. Pests and diseases are not serious under the present system of production.

PERENNIAL CROPS

Coconuts

In the Samarahan area, coconuts of the tall variety are grown as a cash crop in most villages, particularly those lying downriver of Kampong Melayu. A high proportion of these palms has been planted since 1959 under the Department of Agriculture's Coconut Planting Scheme (CPS). The standard of maintenance is variable. On the heavy soils found in this area, adequate drainage is essential if good yields are to be achieved. While main drains have usually been dug, subsidiary drains, which in most gardens will be needed between alternate rows (i.e. 20 m apart) have not been put in. As a consequence, most mature gardens will be yielding annually less than the 700 kg/ha (= 2 700 nuts/ha) which Ngui (1974) records as the average yield found by a Federal Agricultural Marketing Authority (FAMA) survey of First and Second Divisions. Again, although farmers received an annual subsidy under the CPS for ringweeding their immature coconuts, this is said to have been inadequately carried out in many cases and thus, for this reason also, the time to maturity would have been delayed. When palms have been well maintained, though, good yields can be obtained: one 11 year old garden near Kampong Baru was said to be yielding 2 650 kg/ha of copra. Improvement to the drainage could increase yields in many gardens where the palms are still relatively young (10-15 years) although the response in terms of enlarged harvests would not be obtained for 12-18 months (allowing for improvements to the growth of the palm and the subsequent maturing of the fruit bunches). The crop may be sold either as nuts or as copra (3 640-4 130 nuts are required to make 1 ton of copra).

Squirrel damage is common in the area of Kampongs Baru and Mapar. Apart from this, the crop appeared largely free from pests and diseases.

Intercropping of immature palms with annual crops, bananas or pineapples and mature palms with cacao and coffee, which would increase returns per unit area without adversely affecting coconut yields, is very seldom practised.

In the Sadong-Krang area, apart from coconuts grown in the compound for home use, the crop is largely found between Kampong Gumpeh and Gedong. Most were planted in the 1960s under CPS and growth and yields are almost universally poor. The area upriver from Gedong was declared unsuitable for coconuts by the Department of Agriculture in 1974 and the CPS was withdrawn. Little interest is paid to the palms by the farmers and in Kampong Gumpeh some have been felled and the land planted to rice: other farmers have sown wet rice between the rows of palms. There seems to be little interest in rehabilitating the palms even if this were deemed to be possible.

Rubber

Rubber is found in most of the villages in the two study areas. Holdings established under the Rubber Planting Scheme (RPS) though are confined to the hill areas; the trees in the study areas themselves consist of material established from unselected seedlings: many are over 20 years old, none is immature. On naturally better drained areas where the trees have been given adequate spacing the vegetative growth has been good and potential yields may be in the region of 350 kg/ha. At the other extreme, trees closely planted on poorly drained soils have a poor girth and may not be capable of yielding over 200 kg/ha. The actual yields obtained vary with the intensity of tapping. When the price was low in the early 1970s very little tapping was undertaken and little is done even today at Kampong Rembus. Elsewhere, though, most areas are being tapped now that the farmer price is in the region of $1.30-1.43/kg for the low grade sheet produced. A Rubber Research Institute (RRI)/ Department of Agriculture rubber processing unit has been established at Kampong Pinang. This has shown that the supply of simple facilities will enable the farmer to produce better quality sheet. In September 1976 the price paid for this better quality unsmoked sheet was $1.54/kg compared with $1.30 for the average sheet produced by traditional methods.

Rubber has the attraction for the smallholder that it is relatively free from pests and diseases, does not deteriorate seriously if neglected for periods of time, and can be exploited at need.

MINOR PERENNIAL CROPS

Banana and plantains

Small areas of bananas and plantains are found in most villages, but standards of maintenance are casual and the intensity of fruiting is limited. In Serian there is a limited market for the fruit particularly the plantain Pisang Tandok and for Pisang Kling. Elsewhere the fruit is largely consumed in the home. Common cultivars are Pisang Pisang, Rajah, Embun, Rojak, Mas and Masak Hijau. The Wageningen report (1971) quotes an average annual yield in First Division of 11 t/ha but yields in the study areas would be substantially below this.

Cacao

Seedlings of hybrid cacao (Upper Amazon and Upper Amazon/Amelonado), derived from material received from Sabah, have been planted under the shade of mature coconuts on a very limited scale. A stand of 494/ha planted in paired rows between the rows of coconuts, which are planted on the square 10 m by 10 m, is recommended. Tall coconuts usually offer sufficient shade for establishing cacao when they are 8-10 years old. None of the cacao is yet in bearing but experience on similar soils in the Nonok Peninsula has shown that the crop will yield well if standards of maintenance are adequate.

Citrus

A few trees of different citrus species, particularly pomelo, mandarin and limes, are commonly found in compounds. Near Gedong several small gardens have been established, largely to mandarin, under the Agricultural Diversification Scheme. Maintenance has been good and vegetative growth and fruiting on the gley soils has been satisfactory. Yields in one garden were reported to be 3 500-4 000 kg/ha in 1975/6: the fruit was sold at $1.10-1.54/kg.

Coffee

Small areas of Robusta coffee have been established in both study areas usually under the shade of coconuts. The produce is largely used in the home. Where the drainage has been adequate, vegetative growth and fruiting have been satisfactory, and the annual yields will be similar to the Wageningen estimate of 550 kg/ha. Yields could be further improved if the bushes were pruned and fertilised.

Fruit trees

In addition to citrus a number of other species of fruit trees are grown for home consumption. These include durian, jackfruit guava, rambutan, starfruit and soursop. Under the Agricultural Diversification Scheme farmers are able to get up to 30 points of good quality rambutan, durian and citrus together with fertiliser to a total value of $250. A number of people have taken advantage of this in the last 5 years.

Pepper

A very limited number of pepper gardens, usually with less than 250 vines, is found in the Samarahan area, none of the vines seen was of good shape nor growing vigorously. This was attributed by the farmers to the lack of fertiliser but a contributory cause in most cases was inadequate drainage and, in some cases, poor pruning. On adjacent hill areas, vines were generally growing better and it was apparent from the quantity of corns being sun-dried that the crop is of increasing importance to the Native farmer.

Pineapples

Pineapples in this region are largely confined to the deep peat areas near the Muara Tuang road although some small plots are found on the mineral soils. No fruit induction methods are used; in consequence the harvest appears to be largely confined to a period of a month or so round August when fruit were sold (1976) for 10-30 c each.

Root crops

Tapioca, an important food crop in the hill rice areas, is little grown in the riverain areas. In parts of Sadong-Krang it has become feral. *Colocasia* spp. *(ubi keladi betawi, penimang* and *China)* is grown on a very limited scale.

Sago

Sago is found in scattered stands particularly in the more poorly drained areas. In general it seems to be little used, although in parts of the Sadong, when rice yields are low, it was reported to be an important supplement. In the Samarahan area it is sometimes processed for sale as an animal feeding stuff. The Wageningen report (1971) quotes yields in the First Division as being in the region of 2 750 kg/ha of dry (14%) flour of moderate to bad quality.

Sugar cane

Sugar cane is grown as a compound crop. There is a small market for the stems at 10-30 c each.

APPENDIX 6 LAND TENURE: CUSTOMARY RIGHTS AND THE LAND CODE

INTRODUCTION

The regulation of land rights must take account of a particular farming system. This has been analysed in Appendix 5. The most important factor determining the farming system in Sarawak in the past was the abundance of scarcely populated land covered with virgin forest. Ibans, Land Dayaks and Malays were able to work the land in such an extensive manner that long periods of fallow were allowed for the recuperation of soil fertility. Similar farming systems are found on the more populated riverain areas of the two study areas although, on these alluvial soils, the period of fallow is shorter.

Within this overall system there is variation in land rights. Such rights comply with norms established according to kinship, religion and relations of wealth and power within the community and consequently differ between localities and ethnic communities. The requirements of national administration have to some extent put limits on the possible variations of customary rights even though no attempt has been made to codify these rights. Richards (1961) outlined some of the principles of customary land rights common to all the ethnic communities. In 1962 a Land Committee was set up to report on the situation. And in 1963 the Land Code was passed with the aim of providing a basis for the rational administration of land rights, including customary rights.

CUSTOMARY RIGHTS RELATING TO LAND TENURE

Customary land rights are not, in fact, integrated systematically into the Land Code. The interpretation of such rights therefore relies heavily in practice on the *penghulu* (a government appointee) or the *tua kampong* or *tuai rumah* (the spokesman recognised by the villagers themselves). The general principles of customary land rights are described below:

1. The establishment of rights

In all three ethnic communities (Malay, Iban and Land Dayak) the person who fells virgin forest establishes rights over the land. According to the law of the State, however, no rights could be established in this way after 1 January 1958.

2. The right of accession

Here the particular social organisation of the different communities is of importance. In general, kinship provides a medium through which rights over land can be transferred and claimed.

i. Among Land Dayaks, rights pass to all descendants of the original feller of forest. This group of people is known as the *turun* though it exists only for the purpose of transferring rights and plays no further part in community life. A person may be a member of more than one *turun* and so has claims to many pieces of land. Membership of the *turun* is no guarantee that this person will actually have a chance to work the land, especially where there is a land shortage (Geddes, 1954b).

ii. Among the Iban, rights are inherited within the immediate household known as the *bilek*. "Whoever stands by the *bilek* inherits the property". Thus, on marriage, a person has to decide whether to continue to live in the *bilek*, to transfer to that of the spouse, or to establish a new one (Freeman, 1970).

iii. Studies of Malay land tenure have so far been restricted to Peninsular Malaysia which does not provide an adequate comparison. It seems that in the First Division of Sarawak, Islamic law is superimposed on Land Dayak social structure; rights pass to the descendants of the original feller of forest, women obtaining an equal share with men in accordance with the rule of *hukum pereh* where equal work is so rewarded. The land tends to be divided into smaller plots than among other ethnic groups in accordance with Muslim practice (Harrisson, 1970).

3. The regulation of rights among the claimants

i. Among the Land Dayaks, Geddes (1954a) specifies two rules; that of superiority of the eldest and that of least use. Hence rights to land are rotated through the *turun* in a way which takes account of individual life cycles within the community. Rights to land do not deteriorate with time but become stronger. These are simple and effective rules for a small community organised on the basis of kinship but they do not specify how land disputes between villages can be resolved: this is not a problem provided there is a surplus of land.

ii. Among the Iban, rights to land are lost if a member of the *bilek* moves away permanently, while those who stay with the *bilek* work the land and stand to inherit equally. Assuming an abundance of virgin forest there is no need to regulate the claims of different individuals (Freeman, 1970).

iii. Among Malays, where landholdings tend to fragment on inheritance, the effect of this may be offset in a number of ways. For example, one person in the family might buy the shares of the others who then have to move away, or the land is worked collectively even though each small plot is owned by a single nuclear family (Harrisson, 1970).

4. The rights of the community

Customary land rights define a relationship between an individual and the immediate community in respect of land. Possession of the land is granted to individuals as social beings. Thus while the individual and his household might use the land there is social control over the disposal of land. The fluctuation of the respective rights of the individual and the community are specified in terms of vegetation type: *jerami* (weed growth just after the harvest) when the individual's rights are still strong, *temuda* (old fallow) when the individual's rights are declining, *damun* (secondary forest) when the community has stronger rights. In other words customary rights do not specify absolute ownership but are concerned with a 'bundle' of claims by differ individuals within the community related by kinship (Richards, 1961). Thus there are strong community pressures on those with surplus land to allow those farmers with little to 'borrow' land. The return payment (*tungkus asi* among the Iban) is a symbolic assertion of the owner's right to the land, not a rental nor a contract of sale. Indeed there was no provision for the disposal or alienation of land rights to those outside the kinship group.

It is clear from this brief description of the different 'customs' that Iban and Land Dayak (and, to some extent, Malay) systems of land tenure assume abundant land, large tracts of virgin forest, into which it is possible to expand. The ecology of Sarawak provides a framework in which Ibans were able to take ready advantage; the community would constantly split so that further areas could be exploited.

The customary rules set out above do not meet basic problems important for sedentary agriculture in riverain areas where population growth eventually puts pressure on available land resources. Here it is important to look at the ways in which 'custom' changes. The rules have to adapt to changes in the farming system. One important factor here is the control which the national administration now exercises in the felling of virgin forest. Other factors are population pressure on the land, the decline of soil fertility, and the introduction of cash crops (Leach, 1957).

The introduction of cash crops into a subsistence economy has a profound impact. Land tenure rules accordingly change. While rights over land were established by the original feller of forest and could be inherited by certain members of his kinship group there had been no provision in customary laws for the alienation of those rights to outsiders. The cash economy, however, tends to transform land itself into a market commodity to be rented or sold.

Richards (1961) points out how the structure of society changes as a consequence of this market-oriented view of the value of land: 'The more successful individuals in any society will make use of economic and status power to increase themselves in relation to others.' This is achieved as customary rules of land tenure are redefined within the village by those with 'economic and status power'. Hence customary law recognises an individual's absolute claim of ownership of land planted with perennial cash crops such as coconuts, rubber and pepper. Such claims can be recognised in statute law by the process of adjudication and by the granting of title to land which is considered to be 'alienated' i.e. individually owned and capable of being bought and sold without being subject to other claims within the community.

The system of customary land tenure does not automatically disappear as the pattern of land use changes to accommodate cash crops. First of all, by recognising customary land tenure, the Land Code has checked its erosion as a legal system. Secondly, and perhaps more importantly, the rules of customary land tenure are relevant to the present Government policy of increasing rice production. In this respect it is necessary to understand the way in which customary land tenure rules adapt to changing patterns of land use as a result of the introduction of cash crops. It must be reiterated here that customary land tenure rules exist within a social structure in which kinship and religion play fundamental parts. Thus 'the Iban farmer does not "own" land: it continues to belong to the spirit, that is, Pulang Gana. Through the correct ritual procedure the Iban leases the use of it and acquires rights to the harvest' (Jensen, 1974 p.80). Religion and kinship provide an ideological framework of land tenure claims; changing patterns of land use are explained and modified in this context.

LAND USE

The development of roads in the study areas has reinforced the trend to cash crops. As a result land is used to accommodate a mixture of cash and subsistence crops. Communities make use of the topographical features and soil types in the immediate vicinity of the village. The ideal land use for a village would involve the planting of wet padi in the wetter alluvial areas (*payas*), coconuts on the lighter soils near natural drains, rubber on higher ground, and pepper on hillsides. Not every village in fact has this mixture of land types and, in the study areas, rubber and coconuts are frequently planted on soils more suitable for wet padi.

In the context of smallholder agriculture lacking the technology to transform the geography of the area in accordance with village economic requirements, the resulting pattern of land use is rational. The various subsidy schemes of the Department of Agriculture are designed to support smallholder agriculture and, in consequence, they reinforce the prevailing pattern of land use.

The land use pattern is rational from the point of view of individual farmers in the village and it forms the basis of customary land rights. From the point of view of the administrators of a development scheme involving large engineering structures, however, the prevailing land use pattern is unsuitable. To change this pattern of land use the administration must take action in the sphere of land tenure law which is the legal support to the prevailing land use. In this situation it is important to analyse the relation between customary and statute laws of land tenure to see how the Government aims to overcome the problems posed by the prevailing land use in order to promote development while at the same time to protect the smallholder.

THE LAND CODE

The Land Code (1963) brought together a number of existing (and often disparate) laws. These laws had been formulated for the purpose of regulating land dealings in a multi-ethnic society, a major objective being to protect Native smallholders. Fundamental in this respect was the definition in the Land Classification Ordinance (1948) of five categories of land:

1. Interior Area Land
2. Native Area Land
3. Mixed Zone Land
4. Native Customary Land
5. State Reserve Land

Only Natives can hold land in categories 1, 2 and 4. In areas defined as Mixed Zone Land, non-Natives can acquire land. This Ordinance was primarily concerned with 'alienated' lands (categories 2 and 3) where land dealings between individuals are facilitated by the issue of legal title to land. At the same time the Ordinance protected the rights of Natives from the incursion of non-Natives while it was possible that sufficient land could be granted to non-Natives for their agricultural requirements.

This system of land classification is maintained by the Land Code. There are however a number of problems with regard to the operation of the Land Code which have been discussed by Porter (1967). Two problems can be outlined here. First, who is defined as a Native? Second, how does this system regulate development schemes in areas of mainly Native Customary Land?

The lack of definition of Native in 1948 was rectified in an Interpretation Ordinance 1953. Many of the peoples of Sarawak had migrated from the surrounding areas of Borneo and Peninsular Malaysia and the term 'Native' was defined accordingly to include these groups. The Land Code goes further to consider the position of the individual. Thus a non-Native who is identified with a 'Native system of personal law' can be treated, for the purposes of the law, as a Native. It is not clear, however, what 'Native system of personal law' actually means. This lack of clarity arises because customary law is nowhere defined, which is the second problem mentioned above.

The objective of the Sarawak Land Code is to arrive at a rational system of land administration. Customary tenure is, however, only in a fragmentary fashion integrated into the Land Code. Section 4 specifies that no further customary rights can be established. Section 8 specifies that only Natives can obtain rights in land classified as Native Customary Land. The classification of lands is designed to regulate the transfer of lands between different ethnic communities but such rules make no provision for the regulation of transfers within communities.

Customary rights are therefore legally recognised but are nowhere defined. The difficulties of such definition and codification should not be underestimated. What in fact has happened is that customary laws are primarily applied in the villages by the people involved, with the arbitration of local leaders, *tua kampong* or *penghulu*. This is perfectly reasonable while land matters are a concern only for the people of the village, but Geddes (1954a) pointed out that customary laws do not specify the rights in cases where villages themselves are in dispute. In such cases disputes are heard by the District Officer who seeks the advice of the *penghulus*.

In similar fashion, customary land rights do not regulate land tenure within large scale development schemes involving different villages and different ethnic communities. In these cases where the State has to intervene in land dealings to effect its development policy, the Land Code specifies certain procedures by which the land tenure situation in an area is 'settled'. Settlement is based on the Torrens system, 'the registration of demarcated parcels of land as units of property with reference to which the private owners thereof and their particular kinds of ownership are recorded' (Wong, 1975 p.108). This system involves an elaborate procedure requiring cadastral surveys to ascertain the extent of the plots of land and the hearing of claims so that they might be recorded.

The procedure is reasonable in relation to registration of alienated land. However, it often lasts for years where customary rights are concerned because individual 'ownership', recognised legally by the issuance of title, cannot easily be established in reality. This, however, has to be qualified. In the case of land bearing perennial crops, individual rights are loosened from the control of the community, a situation recognised by 'custom'. Here, ownership of land as a unit of property is easier to establish and thus to register. Secondly, in areas without perennial cash crops, the procedure of registration itself tends to create absolute ownership, or at least the illusion that this is so. Some explanation is required; individuals with claims to a piece of land are often willing to allow one person's name to be registered but this does not in fact imply community acceptance of legal ownership but rather that the community registers its right to land through individuals. Nonetheless, administrative procedures are carried out on the assumption that individual ownership has been established.

Administrative procedures thus tend to produce individual ownership where none was recognised by the community previously. This problem in the relation between administrative and community understandings of land tenure can have important consequences when development schemes greatly increase the economic value of the land. In this situation, the registered 'owner' enters into dispute with others in the community with claims to the same land.

himself is involved. Japaro the other side laid upon the fact he planted coconuts and tapioca. Tan appealed to the land office which his land was planting that the penghulu has usurped his right.

Clearly it is not the purpose here to decide the merits of each case but it is important that they are taken seriously. Perennial crops are planted in order to establish customary claims. But there are two significant differences. In the first case, a person from outside the boundary (as that is defined by the people) claims what is involved. According to the headman it is defined by the provision in the Land Code to protect rural Malays from the encroachment of members of other ethnic community from the original. In the second case the penghulu is involved in the dispute himself and is not... as the district officer... necessary. It is not surprising that neither of the disputes has been settled and the land title issued. To uphold the custom that perennial crops are for individual ownership might suit the penghulu in one case but would certainly help the exception of the rest of the village in the other. For the penghulu to uphold community rights of dispute in the first case with a view to the necessary protection of Malays would call into question his own position in the second. The role of the penghulu in the administration of land circumstances is thus an important area for economic and political operation within the local community.

THE STUDY AREAS

There are a number of problems involved in the application of the Land Code but as the Code forms the legal basis for the regulation of land holdings and its provisions are of importance in the administration of development schemes. Maps 2 and 3 show the distribution of different categories of land in the study areas insofar as this has been ascertained by reference to maps worked out by the Land and Survey Department. Such information is clearly available from the appropriate documents for the two study villages of 1 settlement... along the Kuching-Serian road in 1970 to receive a number of the villagers who also decline for the purposes himself is involved. Having the use of padi land along the road he planted coconuts and rubber. The original landholder now wants his land back claiming that the *penghulu* had usurped his land.

Clearly it is not the purpose here to decide the merits of each case but it is significant that they are rather similar. Perennial crops are planted in order to establish customary rights. But there are two significant differences. In the first case someone who is from outside the community (as that is defined by the people themselves) is involved. According to law 'community' is defined ethnically so there is no provision in the Land Code to protect rural Malays from the encroachment of members of their own ethnic community from the capital. In the second case the *penghulu* is involved in the dispute whereas in the first case he had to act as neutral adviser on customary law. It is not surprising that neither of the disputes have been settled and the land lies fallow. To uphold the custom that perennial crops make for individual ownership might suit the *penghulu* in one case but would certainly gain the disapproval of the rest of the village in the other. For the *penghulu* to uphold community rights of disposal in the first case with a view to the necessary protection of Natives would call into question his own position in the second. The role of the *penghulu* in the administration of land tenure cannot in fact be separated from his economic and political position within the local community.

THE STUDY AREAS

There are a number of problems involved in the application of the Land Code but nonetheless it forms the legal basis for the regulation of land dealings and its provisions are of importance in the administration of development schemes. Maps 2 and 5 show the distribution of different categories of land in the study areas insofar as this has been ascertained by cadastral surveys carried out by the Land and Survey Department. Much information is already available from the documents of this Department for the two areas because of a Settlement operation carried out along the Muara Tuang road in 1970 to resolve a number of land disputes, and also because of two proposed development schemes. The Gedong areas was proposed for a scheme in 1970 (called a Muhibbah or Goodwill scheme in accordance with Government policy of the time), and later for a pineapple scheme. The Samarahan was later considered a more suitable site for the pineapple scheme.

All of the rural areas fall in the broad category of Interior Area Land. Within this the land of the study areas can be divided into Native Customary Land, Native Area Land, Mixed Zone Land, State Land, and Native Communal Reserve as shown on Maps 2 and 5. The land of the study areas is mostly Native Customary Land but specific recommendations for the treatment of such land for the purposes of administration are not given in the Land Code. Any development scheme must therefore undertake to deal with the lands of the study areas either as alienated land (Native Area Land or Mixed Zone Land) or as Native Communal Reserve. Recommendations in this regard are made in Appendix 8.

Lower Samarahan Scheme

Much of the area around Kg. Baru has not been surveyed. In view of a demand for padi land from the people of Kg. Baru and Kg. S. Batu, which has led to a dispute between the villages, it is necessary immediately to carry out a cadastral survey to establish the distribution of landholdings in the area.

In the area proposed for Stage 1 much of the land has been declared Native Communal (Padi) Reserve. This greatly facilitates an early start to development in the area. It is suggested that the whole of Stage 1 be declared Native Communal Reserve, with defined areas for padi and tree crops.

S. Empila Scheme

In this scheme it will be extremely important to decide whether to issue title to lands or to declare the whole area Native Communal (Padi) Reserve. At Kg. Niup there is a certain amount of Native Area Land. Some of this land is being sold to non-farming families in Muara Tuang and Kuching. While this mostly affects land across the Samarahan river from the scheme there are reports of sales in the scheme area itself, notably in the lands of Kg. Empila at Stage 2. It is necessary to understand the reasons for these sales and to determine the likely effect on a development scheme. On the basis of these studies it will be possible to decide whether the best interests of the scheme will be met by issuing title to land with various conditions ensuring the planting of padi or by declaring a Native Communal (Padi) Reserve within which titles would be bought by the State.

At Stage 4 there is a certain amount of State Land which is actually being cultivated. The land is therefore subject to customary claims. Cadastral survey will have to be undertaken and the legality of the claims established. It might be discovered that if this cultivation has followed illegal felling occasioned by the sale of padi land across the river Samarahan.

A block of Mixed Zone Land in primary forest near Kg. Endap lies across the line of the canal if it is decided to bring irrigation water to Stage 3 and 4, and to the Upper Empila Scheme. Only 24 lots (99.5 ha) have been issued with title and the remainder (358.8 ha) is State Land. Until the canal alignment is determined it is advisable to avoid the further issue of title.

Gedong Scheme

Most of the area has not been surveyed at all and a cadastral survey must be carried out.

S. Kuala Scheme

The land in the scheme area is mostly Native Customary Land. In addition there is a block of Native Communal Reserve for the Malays of Gedong. This was defined as a cattle grazing area but in fact it is being cultivated with rice in the usual manner. Within the area of the proposed schme there is an extensive block of State Land.

An analysis of landholdings shown in the documents of the Muhibbah Scheme is given in Appendix 7. A fuller analysis of all the lands in the area should be carried out especially with regard to the relations between the villages of Kuala, Nyabah and Gedong Ulu.

THE LAND CODE AND DEVELOPMENT IN THE STUDY AREAS

The study areas have been described above in terms of land categories set down in the Land Code. It is recognised that the Land Code suffers from a number of logical flaws. In addition it is inadequate as a national system of land administration to support development objectives (Porter, 1967). Most significantly in this respect the Land Code does not specify how Native Customary Land is to be administered. In effect this is carried out by the District Officer in consultation with the *penghulu* or *tua kampong*. In situations which are reasonably stable, this is sufficient, but in a rapidly changing situation such as in a development scheme, 'custom' is itself changing rapidly. Land disputes which arise in this situation focus on the problems of how to interpret 'custom'. The District administrative apparatus is not equipped to deal with this situation and a Settlement operation must be undertaken. Settlement, however, deals effectively only with alienated land where individual rights can be adjudicated on the production of titles. Some more effective method of consulting with smallholders over land tenure issues is needed.

To facilitate development the Land and Survey Department has, over the years, tried different practices. Briefly these have been either the issue of title or the declaration of Native Communal Reserve. In Appendix 8 the advantages and disadvantages of each system of dealing with Native Customary Land are considered and recommendations given with a view to involving smallholders in the land administration of the scheme. In order to make recommendations with regard to the study areas it is important to understand not just the legal situation but also the amount of land available to farming households. This is considered in Appendix 7 following.

The study areas have been described above in terms of land categories set

District Officer in consultation with the penghulu of the Kampong. In

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APPENDIX 7 LAND TENURE: LANDHOLDINGS

INTRODUCTION

The rules of land tenure in Sarawak were developed in the context of a system of agriculture which had an extensive pattern of land use. There were large tracts of virgin forest available into which it was possible to expand. The growth of population in one rural area could therefore be compensated by the movement of young people and whole families to other areas. Migration has become an institutionalised feature in the life of the peoples of Sarawak.

In the three districts in which the study areas are situated, Kuching provides the major attraction for both seasonal and permanent migrants. Data for the three districts are summarised in Table 1.

TABLE 1 Land and population in the three districts of the study areas, 1970 (Source: Chander, 1976)

		Kuching	Serian	Simunjan
Population	Total	214 839	53 658	31 042
	Urban	63 535	2 209	629
	Rural	151 304	51 449	30 413
Area (km^2)	Total	2 434.6	2 014.7	1 681.9
	Urban	20.5	2.2	0.4
	Rural	2 414.1	2 012.5	1 681.5
Population density/km^2	Mean	88.2	26.6	18.5
	Urban	3 099.3	1 004.0	1 572.5
	Rural	62.7	25.6	18.1

The rural areas of Sarawak are sparsely populated. Population density for the nation as a whole in 1970 was $47.9/km^2$. Much of the land of the floodplains is covered with peat forest. The rural population is dispersed over the better soils of the river valleys which are cultivated extensively. Despite this general sparsity of population, land disputes between villages would seem to demonstrate that there are land shortages at village and household level with present farming methods.

This is the situation in the study areas where Malay communities are subject to a process tending to reduce the amount of available padi land. As a result, Malays without padi land are compelled to encroach on neighbouring areas, whether they be State Land or the seemingly extensive lands of Iban communities. It is important to understand this process in the study areas in order to regulate land matters in the interest of national agricultural objectives.

THE STUDY AREAS

The gross population in the study areas and the land operated by the villages can be seen in Table 2, which also shows population according to villages in the separate schemes proposed within the two study areas.

TABLE 2 Land and population in the study areas, 1970 (Source: Department of Statistics)

Proposed Scheme	Village	Population	Households	Operated land (ha)		
				Owned	Not owned	Total
A. Samarahan study area						
Lower Samarahan	Muara Tuang	738	128	162.9	7	169.9
	Tg. Bundong	471	81	121.25	9	130.25
	Terusan	43	7	25.9	5.3	31.2
	Baru	1 291	225	347.85	56	403.85
	Rembus	303	48	95.7	0.8	96.5
	Tambai	331	55	95.4	1.2	96.6
	Semawang	146	23	52.6	0.8	53.4
	Mapar	35	7	18.4	0	18.4
	Pla-i	193	33	39.6	3.3	42.9
	Nangka	88	14	84.2	6.5	90.7
	Melaban	143	23	66.2	0.6	66.8
	Binyok	179	29	15.0	0	15.0
	S. Batu	71	13	23.5	0	23.5
	Niada	43	9	31.2	0	31.2
	Jernang	248	35	90.3	7.7	98.0
	Sebenkoi	105	16	13.4	0	13.4
Subtotal	16	4 428	746	1 283.4	98.2	1 381.6
S. Empila	Niup	325	56	83.8	1.7	85.5
	S. Mata	295	57	56.3	4.9	61.2
	Semong	49	10	12.6	0	12.6
	Naie	96	15	6.3	0.8	7.1
	Melayu	572	112	131.6	0.8	132.4
	Nakong	88	24	7.1	0	7.1
	Empila	550	103	146.7	29.4	176.1
	Tg. Tuang	179	35	19.0	2	21.0
	S. Sueh	12	6	0	3.2	3.2
	Tg. Parang	283	49	149.5	3.6	153.1
	Meranek	718	126	179.8	23.5	203.3
	Mang	337	66	96.6	0	96.6
Subtotal	12	3 504	659	889.3	69.9	959.2

TABLE 2 (Continued)

Proposed Scheme	Village	Population	Households	Operated land (ha)		
				Owned	Not owned	Total
Entingan	Entingan	175	30	56.5	1.2	57.7
	Pinang	592	111	117.4	53.0	170.4
	Nangka	28	8	0.8	0	0.8
	Patung	70	15	16.6	0	16.6
	Endap	370	66	43.2	1.2	44.4
Subtotal	5	1 235	230	234.5	55.4	289.9
Siniawan	Siniawan	142	29	2.9	1.3	4.2
	Lubok Antu	239	50	18.5	1.9	20.4
	Reban	101	26	46.0	1.6	47.6
	Sok	141	28	110.5	0	110.5
	Raih	93	25	61.9	0	61.9
Subtotal	5	716	158	239.8	4.8	244.6
Total Samarahan study area	38	9 883	1 793	2 647.0	228.3	2 875.3
B. Sadong-Krang study area						
S. Kuala	Kuala	57	11	8.9	0	8.9
	Nyabah	77	12	15.2	0.4	15.6
	S. Belian	41	10	2.0	3.8	5.8
Subtotal	3	175	33	26.1	4.2	30.3
Gedong	Gedong	3 785	318	557.9	12.7	570.6
	E. Sawmill	269	35	40.5	3.4	43.9
	Tg. Paoh	140	33	61.2	0	61.2
	Gumpeh	225	52	78.3	0	78.3
	Lalang	91	17	31.1	0	31.1
Subtotal	5	4 510	455	769.0	16.1	785.1
Tanah Puteh	Tanah Puteh	323	68	266.8	2.0	268.8
	Munggu Kupi	136	19	49.4	0	49.4
	Sebemban	284	43	48.0	0	48.0
Subtotal	3	743	130	364.2	2.0	366.2
Others	Ampunggan	554	88	165.9	35.4	201.3
	Serian	410	68	31.8	6.9	38.7
	Munggu Limau	414	63	50.0	11.7	61.7
	Saroban	195	28	39.1	0.7	39.8
	Ranchan	109	12	26.3	1.1	27.4
	Tanggok	675	84	246.0	4.9	250.9
	Slabi Empurong	98	15	n.a.	n.a.	n.a.
	Slabi Ent	283	40	119.2	4.3	123.5
	Slabi Tembawang	27	4	15.8	2.0	17.8
	Slabi Sengkam	235	36	105.6	0	105.6
	Lubok Tapang	146	21	55.0	14.4	69.4
	Lubok Pasir	83	12	0.8	0.8	1.6
Subtotal	12	3 229	471	855.5	82.2	937.7
Total Sadong-Krang study area	23	8 657	1 089	2 014.8	104.5	2 119.3

The data presented in Table 2 provides the necessary baseline for the analysis of the situation but it should be borne in mind that the actual situation is dynamic; villages expand or contract, and in some cases move from the area. For example, in 1976, Gedong comprised four villages, namely Lalang, Prentah, Tengah, and Gedong Ulu, and the village of S. Belian (which was situated at S. Midin on the Krang) has, since 1970, moved completely to the Simanggang road and is no longer in the study area.

With regard to the landholdings it must be stressed that these refer to land being operated at the time of the Census and were not based on cadastral surveys. These data should be treated with care because they are recalled by farmers and are unreliable for this reason. Partly this unreliability results from an ambiguity in the term 'operated land'. Fieldwork indicated that some villages record padi land being operated at the time of the Census but not land planted with low-yielding rubber which was being operated in 1976. Because of the Census record of 'operated land' it is impossible to estimate the amount of land available to different villages from these figures. Overall land available can be estimated on the basis of other data provided by the Soil Survey Division of the Department of Agriculture; this is given in Appendix 5.

It is important to recognise the difficulties of interpreting the data of the 1970 Population Census at village level. Nonetheless it is useful to summarise the findings as they provide a number of guidelines for analysis. Such a summary is presented in Table 3.

TABLE 3 Population and operated land, 1970 (Source: Department of Statistics)

	Samarahan	Sadong-Krang
Total population	9 883	8 657
Total households	1 793	1 089
Total villages	38	23
Mean household size	5.5	7.9
Total hectares operated	2 875	2 119
Hectares/household	1.6	1.9
Hectares operated but not owned	228.3	104.5
% tenancy	7.9	4.9

In the analysis of these figures it is necessary to take certain factors into account:

1. The difference in the household size requires comment. In Gedong the household size is 11.9. The figure is distorted upwards by the presence of large numbers of young men working in the local sawmills. The inclusion of Gedong distorts the figure for the Sadong-Krang as a whole.

2. On the basis of the population figures for 1970 it is not really possible to arrive at an accurate estimate of the present population in the study areas. First of all, comparable figures for 1960 were not available.* Secondly, gross estimates of population growth in the three districts do not take account of migration from the study areas specifically. As already mentioned the whole village of S. Belian has moved from the area. With these qualifications in mind an estimate can be made of the likely population in the study areas. For this estimate the rate of annual growth of population is taken to be 2.5%. This is based on a comparison of the field survey of selected villages in 1976 with the figures for the Population Census 1970.≠ The estimates are given in Table 4.

TABLE 4 Estimated population of the study areas

	Samarahan	Sadong-Krang
Population 1970	9 883	8 657
Estimated population 1976	11 459	10 036

3. Despite the difficulties over the data on landholdings it is possible to gain a rough estimate of the amount of tenancy in each area by dividing the hectares operated but not owned into the total area operated. This

*The figures are obtainable from the Department of Statistics in Kuala Lumpur. A separate computer programme would have to be written, however, to obtain the information. This was not considered necessary at this stage.

≠The national figure for annual growth of population is 2.958% (Chander 1975). In the study areas the population is comprised of Malays, Ibans and Land Dayaks for whom annual growth rates are given as 3.193%, 2.796% and 3.040% respectively. These figures do not take account of migration in a particular study area.

remains a rough estimate because there is a certain amount of land which is not operated in the areas though it has customary rights attached to it. It can be seen that more land is 'rented' in this way in the Samarahan area than in the Sadong-Krang. In Samarahan it seems that the villages of Baru and Empila have the most 'tenancy' (16.15% and 20.05% respectively) while in the Sadong the village of Ampunggan has 21.35% 'tenancy'.

The terms 'rent' and tenancy' have to be used with caution since the people themselves do not always regard arrangements in which land is used by a person other than the landholder as an economic transaction. According to customary law land is 'borrowed' and any payment is intended solely to confirm the rights of the original landholder. Payment is normally given as a certain proportion of the harvest or alternatively the 'tenant' is required to work for the landholder for 2-3 days during the year. This has to be understood in the context of customary practice outlined in Appendix 6.

While the above customary notion of 'borrowing' land would seem to account for the situation at Ampunggan and Empila, in other villages there has occurred a certain amount of economic differentiation so that 'rent' and 'tenancy' can be understood as economic terms. This seems to be the situation in Kg. Baru. Studies in the area indicate that, with the opening of the Muara Tuang road, this type of tenancy is increasing in the Samarahan area notably affecting the villages of Meranek, Melayu and Niup as well as Baru (see above). These are all areas in which there is a significant amount of alienated land; this is not surprising given that individual title to land facilitates land dealings. The increasing amount of tenancy is related to increasing sales of Native Area Land. For example, at Kg. Niup, land is being sold to non-farming interests in Muara Tuang and Kuching. Farmers are obliged to sell land in order to pay debts which arise for a number of reasons, including the financing of ritual activities (e.g. weddings and Hari Raya). Later these same farmers either rent back the land from the new landowners or they begin to clear State Land illegally in the area adjacent to Kg. Melayu. Often this process leads to a number of land disputes.

LAND DISPUTES

The opening of the Muara Tuang-Kuching road has had an effect on landholdings whether they are held under customary right or under title. In Appendix 6 it was mentioned that the increase in the values of land adjacent to the road had led to attempts to establish absolute rights of ownership according to customary tenure by the planting of tree crops. This tendency led to a major dispute in the area and eventually to a Settlement operation involving 2 039 ha (5 036 ac) though the different claims have still not been resolved. This dispute involves the villages of Pla-i, Rembus, Meranek, Tg. Bundong, Muara Tuang, and Nangka in the study area and Merdang and Bayor nearby.

The dispute arose when the people in villages adjacent to the new road began to use the land for other purposes than the planting of padi. In the first place coconuts were planted on padi land. Secondly the people of Nangka sold their land either legally or illegally to outsiders. With the reduction of padi land available to the roadside communities, there were encroachments led by the people of Nangka on the communal reserves of other communities. In particular the people of Nangka felled old rubber belonging to the Ibans of Rembus. This situation has led to a number of conflicting claims to land. For example, the Iban villages of Rembus and Pla-i both claim an area of primary forest adjacent to the road. Rembus can produce a map of the area drawn in 1940 in which the area is marked as Native Communal (Forest) Reserve for that village. The Land and Survey Department, however, has pointed out that such maps were drawn without benefit of cadastral survey, the boundaries marked on the map being therefore without legal status. Despite the Settlement operation this dispute continues in the present and illegal felling of primary forest was reported in 1976.

The disputes were occasioned by the increase in land values as a result of the opening of the Muara Tuang-Kuching road. Underlying the disputes, however, seem to be differences within and between communities in respect of available padi land. At Kg. Baru, for example, there are indications that economic differentiation is occurring. Some members of the village are acquiring more padi land while others lose what land they have. In this case 84 people from Kg. Baru applied for State Land in order to grow padi. Of these, some have adequate landholdings (3.25 ha) but little or no padi land, while 39 are officially classified as landless (although 23 have access to padi land by 'borrowing' or 'renting'). The land requested lies on the Loba Batu Belat in an area of nipah palm and is already claimed by the people of Kg. S. Batu. Again the reduction in padi land available to the community might have been caused by the planting of coconuts on padi land.*

As the land available for the planting of padi is reduced within a village so people encroach on the lands of other villages. This is possible because of the quite considerable differences in landholdings between villages. An example of this can be given on the basis of the detailed cadastral surveys undertaken for the Muhibbah Settlement Scheme at Gedong.

LANDHOLDINGS IN TWO VILLAGES

The Muhibbah Scheme comprised an area of 2 190 ha stretching from Gedong to S. Midin. Within this scheme, which was not in fact implemented, it is possible to compare the landholdings of two villages. This is done in Table 5.

TABLE 5 Population and land registered for two villages, Gedong Ulu and Kuala.

	Gedong Ulu	Kuala
Main ethnic group	Malay	Iban
Households with land	54	17
Alienated land		
Number of lots	38	0
Hectares	13.5	0
Customary land		
Number of lots	74	76
Hectares	35.7	144.8
Total land registered		
Number of lots	112	76
Hectares	49.2	144.8
Landholdings per household (ha)	0.	
Average	0.9	8.5
Maximum	2.8	19.4
Minimum	0.1	0.8
Size of lots (ha)		
Average	0.4	1.9
Maximum	2.5	8.7
Minimum	0.06	0.03
Source: Land and Survey Department: <u>Schedule of Alienated Lands</u> and <u>Register of Customary Lands</u> in the proposed Muhibbah Scheme 1973.		

*The information for this section comes from the files of the Land and Survey Department and was checked during a short fieldwork visit. The area in question is shown on Plate 1.

Since comparisons of Malay and Iban communities in respect of landholdings are not possible on the basis of the data for 'operated land' given in the Population Census, the villages given in Table 5 cannot be considered to be representative. Nonetheless, in view of the encroachment on Iban village lands by Malay communities in the Lower Samarahan area, it would seem that Table 5 reflects a more general situation in which Malay households have much less land available to them on average than Ibans.

There are a number of interrelated points to be borne in mind in comparing the figures of the two villages:

1. Iban population growth is less than that of Malays. There is then, a demographic cause of Malay land shortage.

2. Ibans hold lands under customary rights while a third of the land in Gedong Ulu is held under title. This means that the Iban *bilek*-household cannot really be compared with the Malay household as a land-owing unit for the basis of landownership is different.

3. Malay inheritance rules are such that landholdings are divided among the children on the death of the household head while, for the Ibans, land remains within the *bilek*-household. This has the effect of fragmenting the landholdings of the Malays, who therefore tend to have uneconomic lots.

The above qualifications have to be made in any accurate assessment of landholdings. The problem remains, however, that given the present population in the study areas there is a surplus of land which is not used in any one year. The system of leaving land fallow from 1 to 5 years has been mentioned in Appendix 5. In this situation the reduction of padi land in Malay communities results either in illegal felling of State Land or encroachment on the seemingly extensive lands of the Ibans.

THE COCONUT PLANTING SCHEME AND THE AVAILABILITY OF PADI LAND

The reduction of padi land available to Malays, it was suggested, is caused by the planting of coconuts. This crop is attractive to Malays with surplus land in the area because by planting a perennial cash crop a farmer can establish absolute rights in land according to customary law. Furthermore, coconuts can be established with the aid of the Coconut Planting Scheme (CPS) and once established produce an economic return with little labour input. This establishment of land rights becomes particularly attractive when the value of the land starts to rise, e.g. as a result of a new road such as the one from Muara Tuang to Kuching.

The tendency to plant coconuts on padi land is not in the interests of Sarawak nor of those smaller farmers who used to 'borrow' land traditionally. In the study areas the yield of coconuts is poor generally (possibly because the subsidy is not adequate to provide the drainage required in the alluvial padi lands). Thus even for the larger farmers there is little economic benefit from planting coconuts. There is a benefit to them, however, in establishing absolute rights to land. This might have considerable economic value in the long term were title to such land to be issued. The reduction of padi land involved in this process is detrimental to national objectives. This situation can be controlled and directed along ways beneficial both to the national policy of increasing rice production and to the people in the area as a whole. Recommendations in this regard are made in Appendix 8.

APPENDIX 8 LAND ADMINISTRATION: RECOMMENDATIONS

INTRODUCTION

In Appendixes 6 and 7 two problems of land administration in the context of agricultural development objectives were identified:

1. A surplus of land in relation to household requirements for rice production, occurring locally even in areas where generally there is land shortage

2. The difficulties of administration posed by customary land tenure

Two distinct approaches can be followed to provide a legal framework for resolving the problem of surpluses of land above that which a farming household can adequately work. The distinction is made on the basis of the predominant form of land tenure in the area. The resolution of the problem will now be considered in the light of experiences gained on schemes outside the study areas.

ALIENATED LAND

Where land is mainly held by individuals, either as Native Area Land or as Mixed Zone Land, it is necessary to adjudicate the remaining areas held under customary rights in order to issue legal title to the land. The procedure by which title is issued is regulated by the Land Code. The issue of legal title is, however, only a preliminary stage in the rationalisation of land administration as can be demonstrated briefly in relation to different schemes in Sarawak. In each of the three schemes mentioned below there was a surplus of land over the requirements of the landholding households (as in the study areas) and this situation resulted in problems associated with underutilisation of land, tenancy, fragmentation and land speculation. These problems will now be discussed in turn.

Underutilisation of land

In the mid-Sadong scheme, just to the north of the Sadong-Krang study area, acceptance of employment opportunities outside the scheme effectively reduces the time which a farming household can devote to labour within the scheme. This applies whether the off-scheme employment or income opportunities are in agriculture or in other industries. For example, Ibans at Stage 1 of the scheme, have a greater amount of land (mostly planted with rubber) than Malays outside the scheme and, as a result, are less committed to production within the scheme. This is demonstrated by Table 1.

TABLE 1 Lands cultivated at mid-Sadong Stage 1 (Source: Solhee H. 1976)

	Malay	Iban
% of farmers with off-scheme lands	25	32.5
Average holdings off scheme (ha)	1.25	2.95
Average area planted on scheme (ha)		
By farmers with lands only on scheme	0.88	1.00
By farmers with lands on and off scheme	0.93	0.77

This is the situation in which a village is already established and the participants of the scheme are fully employed in agriculture. In Stages 2 and 3 of the scheme the lack of agricultural activity is marked. At Stage 2 only half of the area had been cleared of primary forest in 1976 even though the drainage works were completed in 1971 while no clearing had been done at all at Stage 3. In this case 50% of the participants of Stage 2 lived in Gedong, 4 hours journey away by river, which provides a major counter-attraction for people of the scheme as it is a centre of the timber industry.

In the implementation of any scheme, consideration has to be given to land tenure in the locality and not just within the area of the scheme itself. In addition, the likely effect of nearby non-farm employment opportunities on the labour supply for the scheme must be considered. For example, as the mid-Sadong Scheme is close to Gedong account must be taken of the effect this scheme might have on the proposed Gedong Scheme which is adjacent to it. The question of introducing new settlers into the area to overcome labour shortages will be considered later.

Tenancy

A high level of tenancy is recognised by the Department of Agriculture as a major reason for the problems of the irrigation scheme at Tg. Purun. This is situated in Lundu District in the First Division, and is capable of producing two crops of padi annually on 140 ha (out of a total area of 195 ha). Problems on the scheme include disputes between farmers about water control and distribution, which are directly caused by the lack of commitment to an agreed farming programme, and the inability to establish a fund to finance agricultural inputs when the APPS subsidy arrangement ends in 1977.

Fundamentally the problems of the scheme are caused by the heterogeneity of the farming population. While the majority are owner-operators (64% according to a sample analysed by Solhee, 1975), the remainder rent all or part of their land. There is no common interest of owner-operators, landlords, and tenants. Tenancies are not agreed contracts: 'the landowner normally allowed the operator to cultivate the land as long as the farmer was not using it himself' (Solhee, 1975). Rents charged vary depending on kinship relations between landlord and tenant; there is no rental for kinsmen but non-kin pay 1½ piculs of padi per acre (225 kg/ha) each season. Tenancy arrangements are not secure and it is unlikely that tenants could be fully committed to the scheme. More significantly perhaps, in view of the problems above, there is no guarantee that a farming programme agreed by the Scheme Committee can actually be administered where many of the actual cultivators for any particular season are unknown to the Committee. Similarly there is no guarantee that tenant cultivators receive the APPS subsidy; a short field survey in 1976 revealed that, while some tenants receive some of the subsidy, they are not aware of the actual amount of the subsidy which is given to the registered landowner. In view of this situation it is not surprising that the APPS Committee of Scheme participants is unwilling to establish a fund to finance future purchases of agricultural inputs by tenants.

The problems of tenanting surplus land at Tg. Purun had been recognised in 1957:

"The decision to issue title to all owners of customary land at Tg. Purun requires further consideration. Many owners (mainly Dayak) who have adequate land elsewhere are renting land to others who have no other or insufficient other land, and the issue of titles will do nothing to effect a redistribution of land which would appear necessary if the landlord relations are to be resolved."

(File 9-4/8 Agriculture Dept. Lundu)

Follow-up studies by the administration revealed that 29 owners of land at Tg. Purun (out of 176) had from 0.8 to 12 ha outside the proposed scheme. Nothing however was done about this situation to the detriment of the scheme.

Fragmentation of landholdings

The problems faced by the scheme at Tg. Purun are not entirely caused by the high level of tenancy. Another related cause of the problems is the fragmented nature of the landholdings. Plots vary greatly in size and farmers own a number of plots dispersed throughout the scheme. This creates problems for management of the scheme.

It was pointed out above that the lack of coordination between farmers is apparent in dispute about the distribution of water throughout the scheme. The fragmented pattern of the landholdings is not suitable for the equitable distribution of water, though the layout of canals in a grid pattern instead of following the fan-shaped natural drainage pattern and the inadequate pump design exacerbate the problems*. Dispute about water distribution between farmers have been reflected in disputes between the agencies with responsibility within the scheme, namely the Department of Agriculture and the Drainage and Irrigation Department.

Land speculation

Where land surplus to a farming family's requirements rapidly and significantly

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*To some extent the inclusion of a speed regulator in the pumps used on the scheme would serve to alleviate the problems of water distribution discussed here.

gains in value there is a great temptation to sell the land to non-farmers who acquire land as an investment but without any plans to develop it themselves. In Paya Selanyau, an irrigation scheme in the Fourth Division, about 40 ha (out of 485 ha) have been sold to non-farming interests in Miri.

When the scheme began in 1974 the Department of Agriculture was aware that there was land surplus to the requirements of the existing population. Sather and Solhee (1974) demonstrated that 22 (out of a total of 35) households in Kg. Selanyau owned 41.3 ha of padi land in the scheme. For the planting of padi 0.8 ha was considered sufficient for each household and thus 22 households actually owned 23.7 ha of padi land more than they could work, especially considering that they also had an average of 1.8 ha of rubber, and small pepper gardens (50-200 vines).

The Department of Agriculture recommended to the participants of the scheme that they should 'lend' land to kinsmen in the area. This was successful to some extent; all the land of Stage 1 (85 ha) was redistributed within the immediate community in plots of 0.8 ha minimum size without rent being charged. Land values increased from $500 to $2 500 per ha, however, and land in Stage 2 surplus to the requirements of the immediate community was sold to traders in Miri.

Land administration in areas of alienated land

The alienation of land promotes rather than prevents the sale of land to outsiders, thus increasing the dangers of land speculation and tenancy. Nor does alienation of land guarantee that land is utilised efficiently (holdings often tending to fragment as they are sold in parcels) or even utilised at all. However, in issuing title to land it is possible to institute conditions which would promote Government development objectives. These conditions are:

1. Land is designated to be used for either padi or tree crops in accordance with the aims of the scheme

2. No subdivision of the land is to be allowed

3. No dealing is to be allowed for 10 years without the permission of the Department of Land and Survey

4. The land must be cultivated in accordance with recommendations of the Department of Agriculture

5. If the above conditions are not met, the Government can re-enter

In order to achieve these conditions, previous titles would have to be surrendered on the understanding that new titles would be issued for the land in the scheme. Even with the surrender of titles, difficulties can be expected in the enforcement of the conditions. The Padi Production Unit (n.d.) has proposed that landowners who do not plant crops in accordance with the policy of the Agriculture Department should be penalised financially. For this purpose, the PPU recommends a 'capital charge' based on the amortization of the capital cost of drainage and irrigation facilities over a period of 25 years at 6%. The annual amortized cost would be considered a 'capital charge' per unit area. If land is worked up to a certain area (to be determined for each scheme) directly by the landowner a rebate of 100% would be granted each year. Land worked over that area (or land worked by tenants) would be given a partial rebate to be paid to the landowner. Land not worked at all would receive the full charge.

There are likely to be real problems in the implementation of such a scheme. Tenancy arrangements are normally oral and informal and, as a result, it might prove difficult to discover whether the landowner was working an area above the specified amount directly or by the use of tenants unless the administration of the scheme also maintained an up-to-date register of tenancies. In this way it might be possible to encourage landowners to formalise tenancy agreements by specifying the conditions and duration of tenure. The chief difficulty here is likely to be in the sphere of rents. It is probable, in the early stages of development at least, that overall production will increase while productivity per hectare will remain constant. In this situation, landlord and tenant will have quite different views of what constitutes a fair rent. The landlord is likely to pass on the capital charge to the tenant.

To what extent the above will become a problem in the schemes proposed for the two study areas depends on the specific situation with regard to landholdings. In this respect it is important to decide what is an economic holding for a household given the range of crops which it is possible to grow within the scheme. It seems desirable that, in order to control agricultural production in the scheme in accordance with its objectives, a certain amount of redistribution of landholdings should be undertaken. This will reinforce smallholder production by ensuring that each household has an economic lot, and is essential for mechanised production.

The actual mechanics of land distribution have to be discussed further and the following suggestions are a contribution in this direction:

1. If a farmer has surplus padi land this should be purchased and resold to farmers in the area in need of land for planting padi. Purchases and sales should be at the market rate for unimproved land where possible.

2. In the case of a farmer who has land planted with productive tree crops in an area designated for padi, the land could be bought at full market rate and full compensation paid for the crops. The option to buy land in the designated tree crop zone at the undeveloped rate could also be given to this farmer.

3. In the case of the farmer who has land planted with unproductive crops in the padi area (some CPS coconuts for example), the land might be bought at the undeveloped padi land rate, or he might be offered an exchange for land in the tree crop zone.

4. Both for farmers with productive and for those with unproductive tree crops who must be relocated, application for tree crop subsidies would be approved.

In this way redistribution of surplus land, which is necessary in order to avoid the problems encountered on other schemes and also to promote the appropriate mechanisation by consolidating landholdings as economic lots, can be achieved with the approval of the people concerned. The State would, in effect, subsidise the redistribution, by purchasing lands at various rates and selling it to those without padi land or with insufficient padi land at the undeveloped rate. This is the current practice.

The element of subsidy in this procedure would be necessary if the poorer farmers were not to be indebted to the scheme at its very inception, which would have disastrous consequences, negating all the above proposals. The benefit to the Government of this procedure would be the increased rice production from a strengthened smallholder agricultural system.

Land redistribution alone ensures the equitable allocation of land to participants in the scheme at the start. It does not prevent land dealings from undermining a scheme in the future. For this reason, land redistribution must be introduced in conjunction with endorsement of titles mentioned previously.

NATIVE CUSTOMARY LAND

Where land is held according to customary rights, Native Communal Reserves should be created. These would be designated as either padi or tree crops reserves according to directions from the Department of Agriculture. Any areas of alienated land should be either purchased or exchanged for land outside the scheme; alternatively, the farmer might be persuaded to surrender the rights if he also has customary rights to land within the scheme.

This procedure has a number of advantages over that of adjudication and the issue of title:

1. The procedure does not require any lengthy adjudication. Cadastral survey is required in order to establish the extent of alienated lands within the scheme but every plot of customary rights land does not need to be adjudicated

2. The designation of Native Communal Reserve prevents land dealings with people from outside the village community because communal rights over the disposal of land (one of the most salient of customary rights) are maintained

3. As a result of 2. above, land speculation is prevented

4. The problems of landlord-tenant relations are avoided because the community as a whole is in effective control of the land

On the other hand, the legal procedure itself cannot guarantee that surplus land is fully utilised. There are Native Communal Reserves in the study areas, principally at Stage 1 of the Lower Samarahan Scheme and at the S. Kuala Scheme; both of these areas are farmed in the extensive manner which is usual in the study areas. It is therefore necessary to outline an administrative structure within the Native Communal Reserve which will promote full utilisation of the land.

Land administration within the Reserve

Guidelines for the administration of the Reserve as a development scheme are provided on the basis of the experience at Tg. Bijat. An improvement scheme began in the Second Division at Tg. Bijat in the 1960's and was thought to be a model for future development by the Department of Land and Survey, especially in the administration of customary rights land.

There is, however, one major difference between the situation at Tg. Bijat and that of the study areas. At Tg. Bijat the 'block' system had been introduced by the Japanese administration without regard to existing land rights. As a result, after the improvements in the 1960's, the owners of the original titles to land began to claim back their rights even though the distinctions between State Land, alienated land and customary rights land had been ignored for over 20 years. A number of disputes arose and in the ensuing Settlement Operation (carried out in accordance with Part V of the Land Code) it was discovered that to uphold the titles would mean the dispossession of 60% of the farming population. On the other hand it is not envisaged that Native Communal Reserves would be established in the study areas where there are large amounts of titled land. Certainly the claims of those with titled land would be recognised and appropriate action taken e.g. purchase of such land.

Another major factor in the situation at Tg. Bijat which is comparable with the study areas concerns the amount of land available to the farming community. In the study areas it has been pointed out that while land appears to be abundant there are shortages in specific areas as a result of the farming system and the tendency to plant coconuts on padi land. Tg. Bijat was generally considered to be an area of land shortage. However, after the improvements there was actually a surplus of land over the requirements of the existing population. This surplus was made available to people in 12 longhouses from just outside the area who were allocated blocks within the scheme. As a result of the introduction of the newcomers and of natural population growth in the area as a whole, land surplus quickly became an acute land shortage, which led to further disputes.

In a situation of land shortage those in control of the allocation of land gain considerable power. In the case of Tg. Bijat the allocation of land was in the charge of the tuai block. Disputes arose as a result of the maldistribution of land within the block as one individual was able to provide land to followers as a means of political patronage.

It is envisaged that the introduction of a Village Land Committee in the proposed schemes will ensure equitable allocation of land within the village. Similarly the Scheme Land Committee would be responsible for the resolution of land disputes between villages. Recommendations in this respect are made as follows:

1. Village lands should be defined in accordance with the needs of the people in the village

2. Lands currently owned by the village which would be surplus to the requirements of the village after development should be kept as a reserve for that village

3. A Land Committee elected within each village would be responsible for the allocation of land each season. While it would be expected that household requirements would remain relatively constant over the short term and therefore the lands used by each household would also remain similar, small adjustments would be required from time to time because of natural population growth. Such adjustments would be facilitated by the work of the Committee.

4. Representatives from each village Land Committee would be elected to a Scheme Land Committee. This would be responsible for allocating more land to villages from the reserve mentioned in point 2. above, and would also be responsible for the resolution of land disputes which might arise between villages.

5. The Village Land Committee would be under the chairmanship of the tua kampong or tua rumah and the Scheme Land Committee would be under the chairmanship of the agricultural officer in charge of the scheme.

The above administrative structure is designed to retain the essential principle of Tg. Bijat in which individual households were allocated lands within a 'block. Within the block, and even over several blocks, the land was in fact worked on the basis of gotong royong labour exchange. The above administrative structure takes account of problems, which subsequently arose in Tg. Bijat.

THE INTRODUCTION OF NEW SETTLERS

The above discussion of the situation at Tg. Bijat demonstrated that lands surplus to a community's requirements should not be distributed to new settlers where this is likely to cause a land shortage. In certain proposed schemes, however, it seems likely that, with improvements, there will be a large surplus of land over that which the community can effectively work. This is especially true of the S. Kuala Scheme where there is a large area of State Land presently uncultivated, but it might also apply to the Gedong Scheme. In such cases, the introduction of new settlers might be considered.

Before any final decision could be made with regard to the advisability of introducing new settlers, the following points would have to be considered:

1. With the introduction of mechanisation, land which is surplus to requirements at the present level of technology might be fully utilised

2. Land which remains in surplus even after the introduction of new technology might quickly be utilised by the attraction of members of the households who at present migrate for employment

3. Land which is in surplus after the introduction of mechanised rice production might be fully utilised if other crops such as coconuts, were planted on that surplus land

4. Any surplus land might be held in reserve for the community thus allowing for natural population growth. Such a reserve might be managed in the present by the Sarawak Land Development Board (SLDB)

In this regard it should be remembered that, while reallocation of land within the community is possible according to customary land rights, the disposal of community land to outsiders can only be achieved with difficulty. For this reason the introduction of new settlers can be envisaged for the area of State Land in S. Kuala Scheme but would not be desirable in other areas where community rights are established.

New settlers could be introduced into an area either by the issuance of title to land or by the creation of a Native Communal Reserve, although only the former method would be applicable in the case of Chinese settlers. In either situation it would be desirable that the initial introduction would be facilitated by the SLDB whose role has been to open new lands to settlers.

SUMMARY

The problems of land administration in the context of agricultural development objectives were outlined. First, there is a problem of utilising effectively all land which is surplus to the requirements of the existing population. This affects both areas of alienated land and of customary land. Secondly, it is difficult for the administration to pursue its development objectives in areas of customary land.

In areas of alienated land the experience gained from three development schemes demonstrates that the issuance of title to land in order to facilitate land dealings does not guarantee the full realisation of the agricultural objectives of the scheme. A number of recommendations were made in order to overcome this problem in areas where land is already predominantly held under title. In areas of predominantly customary land, an alternative policy to the issuance of land title was considered; the creation of Native Communal Reserves would be helpful in ensuring full utilisation of the land. A number of administrative problems were outlined and recommendations were made to overcome these problems.

Finally, it was suggested that, should the recommended policies for land administration not ensure the effective utilisation of land in specific areas, the introduction of new settlers might be considered. It was recommended, however, that attention be given first to the needs in respect of land of the local population (allowing for natural population growth and the use of new technologies) before settlers are introduced into an area.

The above recommendations are applicable to the proposed schemes in the study areas. Immediate actions in these areas in the light of the above recommendations will now be outlined.

IMMEDIATE ACTIONS FOR PROPOSED SCHEMES

Lower Samarahan Scheme

1. Stage 2 of the scheme has only partly been subject to cadastral survey and this needs to be completed as a matter of urgency.

2. The area to the south of the village of Rembus which is gazetted as Native Communal Reserve should be extended to include the whole of Stage 1 of the scheme. Gazette notification should take account of recommendations with regard to areas of padi and tree crops and respect the requirements of the communities involved.

3. Studies must be undertaken to decide the holding of padi land and tree crop land appropriate to each household.

S. Empila Scheme

1. Cadastral survey must be carried out at Stage 4 in the area of State Land between Kg. Niup and Kg. Melayu, and also in the area of Stage 1 used by Kg. Empila.

2. Studies must be implemented to allow a decision to be made whether to adjudicate all rights in the area or to declare it all a Native Communal Reserve.

3. A moratorium should be imposed on the sale of State Land in the area of Mixed Zone Land at Kg. Endap until the possible alignment of the canal has been established.

S. Kuala Scheme

1. Native Communal Reserves must be declared for the existing communities.

2. Studies must be implemented in order to decide on the desirability of introducing settlers from outside the area and of the form of such an introduction. This will involve a full analysis of the Register of Customary Land and the Schedule of Alienated Land.

Gedong Scheme

1. Cadastral survey is required for the three <u>tanjongs</u> of Gumpeh, Paoh, and Larang.

2. The amount of land surplus to the requirements of the existing population, especially in areas of State Land, must be ascertained. In this respect the influence of the mid-Sadong Scheme should be considered.

APPENDIX 9 ENGINEERING AND MECHANISATION

INTRODUCTION

The proposals for the schemes recommended for immediate development have been described briefly in the main report. This chapter goes further into the detail of the engineering and other works involved in these proposals. Estimates of engineering cost are shown in tables for each of the main schemes, followed by estimates for the agricultural works and equipment required for mechanised cultivation.

Engineering unit costs

All costs are based on 1975 prices. For excavation for the canals, drains and bunds, two rates are used. The first is based on DID (Drainage and Irrigation Department) rates for work undertaken using government excavators; the second uses current contract rates, assuming that this work is undertaken by contract. Costings using the former figures are useful when making comparisons with other schemes costed by the DID. The latter prices, however provide a more accurate indication of the true cost of this work.

In general, rates for the various engineering tasks involved for scheme construction have been taken from typical costs of comparable completed schemes. Where forest clearing is involved, it is assumed that no timber of commercial value is recovered to reduce the overall cost. Land acquisition for access canals, etc., has been taken at a rate of $1 250/ha throughout the estimates.

Agricultural works

This term covers the portion of the work on scheme construction which is associated with initial land clearing for farms, land preparation and farm drainage. This work is distinct from the engineering work and is costed separately. In Sarawak this work is not normally undertaken by the DID.

The initial part of this work will be associated with clearing and destumping land which is not at present cleared and under rice cultivation (Table 1)

TABLE 1 Rates for clearing and destumping land by contract

Existing cover	Rate ($/ha)
Primary forest	1 200
Old secondary forest	750
Young secondary forest	300
Nipah	800
Rubber plantation	600
Coconut plantation	500

These rates are distinct from the engineering rate for land clearing. It is also assumed here that there is no timber of any value in the primary forest to offset the high cost involved in this work.

On completion of the land clearing, the first mechanical cultivation has to be undertaken. The initial work of breaking in virgin land is considerable. Though little specialised equipment is required, it will be necessary for operatives to develop new skills such as those needed in rotovator operation. The most effective way of providing appropriate training would be to appoint an agricultural engineer from Peninsular Malaysia or elsewhere to organise suitable courses.

Two-wheel drive agricultural tractors of about 80 hp are suitable for breaking in virgin land which has just been cleared and destumped, provided tracked machines are available for use in particularly difficult areas. A total of six operations will be required to prepare the ground for the first rice crop. Where land has already been under rice, only the last four operations will be needed.

The operations required consist of ploughing the land, raking to collect roots and small timber, harrowing to level the land, and ploughing and raking again to collect more roots. Finally, the land will be rotovated.

For the construction of the secondary, or field drains, it is proposed that a hydraulic excavator is employed. This type of machine is particularly efficient at digging small drains in new land, if it is a tracked machine operating on timber mats, it would be able to reach even the wettest areas.

THE LOWER SAMARAHAN SCHEME

This scheme covers a total area of 1 195 ha. It can be constructed in two stages which are costed separately. The first stage covers the southern rice block and the tree crops area as far as the line marked A-A on Plate 1 (see Table 2).

TABLE 2 Lower Samarahan Scheme: areas of Stages 1 and 2

Land use	Stage 1	Stage 2	Total
Rice	185 ha	725 ha	910 ha
Tree crops	98 ha	187 ha	285 ha
Total	283 ha	912 ha	1 195 ha

Engineering works estimates

The estimate for the engineering work involved in construction of this scheme is shown in Table 3. The following is an explanation of the items and quantities used in this estimate.

A. *Earthworks*

i. *Perimeter bund* The total length around the perimeter of the scheme is 19 km. 6 km of this surrounds Stage 1 and the remaining 13 km surrounds Stage 2. A 30 m wide government reserve is required. Land acquisition totals 18 ha for Stage I and 39 ha for Stage 2. A bund averaging 1 m in height and with a top width of 4 m is proposed. This requires a total of 6 m^3 for every metre that is constructed. The borrow pit for this bund would be sited on the inner side of the bund and would form a perimeter drain.

TABLE 3 Estimate of engineering works, Lower Samarahan Scheme

ITEM	UNIT	STAGE I				STAGE 2				TOTAL			
		Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $
A. EARTHWORKS													
i. Perimeter bund	km	6				13				19			
Land acquisition	ha	18	1 250	22 500		39	1 250	48 750		57	1 250	71 250	
Land clearing	ha	18	300	5 400		39	300	11 700		57	300	17 100	
Excavation	m^3	36 000	0.60/2.00*	21 600	72 000	78 000	0.60/2.00	46 800	156 000	114 000	0.60/2.00	68 400	228 000
Total				49 500	99 900			107 250	216 450			156 750	316 350
ii. Internal bund	km	4.5				3.5				8			
Land acquisition	ha	13.5	1 250	16 875		10.5	1 250	13 125		24	1 250	30 000	
Land clearing	ha	13.5	300	4 050		10.5	300	3 150		24	300	7 200	
Excavation	m^3	20 250	0.60/2.00	12 150	40 500	15 750	0.60/2.00	9 450	31 500	36 000	0.60/2.00	21 600	72 000
Total				33 075	61 425			25 725	47 775			58 800	109 200
iii. Main drains	km	4.5				12.5				17			
Land acquisition	ha	13.5	1 250	16 875		37.5	1 250	46 875		51	1 250	63 750	
Land clearing	ha	13.5	300	4 050		37.5	300	11 250		51	300	15 300	
Excavation	m^3	45 000	0.60/2.00	27 000	90 000	125 000	0.60/2.00	75 000	250 000	170 000	0.60/2.00	102 000	340 000
Total				47 925	110 925			133 125	308 125			181 050	419 050
iv. Stream clearing	km	0.5				4.5				5			
Land clearing	ha	2.5	300	750		22.5	300	6 750		25	300	7 500	
Excavation	m^3	2 500	0.60/2.00	1 500	5 000	22 500	0.60/2.00	13 500	45 000	25 000	0.60/2.00	15 000	50 000
Total				2 250	5 750			20 250	51 750			22 500	57 500

TABLE 3 (continued)

ITEM	UNIT	STAGE I				STAGE 2				TOTAL			
		Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $
B. STRUCTURES													
i. Kruin gate	no.					1	sum	160 000		1	sum	160 000	
ii. Rembus gate	no.	1	sum	140 000						1	sum	140 000	
iii. South gate	no.	1	sum	80 000						1	sum	80 000	
iv. Check structures	no.	4	7 500	30 000		12	7 500	90 000		16	7 500	120 000	
v. Access bridges	no.	3	4 000	12 000		7	4 000	28 000		10	4 000	40 000	
vi. Culverts	no.	7	1 000	7 000		13	1 000	13 000		20	1 000	20 000	
vii. Gate quarters	no.	2	20 000	40 000		1	20 000	20 000		3	20 000	60 000	
viii. Site camp	no.	1	30 000	30 000						1	30 000	30 000	
Total				339 000	339 000			311 000	311 000			650 000	650 000
C. MISCELLANEOUS													
i. River transport	sum		10 000	10 000			10 000	10 000			20 000	20 000	
ii. Contingencies	sum		30 000	30 000			70 000	70 000			100 000	100 000	
Total				40 000	40 000			80 000	80 000			120 000	120 000
SCHEME TOTAL				511 750	657 000			677 350	1 015 100			1 189 100	1 672 100

* The rate for excavation is \$2.00/m^3 by contractor and 60 cents/m^3 by DID

ii. Internal bund This has a total length of 8 km of which 4.5 km is in Stage 1. A 30 m reserve is required here also. This bund will average 0.8 m in height and have a 4 m top width. It will require 4.5 m^3 of excavation for every metre dug. The borrow pit should be on the rice side of the bund.

iii. Main drains A total of 17 km of main drains are needed. This total includes the drain passing through the coconut area. 4.5 km of these drains are required in Stage 1 and the remaining 12.5 km in Stage 2. The reserve for these will be 30 m wide and the drains will average 2 m in depth and require 10 m^3 of excavation for every metre dug.

iv. Stream clearing 5 km of existing streams will be incorporated in the drainage system. These will require some realignment and straightening. No land acquisition is provided for this work as it is assumed that these streams are not on private land. It is estimated that the excavation required will average 5 m^3 for every metre of drains. 0.5 m of these streams are in Stage 1.

B. Structures

i. Kruin gate This will take the form of a twin 1.5 m x 1.5 m box culvert with flap gates fitted on the river end and screw down gates on the scheme end. The gate will be comparable in size with the Sg. Sebandi gate at Nonok, but access for construction will be easier. The cost has therefore been estimated at $140 000 which was the cost of the Sebandi gate. This gate will be required for Stage 2 of the scheme.

ii. Rembus gate Similar to the Kruin gate but a single barrel 1.5 m x 1.5 m structure. Estimated to cost $80 000.

iii. South gate The same as the Rembus gate but only a 1.2 m x 1.2 m barrel. Estimated to cost $60 000.

iv. Check structures These are located in the main drains within the rice areas. Their purpose is to enable the water in the drains to be maintained at a higher level during the rice season; thus assisting field flooding, but will allow full drainage at other times. These structures will consist of simple box culverts with stop logs in the shape of a duck bill weir. They are estimated to cost $7 500 each and four will be required in Stage 1 and 12 in Stage 2.

v. Access bridges Additional tractor access bridges will be required to facilitate tractor movement. Three are needed in Stage 1 and seven in Stage 2. They are estimated to cost $4 000 each.

vi. Culverts These are needed at the junctions of the internal and perimeter bunds to connect their perimeter borrow pit drains. They will also be needed to form additional access bridges. Seven are required in Stage 1 and 13 in Stage 2.

Agricultural works estimate

The estimate for the Agricultural Works required for the scheme is shown in the Table 4. The following is an explanation of the items and quantities used in this estimate.

A. *Rice land clearing*

Measurements have been made from the 1975 air photography of the present land use in the two stages of the scheme. In the rice areas it is intended that the whole area be cleared and destumped. For this it is presumed that the existing rice areas, totalling 106 ha in Stage 1 and 457 ha in Stage 2, require no further clearing or destumping. Costs for clearing and destumping the remaining 79 ha in Stage 1 and 268 ha in Stage 2 are itemised (Table 4).

TABLE 4 Estimate of agricultural works, Lower Samarahan Scheme

ITEM	UNIT	STAGE I			STAGE 2			TOTAL		
		Quantity	Rate	Amount $	Quantity	Rate	Amount $	Quantity	Rate	Amount $
A. RICE LAND CLEARING	ha	185			725			910		
Primary forest	ha	12	1 200	14 400				12	1 200	14 400
Old secondary forest	ha	31	750	23 250	134	750	100 500	165	750	123 750
Young secondary forest	ha				81	300	24 300	81	300	24 300
Nipah	ha	3	800	2 400	11	800	8 800	14	800	11 200
Rubber	ha	5	600	3 000				5	600	3 000
Coconut	ha	28	500	14 000	42	500	21 000	70	500	35 000
Total		79		57 050	268		154 600			211 650
B. RICE LAND TILLING										
1st plough	ha	79	50	3 950	268	50	13 400	347	50	17 350
1st rake	ha	79	50	3 950	268	50	13 400	347	50	17 350
1st harrow	ha	185	20	3 700	725	20	14 500	910	20	18 200
2nd plough	ha	185	25	4 625	725	25	18 125	910	25	22 750
2nd rake	ha	185	25	4 625	725	25	18 125	910	25	22 750
1st rotovate	ha	185	30	5 550	725	30	21 750	910	30	27 300
Total				26 400			99 300			125 700
C. SECONDARY DRAINS (RICE AREA)	km	37	320	11 840	145	320	46 400	182	320	58 240
TOTAL RICE AREA	ha	185		95 290	725		300 300	910		395 590
D. COCONUT LAND CLEARING	ha	18	300	5 400	20	300	6 000	38		11 400
E. SECONDARY DRAINS (COCONUT AREA)	km	40	320	12 800	75	320	24 000	115	320	36 800
TOTAL COCONUT AREA	ha	98		18 200	187		30 000	285		48 200
SCHEME TOTAL	ha	283		$ 113 490	912		$ 330 300	1 195		$ 443 790

B. Rice land tilling

As described in the introduction, to get the land into reasonable shape for cultivation will require a number of passes of tractors using various implements. This is intended as a once-only process as, after completion of this work and subsequent drainage, it will be possible in future years to plough or rotovate the land in a single operation. The total cost of this primary work is calculated to be $200/ha in the case of recently cleared land and $100 in the case of existing rice land. This would compare with subsequent operations of $30/ha for rotovation and $25/ha for ploughing.

C. Secondary drains (rice area)

Secondary drains will be required in the rice area at 50 m intervals. This is equivalent to 20 km of drain for every 100 ha. It is intended that initially these drains would be dug by hydraulic excavator. This type of machine can construct drains 1 m deep at a rate of 250 m a day and it is estimated that the total running cost of the machine would be $80/day. This work therefore costs $64/ha.

D. Coconut land clearing

This item is for clearing land in the coconut area that is not at present under either rice or coconut. This amountsto 18 ha in Stage 1 and 20 ha in Stage 2. No destumping is required and a rate of $300 is used for this work.

E. Secondary drains (Coconut Area)

It is proposed that secondary drains are dug in the coconut area by machine, similar to those proposed for the rice area. These drains should be spaced 25 m apart, i.e. 40 km of drain per 100 ha of coconut land. The rate for this work is $320/km, which works out at $128/ha.

Agricultural equipment estimate

Table 5 gives the estimate for the equipment required to undertake the agricultural works and afterwards provide a tractor service for the scheme.

Tractors These should be agricultural tractors of at least 80 hp. They should each be supplied with the following tools:-

i. 3-furrow disc ploughs for general ploughing
ii. Spring-tine tiller for root extraction
iii. Disc harrow for land levelling
iv. 70" rotovator for tilling land for rice
v. Cage wheel assemblies for working on soft ground
vi. Ridger for land preparation for off-season crops

It is estimated that tractors to this specification with these implements will cost $40 000 each.

Tractor spares In addition to the tractors it is necessary to carry 10% of their cost in spares to prevent unnecessary delays due to breakdown and maintenance.

Excavators In order to undertake the construction of the secondary drains (C. and E. in the Agricultural Works estimate), it is recommended that a tracked hydraulic excavator be purchased. This machine will be able to complete the target drainage programme in the rice area in 3 years, after which it would be available to undertake drain digging in the coconut areas: this would take a further year. A machine similar to one at present in operation with the Drainage and Irrigation Department would cost $150 000 and would be suitable for this work.

Excavator spares 10% spares should be kept on site for the excavator.

Minor equipment This would include some extra implements for the tractors such as a land plane and mole board ridger and ditcher equipment. $20 000 is allocated for this.

Workshop unit As stated in the introduction to this chapter, the techniques involved in breaking in virgin land for cultivation and the methods of efficient economical cultivation require expertise not at present available in Sarawak. Training of operators, maintenance and repair of tractors and equipment will require the services of an agricultural engineer during the first few years of operation. This man would have to be found in Peninsular Malaysia or elsewhere. In order to take full advantage of this engineer's potential, workshop facilities should be provided within the scheme area. $60 000 has been allowed for this.

Work programme

It is envisaged that the Stage 1 construction work will be completed in 1 year and that this will be followed immediately by Stage 2 which will be completed in a further 2 years. A slower construction schedule could be adopted but this would result in development staff being less efficiently employed and a general loss of enthusiasm on the part of the local people.

It is also envisaged that the construction of the Sg. Empila Scheme will be phased to coincide with this project and that the overall organisation of the two projects will be coordinated under a single project manager.

The achievement of this construction target will depend not only on the availability of finance, staff and equipment, but on the effective completion of the preliminary planning and design work before any construction begins. These preliminary works include the following:

i. The detailed study of land tenure and the subsequent policy decision on the methods to be adopted in effecting redistribution

ii. The publicity and acceptance of these proposals by the people within the villages affected by the scheme

iii. The detailed topographic and engineering survey of the area

iv. The design of the engineering structures, bunds and drains

v. The tender for the selection of the type of agricultural machinery

vi. The recruitment of local and expatriate staff for the construction and extension work that is to be undertaken

Table 6 is a construction bar chart which gives a general quide to the sequence of scheme implementation. It is presumed that the preliminary works are undertaken during 1977 and that the construction work commences in 1978.

The critical tasks during construction will be excavation and land preparation. The former covers the construction of the bunds and drains. 100 000 m^3 of earthworks are involved and assuming 0.75 cubic metre draglines are available, four will be needed to undertake this work in the time available. A high level of supervision and service will be needed by these machines if the required output of 5 000 m^3 per machine is to be achieved. The necessity for land preparation makes the delivery of tractors and rapid training of operators crucial. Every available day of the dry season will be needed for the difficult task of the first cultivation of this land in order to have it ready for the 1978 rice season.

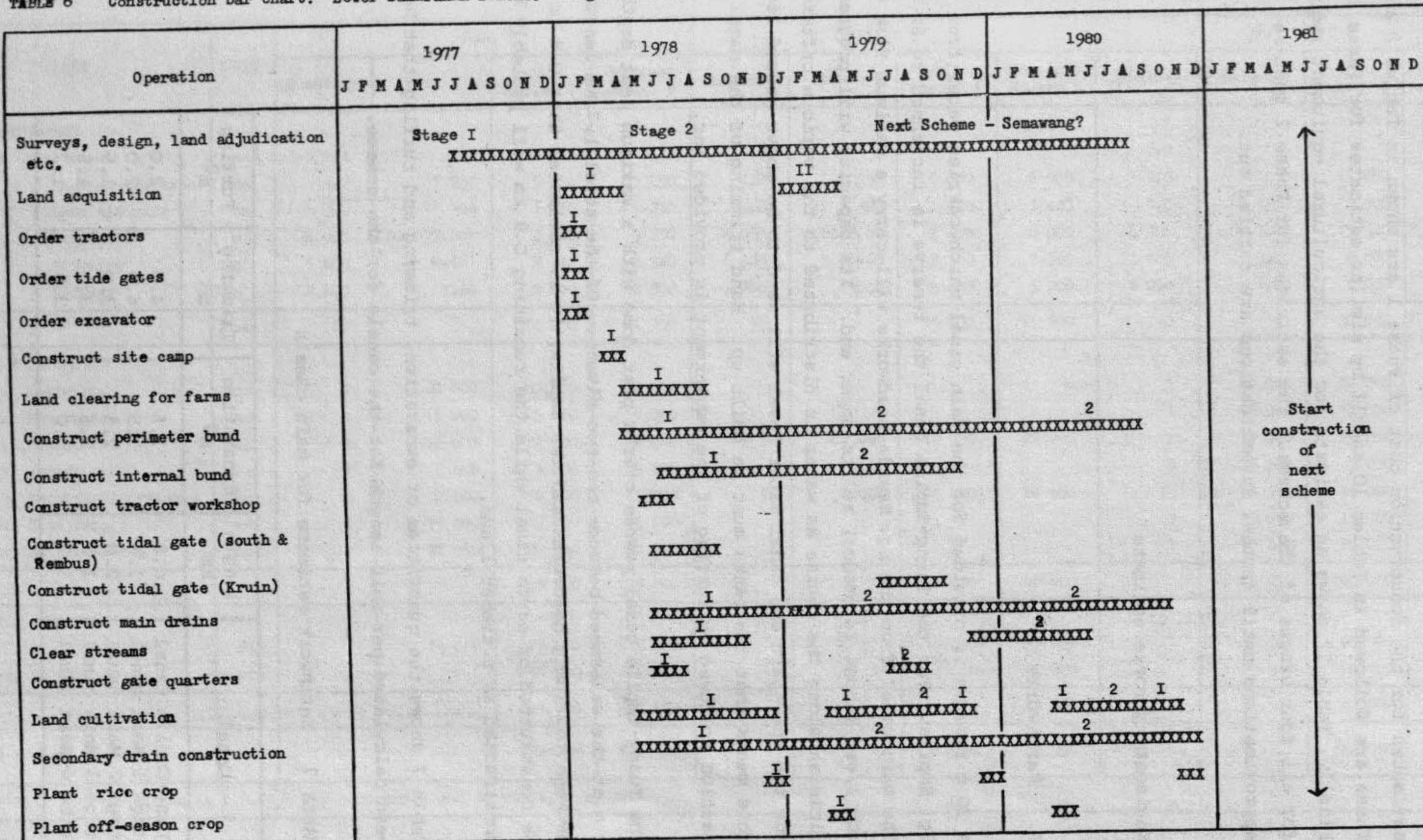
THE SUNGEI EMPILA SCHEME

This scheme is to irrigate 400 ha for double cropped rice. The proposals suggest development in four stages (two phases each of two stages):

Phase 1	Stage 1	80 ha
	Stage 2	90 ha
Phase 2	Stage 3	70 ha
	Stage 4	160 ha

Water for the first two stages (Phase 1) will be available from the Sg. Empila. Design, construction and maintenance of this phase are therefore relatively simple and cheap. However, Phase 2 requires a supplementary water supply carried by canal from Sg. Tuang. This proposal will require further studies before its viability can be confirmed. Moreover, once a canal from Sg. Tuang has been completed, there are possibilities of further extensions to the scheme to a total of about 1 000 ha. The general layout is shown on Plate 2.

TABLE 6 Construction bar chart: Lower Samarahan Scheme. Stage I and II



Note:- Where applicable the stage refered to is shown above the relevant bar in the chart

9 1 10

Estimates for the construction cost of Phase 1 are shown in Tables 8 and 9. These are followed in Tables 10 and 11 by similar estimates for Phase 2. Finally, Table 12 shows an estimate for the agricultural equipment required for all four stages of the scheme. The estimates for Phase 2 must be approximations until further investigations are carried out.

Engineering works estimate

A. Earthworks

A 30 m reserve is provided for the main canal which carries water from the Sg. Empila. For the Tuang-Empila canal the reserve is increased to 50 m. The main canal from the Sg. Empila headworks will carry a maximum flow of 400 l/sec (about 14 cusecs) at its upper end. Its capacity will progressively diminish along the course as water is distributed to the various offtakes. For the most part the canal water level will need to be above ground level. This means that the banks must be built up. Hand trimming of the canal section followed by turfing of the embankment is provided for.

The Tuang-Empila canal passes over a peat dome with a maximum peat depth of 2 m at the watershed between the two rivers. Of the total 1.7 km length between the Tuang headworks and the Empila, it is estimated that 0.8 km will be constructed of earth canal while the remaining 0.9 km will probably be constructed as a timber flume.

Table 7 shows the quantities of excavation, trimming and turfing that have been calculated per unit length for the canals for the scheme.

TABLE 7 Earthwork estimate for main canals

Canal	Length km	Excavation m^3	Trimming m^2	Turfing m^2
Tuang-Empila Canal	0.8	3.5	4.0	2.0
Stage 1 Main canal	1.4	3.5	4.0	2.0
Stage 2 Main canal	2.0	2.5	3.0	1.5
Stage 3 Main canal	1.5	2.5	3.0	1.5
State 4 Main canal	3.2	3.0	3.5	1.75

TABLE 8 Estimate of engineering works, The Sg. Empila Scheme Phase 1 (Stage 1 and 2)

ITEM	UNIT	STAGE 1				STAGE 2				TOTAL PHASE 1			
		Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $
A. EARTHWORKS													
i. Main canal	km	1.4				1.6				3.0			
Land acquisition	ha	4.2	1 250	5 250	5 250	4.8	1 250	6 000	6 000	9.0	1 250	11 250	11 250
Land clearing	ha	4.2	300	1 260	1 260	4.8	300	1 440	1 440	9.0	300	2 700	2 700
Excavation	m^3	4 900	0.60/2.00*	2 940	9 800	4 000	0.60/2.00	2 400	8 000	8 900	0.60/2.00	5 340	17 800
Trimming	m^2	5 600	0.40	2 240	2 240	6 400	0.40	2 560	2 560	12 000	0.40	4 800	4 800
Turfing	m^2	2 800	1.00	2 800	2 800	3 200	1.00	3 200	3 200	6 000	1.00	6 000	6 000
Total	ha	80		14 490	21 350	90		15 600	21 200	170		30 090	42 550
B. STRUCTURES													
i. Headworks	no.	1	60 000	60 000	60 000					1	60 000	60 000	60 000
ii. Pumphouse	no.	1	15 000	15 000	15 000					1	15 000	15 000	15 000
iii. Pumps	no.	1	12 000	12 000	12 000	1	12 000	12 000	12 000	2	12 000	24 000	24 000
iv. Jetty	no.	1	5 000	5 000	5 000					1	5 000	5 000	5 000
v. Main canal offtakes	no.	6	2 000	12 000	12 000	7	2 000	14 000	14 000	13	2 000	26 000	26 000
vi. Site camp	no.	1	15 000	15 000	15 000					1	15 000	15 000	15 000
vii. Gate quarters	no.	1	20 000	20 000	20 000					1	20 000	20 000	20 000
Total				139 000	139 000			26 000	26 000			165 000	165 000
C. MISCELLANEOUS													
i. River transport	sum		15 000	15 000	15 000		10 000	10 000	10 000		25 000	25 000	25 000
ii. Contingencies	sum			16 000	16 000			4 000	4 000		20 000	20 000	20 000
Total				31 000	31 000			14 000	14 000			45 000	45 000
PHASE 1 TOTAL				184 490	191 350			55 600	61 200			240 090	252 550

* The rate for excavation is \$ 2.00/m^3 by contractor and 60 cents/m^3 by DID

TABLE 9 Estimate of agricultural works, The Sg. Empila Scheme (Phase 1) Stage 1 and 2

ITEM	UNIT	STAGE 1			STAGE 2			TOTAL PHASE 1		
		Quantity	Rate $	Amount $	Quantity	Rate $	Amount $	Quantity	Rate $	Amount $
A. LAND CLEARING										
Primary forest	ha	4	1 200	4 800				4	1 200	4 800
Old secondary forest	ha	3	750	2 250	3	750	2 250	6	750	4 500
Young secondary forest	ha	15	300	4 500	1	300	300	16	300	4 800
Coconut	ha	18	500	9 000	16	500	8 000	34	500	17 000
Total		40		20 550	20		10 550	60		31 100
B. LAND TILLING										
1st plough	ha	40	50	2 000	20	50	1 000	60	50	3 000
1st rake	ha	40	50	2 000	20	50	1 000	60	50	3 000
1st harrow	ha	80	20	1 600	90	20	1 800	170	20	3 400
2nd plough	ha	80	25	2 000	90	25	2 250	170	25	4 250
2nd rake	ha	80	25	2 000	90	25	2 250	170	25	4 250
1st rotovate	ha	80	30	2 400	90	30	2 700	170	30	5 100
Total				12 000			11 000			23 000
C. SECONDARY CANALS	km	3.6	640	2 304	5.7	640	3 648	9.3	640	5 952
D. SECONDARY DRAINS	km	3.6	320	1 152	5.7	320	1 824	9.3	320	2 976
PHASE 1 TOTAL				36 006			27 022			63 028

TABLE 10 Estimate of engineering works, The Sg. Empila Scheme (Phase 2) Stage 3 and 4 and Scheme total

ITEM	UNIT	STAGE 3				STAGE 4				TOTAL SCHEME (PHASE 1 AND 2)			
		Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $
A. EARTHWORKS													
i. Main canal	km	1.5				3.2				6.7			
Land acquisition	ha	4.5	1 250	5 625	5 625	9.6	1 250	12 000	12 000	23.1	1 250	28 875	28 875
Land clearing	ha	2.0	300	600	600	4.0	300	1 200	1 200	15.0	300	4 500	4 500
Excavation	m^3	3 750	0.60/2.00	2 250	7 500	9 600	0.60/2.00	5 760	11 520	22 250	0.60/2.00	13 350	36 820
Trimming	m^2	4 500	0.40	1 800	1 800	11 200	0.40	4 480	4 480	27 700	0.40	11 080	11 080
Turfing	m^2	2 250	1.00	2 250	2 250	5 600	1.00	5 600	5 600	13 850	1.00	13 850	13 850
Total				12 525	17 775			29 040	34 800			71 655	95 125
ii. Tuang Empila canal													
Land acquisition	ha	8.5	1 250	10 625	10 625					8.5	1 250	10 625	10 625
Land clearing	ha	8.5	300	2 550	2 550	35	300	10 500	10 500	43.5	300	13 050	13 050
Excavation	m^3	2 800	0.60/2.00	1 680	5 600					2 800	0.60/2.00	1 680	5 600
Trimming	m^2	3 200	40c	1 280	1 280					3 200	40c	1 280	1 280
Turfing	m^2	1 600	1.00	1 600	1 600					1 600	1.00	1 600	1 600
River clearing	m^3					21 000	0.60/2.00	12 600	42 000	21 000	0.60/2.00	12 600	42 000
Total				17 735	21 655			23 100	52 500			40 825	74 155
B. STRUCTURES													
i. Empila headworks										1	60 000	60 000	60 000
ii. Empila pumphouse										1	15 000	15 000	15 000
iii. Empila pumps	no	1	12 000	12 000	12 000	2	12 000	24 000	24 000	5	12 000	60 000	60 000
iv. Jetty										1	5 000	5 000	5 000
v. Main canal offtakes	no	5	2 000	10 000	10 000	9	2 000	18 000	18 000	27	2 000	54 000	54 000
vi. Site camp	no	1	15 000	15 000	15 000					2	15 000	30 000	30 000
vii. Gate quarters	no	1	20 000	20 000	20 000					2	20 000	40 000	40 000
viii. Tuang headworks	no	1	280 000	280 000	280 000					1	280 000	280 000	280 000
ix. Tuang pumphouse	no	1	25 000	25 000	25 000					1	25 000	25 000	25 000
x. Tuang pumps	no	1	12 000	12 000	12 000	2	12 000	24 000	24 000	3	12 000	36 000	36 000
xi. Tuang flume	km	0.9	30 000	27 000	27 000					0.9	30 000	27 000	27 000
Total				401 000	401 000			66 000	66 000			632 000	632 000
C. MISCELLANEOUS													
i. River transport	sum			10 000	10 000	sum		5 000	5 000	sum		40 000	40 000
ii. Contingencies	sum			35 000	35 000	sum		10 000	10 000	sum		65 000	65 000
Total				45 000	45 000			15 000	15 000			105 000	105 000
PHASE 2 TOTAL				476 260	485 430			133 140	168 300	SCHEME TOTAL		849 490	906 280

TABLE 11 Estimate of agricultural works, The Sg. Empila Scheme Phase 2 (Stage 3 and 4) and scheme total

ITEM	UNIT	STAGE 3			STAGE 4			TOTAL SCHEME (PHASES 1 AND 2)		
		Quantity	Rate $	Amount $	Quantity	Rate $	Amount $	Quantity	Rate $	Amount $
A. LAND CLEARING										
Primary forest	ha				2	1 200	2 400	6	1 200	7 200
Old secondary forest	ha				6	750	4 500	12	750	9 000
Young secondary forest	ha				-	-		16	300	4 800
Rubber	ha				10	600	6 000	10	600	6 000
Coconut	ha	11	500	5 500	20	500	10 000	65	500	32 500
Total		11		5 500			22 900			59 500
B. LAND TILLING										
1st plough	ha	11	50	550	38	50	1 900	109	50	5 450
1st rake	ha	11	50	550	38	50	1 900	109	50	5 450
1st harrow	ha	70	20	1 400	160	20	3 200	400	20	8 000
2nd plough	ha	70	25	1 750	160	25	4 000	400	25	10 000
2nd rake	ha	70	25	1 750	160	25	4 000	400	25	10 000
1st rotovate	ha	70	30	2 100	160	30	4 800	400	30	12 000
Total				8 100			19 800			50 900
C. SECONDARY CANALS	km	3.0	640	1 920	4.6	640	2 944	16.9	640	10 816
D. SECONDARY DRAINS	km	3.0	320	960	4.6	320	1 472	16.9	320	5 408
PHASE 2 TOTAL				16 480			47 116	SCHEME TOTAL		126 624

TABLE 12 Agricultural equipment estimate, government tractor service, Sg. Empila scheme

ITEM	UNIT	RATE $	STAGE 1		STAGE 2		STAGE 3		STAGE 4		TOTAL SCHEME	
			Quantity	Amount $	Quantity	Amount $	Quantity	Amount $	Quantity	Amount $	Quantity	Amount $
Tractors	no	40 000	2	80 000	1	40 000	1	40 000	2	80 000	6	240 000
Tractor spares	sum			8 000		4 000		4 000		8 000		24 000
Minor equipment	sum			20 000						10 000		30 000
Total				108 000		44 000		44 000		98 000		294 000

ix The Tuang pumphouse As with the Empila, this pumphouse must be raised 2 m above ground level to avoid flood damage. The house will be similar to the Empila pumphouse, providing space for a total of five pumps. A sum of $25 000 is estimated for this structure.

x. Tuang pumps These will be similar to those at the Empila pumphouse, each having a maximum capacity of 150 l/sec. They will be installed progressively with the completion of each stage of the scheme.

xi. Tuang flume 0.9 km of the distance between the Tuang headworks and the Sg. Empila is either in deep peat or requires a high level canal. These sections will be more economically constructed by using a steel lined timber flume supported on timber piles. The type of structure would be similar to the flume used at the Tanjong Purun scheme near Lundu, but the flume would be about twice the size of the Purun flume. A cost of $30 000/km has been estimated for this work.

Agricultural works estimate

As in the Lower Samarahan Scheme, it is proposed that all the rice fields are cleared as part of the construction work and also cultivated by machine during the initial years. Tables 9 and 11 show the estimates for this work, for the first two stages and the complete scheme. Mechanised land preparation follows the same pattern as that described for the Lower Samarahan Project and the same rates are used for land clearing and tilling.

For the irrigation of the rice fields, secondary canals are proposed at 200 m intervals to connect with the offtake structures. These are relatively small and a rate of $640/km is taken for this work. In order to achieve rapid drainage, secondary drains are sited between the secondary canals. These are estimated to cost $320/km. Both canals and drains can be formed with tractor-drawn implements. The canals however will require some hand trimming, hence the higher rate.

Cost estimates

Cost estimates for the engineering works are shown in Table 14. These follow a similar pattern to those for the Sg. Empila Scheme. It is proposed that the main canals are lined. The reason for this is two-fold. First, the canal will be raised above ground level in order to have command over the land irrigated. This would make an unlined canal subject to high seepage losses which would greatly increase the pumping costs. A lined canal would be impermeable and have no losses of this type. Secondly, the area is subject to occasional flooding. A lined canal would be less prone to flood damage than an unlined canal.

Pumphouses and pumps

These would be similar to those required for the Sg. Empila Scheme. The wide variation in river level caused by the tide will mean that river bank installation with sloping axial flow pump units will be the most suitable.

Offtakes

Simple offtakes to supply secondary canals at 200 m intervals have been allowed for. A secondary drain will be sited between each secondary canal. Since the land is virtually flat, irrigation can be supplied from each side of the secondary canals so a layout of lots 100 m wide with a secondary drain one side and canal the other would provide each lot with complete water control. It is envisaged that secondary canals and drains will be constructed with the agricultural equipment and are included in the agricultural cost estimate (Table 15).

Of the four stages, Stage 1 (Gumpeh) and Stage 3 (Larang) are sited on the Gedong side of the Batang Sadong. These two stages therefore have land access to the main road and draglines and tractors could reach these stages without the need for landing craft. The other two stages are on the far bank of the river and the use of landing craft is unavoidable.

TABLE 14 Estimate of engineering works, The Gedong Scheme

ITEM	UNIT	Stage I (Gumpeh)				Stage 2 (Paoh)				Stage 3 (Larang)				Stage 4 (Tajo)				Total Scheme			
		Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $	Quantity	Rate $	DID amount $	Contract amount $
A. EARTHWORKS																					
MAIN CANAL	km	1.4				2.1				1.4				1.8				6.7			
Land acquisition	ha	4.2	1 250	5 250	5 250	6.3	1 250	7 875	7 875	4.2	1 250	5 250	5 250	5.4	1 250	6 750	6 750	20.1	1 250	25 125	25 125
Land clearing	ha	4.2	300	1 260	1 260	6.3	300	1 890	1 890	4.2	300	1 260	1 260	5.4	300	1 620	1 620	20.1	300	6 030	
Excavation	m^3	2 450	0.60/2.00	1 470	4 900	3 675	0.60/2.00	2 205	7 350	2 450	0.60/2.00	1 470	4 900	3 150	0.60/2.00	1 890	6 300	11 725	0.60/2.00	7 035	23 450
Trimming	m^2	2 800	0.40	1 120	1 120	4 200	0.40	1 680	1 680	2 800	0.40	1 120	1 120	3 600	0.40	1 440	1 440	13 400	0.40	5 360	5 360
Lining	m	1 400	900	12 600	12 600	2 100	900	18 900	18 900	1 400	900	12 600	12 600	1 800	900	16 200	16 200	6 700	900	60 300	60 300
Turfing	m^2	1 400	100	1 400	1 400	2 100	100	2 100	2 100	1 400	100	1 400	1 400	1 800	100	1 800	1 800	6 700	1 000	6 700	6 700
Total				23 100	26 530			34 650	39 795			23 100	26 530			29 700	34 110			110 550	126 965
B. STRUCTURES																					
i. Pumphouse	No	1	5 000	5 000	5 000	1	5 000	5 000	5 000	1	5 000	5 000	5 000	1	5 000	5 000	5 000	4	5 000	20 000	20 000
ii. Pump	No	1	12 000	12 000	12 000	1	12 000	12 000	12 000	1	12 000	12 000	12 000	1	12 000	12 000	12 000	4	12 000	48 000	48 000
iii. Offtakes	No	6	500	3 000	3 000	8	500	4 000	4 000	6	500	3 000	3 000	8	500	4 000	4 000	28	500	14 000	14 000
iv. Site camp	No	1	5 000	5 000	5 000	1	5 000	5 000	5 000	1	5 000	5 000	5 000	1	5 000	5 000	5 000	4	5 000	20 000	20 000
v. Gate quarters	No	1	15 000	15 000	15 000	1	15 000	15 000	15 000	1	15 000	15 000	15 000	1	15 000	15 000	15 000	4	15 000	60 000	60 000
Total				40 000	40 000			41 000	41 000			40 000	40 000			41 000	41 000			162 000	162 000
C. MISCELLANEOUS																					
i. River transport	Sum		5 000	5 000	5 000		8 000	8 000	8 000		5 000	5 000	5 000		8 000	8 000	8 000			26 000	26 000
ii. Contingencies	Sum		5 000	5 000	5 000		7 000	7 000	7 000		5 000	5 000	5 000		7 000	7 000	7 000			24 000	24 000
Total				10 000	10 000			15 000	15 000		10 000	10 000	10 000			15 000	15 000			50 000	50 000
STAGE TOTALS				73 100	76 530			90 650	95 795			73 100	76 530			35 700	90 110	TOTAL SCHEME		322 550	338 965

TABLE 15 *Estimate of agricultural works, The Gedong Scheme*

ITEM	UNIT	STAGE 1			STAGE 2			STAGE 3			STAGE 4			SCHEME TOTAL		
		Quantity	Rate $	Amount $	Quantity	Rate $	Amount $	Quantity	Rate $	Amount $	Quantity	Rate $	Amount $	Quantity	Rate $	Amount $
A. LAND CLEARING																
Old secondary	ha	8	750	6 000	13.5	750	10 125	13	750	9 750	15	750	11 250	49.5	750	37 125
Rubber	ha										12	600	7 200	12	600	7 200
Coconut	ha	37	500	18 500				39	500	19 500	12	500	6 000	88	500	44 000
Young secondary	ha				13.5	300	4 050	6.5	300	1 950	10	300	3 000	30	300	9 000
Total				24 500			14 175			31 200			27 450			97 325
B. LAND TILLING																
1st plough	ha	45	50	2 250	27	50	1 350	58.5	50	2 925	49	50	2 450	179.5	50	8 975
1st rake	ha	45	50	2 250	27	50	1 350	58.5	50	2 925	49	50	2 450	179.5	50	8 975
1st harrow	ha	53	20	1 060	90	20	1 800	65	20	1 300	60	20	1 200	268	20	5 360
2nd plough	ha	53	25	1 325	90	25	2 250	65	25	1 625	60	25	1 500	268	25	6 700
2nd rake	ha	53	25	1 325	90	25	2 250	65	25	1 625	60	25	1 500	268	25	6 700
1st rotovate	ha	53	30	1 590	90	30	2 700	65	30	1 950	60	30	1 800	268	30	8 000
Total				9 800			11 700			12 350			10 900			44 750
C. SECONDARY CANALS	km	2.9	640	1 856	5	640	3 200	3.2	640	2 048	2.8	640	1 792	13.9	640	8 896
D. SECONDARY DRAINS	km	2.9	320	928	5	320	1 600	3.2	320	1 024	2.8	320	896	13.9	320	4 448
STAGE TOTALS				37 084			30 675			46 622			41 038	SCHEMED TOTAL		155 419

Site camp and gate quarters

These are estimated at $5 000 and $15 000 respectively on each of the four stages.

THE SUNGAI KUALA AREA

As described in the main report, this area totals 385 ha of which about 175 ha is already cleared and cultivated. It is suggested that it might be developed as a resettlement project for landless families. With some rationalisation of the existing farms, the area could absorb 100 families of settlers.

The virgin area is under heavy forest. This will require felling and burning, but as hand cultivation is intended, destumping will not be necessary initially. In addition, a main drain is needed, running down the middle of the area parallel to the two existing streams and joining Sg. Kuala Ilir near the road. This drain will be 6 km long and would have to be built by dragline excavator.

Apart, therefore, from forest clearing, drain construction and land acquisition, costs of settlement will be in the form of settler subsidies and extension services. The tabulation below shows an estimate for the former costs:

Land clearing	210 ha @	300	63 000
Main drain	6 km @	6 000	36 000
Land acquisition	90 ha @	1 250	112 500
		Total	$211 500

APPENDIX 10 ECONOMIC ASSESSMENT OF DEVELOPMENT PROPOSALS

INTRODUCTION

Systematic data on the main economic variables of the study areas are rather sparse; it is not possible, therefore, to carry out a definitive economic analysis of the proposals being put forward by the Mission. Nevertheless, an attempt has been made on a rather tentative basis to set out the costs and benefits which are thought likely to be associated with the proposed developmentsin order to shed some light on whether or not the follow-up studies and the initial stages of development are themselves worth undertaking.

The approach involves estimating the difference in costs and benefits in the areas under study between a situation where development proceeds on the basis recommended by the Mission, and an alternative situation marked by the absence of any special effort of the sort favoured by the Mission. Exercises along these lines have been undertaken for each of two possible developments in the study areas, the Lower Samarahan Drainage project and the Empila Irrigation and Drainage project. Apart from the paucity of data on local price and cost levels, input-output relationships, sources and levels of off-farm income, land tenure and so on, the problems of the analysis are aggravated by the intermixture of land uses in the study areas. This complicates the estimation of current costs and returns and makes it difficult to define the benefits likely to flow from development.

The economic analysis is confined to the Samarahan project and Stages I and II of the Empila project, but the results of these studies should have wider application to other parts of the study areas also.

METHODS

A successful project must obviously appeal to participating farmers in commercial terms i.e. it must be profitable at producer level. One component of the analysis focuses, therefore, on farm costs and returns and indicates the order of net benefits that are likely to accrue to farmers participating in the respective projects; this is the commercial analysis and it is based essentially on estimated local market costs and returns. In addition an attempt has been made to analyse costs and benefits from the viewpoint of society as a whole, ignoring the effects of subsidies and attaching a cost to family labour, and in general using real economic values in so far as they can be defined; this is the social cost-benefit analysis and it is based on adjusted local market prices and costs. A third set of calculations for each project comprising the financial analysis is also presented showing the budgetary implications of each project in terms of the net flow of government expenditure over time associated with the establishment, operation and maintenance of the projects. The financial analysis is based on estimated expenditure and revenue of the various departments involved, calculated at market prices.

The derivation of the prices and costs entering into the analyses will now be discussed in more detail. International price projections are available up to 1985 and for purposes of the analysis future prices are based on the estimates for that year, expressed in terms of 1975 money values.

PRICE DERIVATION

Social cost-benefit analysis

Rice

The Lembaga Padi Dan Beras Negara (LPN) is currently the sole importer of rice into Sarawak. Imported rice is sold to wholesalers at 9 market centres throughout the State and although there is no statutory control over the retail price the LPN recommends the price level at which its rice should be sold to consumers. The current recommended price for Thai 10% is M$1.07/kg (M$3.90 per gantang). It is reported that when prices on the international market are high the recommended retail price is lower than the equivalent international trade price and vice-versa when world market prices are depressed. Consumers are thus protected from the worst effects of high prices and producers are cushioned when world market prices fall to abnormally low levels. Conversely, consumers do not reap the full benefit of depressed international prices, nor do producers realise fully the advantages of buoyant world markets for rice.

Since the working of the internal market is distorted due to constraints on trade, it is necessary for purposes of the social cost-benefit analysis to determine an adjusted (shadow) price for padi which will reflect more accurately than actual market prices the real value of local production. Since Sarawak imports a significant portion of its rice requirements, additional production within the state can best be valued in terms of the c.i.f. price of imported rice for which local rice would substitute, adjusted to cover handling charges and marketing margins. In the approach followed here, a simple average was first calculated of the c.i.f. price of imported rice over the 6 years 1970-75. Then f.o.b. prices Bangkok for 5% Thai rice were converted into terms of M$ and averaged over the same period and the following ratio calculated:

<u>Average c.i.f. price Sarawak</u> (Ref. p. 10-10)
Average f.o.b. price Bangkok

The resulting coefficient was then applied to the projected 1985 Bangkok price, expressed in 1975 constant $ terms, to arrive at an equivalent c.i.f. Sarawak price in 1985. This was then taken as the basis for the shadow price; it was converted to a 1985 padi price equivalent at producer level of M$ 463/t (M$ 28 per picul) by means of various adjustments to cover handling, transporting, milling and marketing margins as shown in Table 1A. Finally, the padi price thus derived was adjusted upwards by 7% to allow for the premium usually enjoyed in the market by local rice over imported rice due to consumer preference for the former.

Maize and soyabeans

Annual imports of maize and soyabeans into Sarawak averaged 22 000 t and 1 500 t respectively over the period 1970-75. Production of both crops is currently very limited in the study areas, but if output could be raised in the future, both commoditites are likely to act as import substitutes. There are no import duties on maize or syoabeans, neither are there any internal constraints on trade, so producer prices should reflect quite closely the real economic value of these crops. Producer prices for the First Division are not widely or frequently quoted for maize or soyabeans, however, and such quotations as do exist may therefore be relatively unreliable. Thus an attempt has been made to derive producer prices that are equivalent to c.i.f. prices using a procedure similar to that employed in the case of rice. The details of the procedure appear on Table 1B for maize and Table 1C for soyabeans. Future prices of local maize and soyabeans are assumed to follow those for US no. 2 yellow maize, f.o.b. Gulf ports, and US soyabeans, c.i.f. Rotterdam, respectively. The calculations result in the following price estimates: Maize - M$ 362 per t (M$ 19.7 per picul); Soyabeans - M$ 785 per t (M$ 47.5 per picul).

Copra

Most of the copra produced in Sarawak is converted into coconut oil which is either used locally or exported. Small quantities of copra, copra cake and refined coconut oil are, however, imported into Sarawak. Additional copra produced as a result of the kind of developments proposed in the report should contribute to an expansion of exports, and adjusted prices have been arrived at on the basis of this assumption. In order to simplify the analysis projected prices for Sarawak copra are based on comparison between wholesale copra prices in Kuching and expected c.i.f. prices of Indonesian and Philippine copra in Rotterdam, rather than on a comparison involving all the various individual products of copra processing entering into Sarawak's external trade. Copra and its products are free of trade tariffs, so wholesale prices should reflect price movements in the international market and, in the absence of internal trade constraints, be closely linked to producer price levels.

In calculating the average wholesale price of copra in Kuching, grades 2 and 3 were each given a weighting double that of grade 1 to reflect the relative importance of these grades in the market. The details of the price breakdown are presented in Table 1D. The projected price is M$ 436 per t (M$ 26.4 per picul).

Cocoa beans

Cocoa is a relatively new crop in Sarawak and no price data relating to this product are available. Data from Sabah have, therefore, been used as the basis for price projections on the assumption that trading conditions in Sarawak will correspond closely to those in Sabah. Cocoa beans will be an export commodity and the starting point for the derivation of an adjusted price is the price of dry beans f.o.b. Sabah. This is then related to the projected spot price of Ghanaian beans in New York in arriving at a future adjusted produer price. The details of the calculations are presented in Table 1E.

Inputs and services

All items of equipment to be purchased for the development of the project areas are valued at local delivered prices, 1975, which are free of import duties but allow normal trading margins. Operating charges are also applied at normal commercial rates. Manual labour used in the production process is assumed to be local kampong labour which is not a marketed item, since it usually consists of family or exchange labour. A shadow price has to be assigned to this resource since local labour has a positive opportunity cost. Accurate assessment of the opportunity costs of labour requires far more data than are available to this Mission. At this stage, however, it is sufficient to estimate the opportunity cost using broad approximations, which can be refined later.

In the landas season land preparation for padi production is a major pre-occupation of the menfolk. On its completion they may engage in off-farm work. Most of the other padi production operations are carried out by the women, including transplanting, weeding and harvesting.

In the off-season employment on the farm is at a low level in the study areas, except for small scale production of rubber, copra and off-season annual crops. Cash income is earned, however, by a proportion of the work force in occupations outside the immediate locality of the kampong, such as timber work. The menfolk also occupy themselves in the off-season with house maintenance, hunting and fishing, while the women may angage in mat-making. It is very difficult at this juncture to place a specific value on labour which would be absorbed into crop production following investment in drainage and irrigation operations and no more than a rough estimate is possible. The shadow wage rate used for present purposes is specified as M$ 4 per day, which falls halfway between a "top" rate of M$ 7 per day associated with work in the timber yards and a "bottom" rate of M$ 1 chosen to reflect a low level of productive activity during the off-season.

Fertilisers and chemicals are subjected to various rates of import duty depending on type. Duty on fertilisers, however, is not very high, ranging from 0 up to M$ 60 per ton and can for practical purposes be ignored. This also applied to duties on chemicals; the latter are of minor importance in the calculation and here also commercial prices have been used.

The 1985 fertiliser price is based on a downward adjustment of local 1975 prices, reflecting an expected drop in value of international quotations over the next decade. In the absence of similar guidelines for other inputs and services discussed above, their future prices are assumed to be the same as those prevailing in 1975.

Commercial and financial analysis

The prices used in these analyses are estimates of the producer prices for the products, inputs and services concerned, projected to 1985 and expressed in terms of 1975 values. While the Department of Agriculture monitors prices received by producers at a number of locations, little processing has been carried out on the price records and no published data are available. Systematic analysis of the records is needed before future price projections can be based on this source. During the visit of the Mission a rough attempt was made to calculate monthly average prices for several commodities at a number of market centres in the First Division as an aid in arriving at price projections. The latter were, however, assumed to be identical to the adjusted prices derived earlier for reasons discussed below.

For padi, producer price quotations at Simunjan, Serian and Muara Tuang were analysed to arrive at an estimate of the 1975 wet padi price in the study areas; this came to M$ 430 per t (M$ 26 per picul). One approach to estimation of future padi price levels would be to weight this average by the ratio:

$$\frac{\text{Internationally projected price for 1985 (in constant 1975 \$)}}{\text{Actual international prices in 1975}}$$

It would be rather risky to do this, however, on the basis of only one year's producer price data, and bearing in mind that in some years producer price may be supported at an artificially high level by government and in other years may be artificially depressed, depending on pricing policy. In view of these uncertainties it was decided to use the same price in the commercial and financial analyses as that derived for purposes of the social cost-benefit analysis (M$ 463 per t, M$ 28 per picul).

There is no very obvious reason why the price of maize and soya beans in local markets should be very different from the adjusted prices derived for purposes of the cost-benefit analysis. Data in an unpublished Agricultural Department study of maize production in the First Division in 1974 indicates that producers received M$ 404 per t (M$ 24.4 per picul), excluding quotations from Kuching market. This was a year when prices were very high on the international market and in real terms the 1985 price level is expected to be only 70% of that in 1974. Taking account of this and allowing for inflation to 1975, the adjusted price derived for 1985 in constant $ (M$ 326 per t, 19.7 per picul) appears to be fairly close to what producers can expect to receive.

The adjusted price for soya beans (M$ 785 per t, 47.5 per picul) seems a little low in relation to reported market levels in the First Division in 1975 (M$ 45 per picul) since prices are expected to rise by 26% in real terms over the decade to 1985. But in 1975 local prices may have been high relative to international levels (this was so for the c.i.f. Sarawak price of soya beans) and if an allowance is made for this the adjusted price would seem to be fairly close to the likely level of producer prices.

Records of producer prices of copra by grade are maintained at a number of market centres in or near the study areas. No data are available on the quantities of each grade marketed or on the distribution of the flow of produce over the year. Supplies seem to be greatest during May-October and least over February-April and if weights of 6 and 1 are attached to the average price for each of these periods respectively and a weight of 3 to the remaining period (November-January), the overall average for smoked copra at Simunjan and Muara Tuang in 1975 works out at M$ 380 per t (M$ 23 per picul). Projected to 1985, using the ratio of 1985:1975 prices at Rotterdam gives a figures of M$ 556 per t (M$ 33.6 per picul) which is much higher than the calculated adjusted price (M$ 436 per t). The latter estimate has been employed in all three forms of the analysis, however, since an approximation of producers' prices in a single year is an inadequate basis for forward projection.

For cocoa there are no producer price data available and it has been assumed that producers prices are identical with adjusted prices.

All inputs and services entering into the commercial and financial analyses are valued at the prices commanded in the market in 1975.

Data used in calculating adjusted prices together with the details of the calculation are presented in the following pages (Table 1). The presentation for each commodity of interest takes up 2 pages: the first gives the international trade and prices data from which the relevant price ratio is derived; the second shows how the price is applied together with various other adjustments in arriving at adjusted prices. Price and quantity data for commodities traded by Sarawak were derived from Ngian and Wong, 1975.

TABLE 1 DATA USED IN CALCULATING ADJUSTED PRICES

A. RICE

Year	SARAWAK Imports ('000 lgt*)	('000 M$)	Price (M$/lgt)
1970	58.8	24 275	413
1971	59.2	21 160	357
1972	62.7	23 334	372
1973	69.9	42 881	613
1974	87.2	95 638	1 097
1975	36.2	36 025	995
		Total:	3 847
		Average:	641/lgt
			631/t

Year	Price fob Bangkok, 5% (US$/t)	Exchange rate (M$=US$1)	Price (M$/mt)
1970	140	3.03	424
1971	140	2.97	416
1972	140	2.81	393
1973	350	2.41	844
1974	542	2.36	1 279
1975	363	2.45	889
Total:	1 675	Total:	4 245
Average:	279	Average:	707

Price ratio: $\frac{\text{cif Sarawak}}{\text{fob Bangkok}} = \frac{631}{707} = 0.893$

* lgt = long ton = 1.016 t

A. R I C E (continued)

	$/t
Adjusted price	
Average of annual cif prices, Sarawak imports, 1970–75	M$631
Average of annual fob prices, Bangkok, 5% brokens, 1970–75	US$279
Equivalent to	M$707
Price ratio = $\frac{\text{cif Sarawak}}{\text{fob Bangkok}}$ =	= 0.89
Projected fob price, Bangkok, 1985 in constant 1975 $	US$337
Equivalent cif price, Sarawak (US$1.0 = M$2.45)	M$(337x2.45x0.89)
	= M$735
(+) Handling charges, ship to dock	12
	747
(+) LPN overheads, say 4%	30
	777
(+) Transportation to wholesaler	17
	794
(–) Transportation of local rice from mill to wholesaler	17
	777
(–) Milling charge	25
	752
(–) Transportation of padi to mill	25
	727
(–) Kampong shopkeeper's margin	50
Adjusted producer's price equivalent	M$ 677
Padi price equivalent (assuming 64% conversion)	433
(+) Price premium on local rice compared to imported (7%)	30
Adjusted producer price of wet padi	M$463

(Equivalent to M$28.0 per picul)

B. MAIZE

Year	SARAWAK Imports (lgt)	(M$1)	Price (M$/lgt)
1970	24 543	5 638 126	230
1971	22 258	5 232 971	235
1972	21 012	4 547 441	216
1973	22 116	6 725 742	304
1974	22 200	9 126 142	411
1975	18 464	7 837 549	424
	130 593		Total: 1 820
Average:	21 765		Average: 303/lgt
			298/t

	Price fob Gulf ports (US$/t)	Exchange rate (M$=US$1)	Price (M$/t)
1970	57.6	3.03	175
1971	57.6	2.97	171
1972	57.6	2.81	162
1973	98.0	2.41	236
1974	132.0	2.36	312
1975	120.0	2.45	294
Total:	522.8		Total: 1 350
Average:	87.1		Average: 225

Price ratio: $\frac{\text{cif Sarawak}}{\text{fob Gulf ports}} = \frac{298}{225} = 1.324$

B. M A I Z E (continued)

Adjusted price

	$/t
Average of annual cif prices, Sarawak imports, 1970–75	M$298
Average of annual fob prices, Gulf ports, US no 2, yellow, 1970–75	US$ 87
Equivalent to	M$225
Price ratio = $\frac{\text{cif Sarawak}}{\text{fob Gulf}}$	1.32
Projected fob price, Gulf ports, 1985, in constant 1975 $	US$107
Equivalent cif price, Sarawak (US$1.0 = M$2.45)	(M$)107x2.45x1.32 = M$346
(+) Handling charges, ship to dock	12
	358
(+) Importer's margin (5%)	18
	376
(+) Transport to trader	17
	393
(–) Transport of local maize to trader	17
	376
(–) Kampong shopkeeper's margin	50
Adjusted producer price of maize	M$326

(Equivalent to M$19.7 per picul)

C. SOYA BEANS

Year	SARAWAK Imports (lgt)	(M$)	Price (M$/lgt)
1970	1 716	733 665	428
1971	1 249	563 835	451
1972	1 405	645 711	460
1973	1 071	749 687	700
1974	1 756	1 369 954	780
1975	1 600	1 142 229	714
	Total: 8 797		Total: 3 533
			Average: 589/lgt
	Average: 1 466		580/ t

	Price cif Rotterdam, US beans (US$/ t)	Exchange rate (M$=US$1)	Price (M$/t)
1970	128	3.03	388
1971	128	2.97	380
1972	128	2.81	360
1973	290	2.41	699
1974	277	2.36	654
1975	220	2.45	539
	Total: 1 171		Total: 3 020
	Average: 195		Average: 503/t

Price ratio: $\frac{\text{cif Sarawak}}{\text{cif Rotterdam}} = \frac{580}{503} = 1.153$

C. SOYA BEANS (continued)

	$/t
Adjusted price	
Average of annual cif prices, Sarawak imports, 1970–75	M$580
Average of annual cif prices, Rotterdam, US soya beans 1970–75	US$195
Equivalent to	M$503
Price ratio: $\frac{\text{cif Sarawak}}{\text{cif Rotterdam}}$	1.15
Projected cif price, Rotterdam, in 1985 in 1975 constant $	278
Equivalent cif price Sarawak (US$1.0 = M$2.45	(M$)278x2.45x1.15 = M$783
(+) Handling charges, ship to dock	12
	795
(+) Importer's margin (5%)	40
	835
(+) Transport to trader	17
	852
(–) Transport of local soya beans to trader	17
	835
(–) Kampong shopkeeper's margin	50
Adjusted producer price of soya beans	M$785

(Equivalent to M$47.5 per picul)

D. COPRA

Year	Annual average price of copra at Kuching (M$/picul)		
Grade	1	2	3
1970	25.78	20.86	15.75
1971	26.46	20.50	16.52
1972	21.20	16.14	12.69
1973	32.78	27.24	22.37
1974	60.11	50.85	44.00
1975	28.91	23.03	20.15
Totals:	195.24	158.62	131.48
Average:	32.5	26.4	21.9
Weight:	0.2	0.4	0.4

Weighted average M$26/picul = 430/t

	Price cif Rotterdam (US$/ t)	Exchange rate (M$=US$1)	Price (M$/t)
1970	185	3.03	561
1971	185	2.97	549
1972	185	2.81	520
1973	363	2.41	875
1974	662	2.36	1 562
1975	256	2.45	627
Total:	1 836		4 694
Average:	306		782

Price ratio: $\frac{\text{Kuching price}}{\text{cif Rotterdam}} = \frac{430}{782} = 0.550$

D. C O P R A (continued)

	$/t
Adjusted prices	
Average of annual Kuching wholesale prices, 1970–75	M$430
Average of annual cif prices, Rotterdam, Indonesian and Philippines copra, 1970–75	US$306
Equivalent to	M$782
Ratio: $\frac{\text{Wholesale Kuching}}{\text{cif Rotterdam}}$	0.55
Projected cif Rotterdam price in 1985, in constant 1975 $	US$373
Equivalent wholesale price Kuching	(M$)373x2.45x0.55
	= 503
(–) Transport to Kuching	17
	486
(–) Kampong shopkeeper's margin	50
Adjusted producer price of copra	M$436

(Equivalent to M$26.4 per picul)

E. COCOA BEANS

Year	SABAH Exports (lgt)	('000 M$)	Price (M$/lgt)
1970	1 948	4 441	2 280
1971	1 986	3 583	1 804
1972	3 084	4 884	1 584
1973	3 744	8 369	2 235
1974	4 432	16 030	3 617
		Total:	11 520
		Average:	2 304/lgt
			2 268/t

Source: Agricultural Statistics of Sabah, 1974. Dept. of Agriculture Sabah.

	Spot price Ghanain beans New York (US$/ t)	Exchange rate (M$=US$1)	Price (M$/t)
1970	683	3.03	2 069
1971	683	2.97	2 029
1972	683	2.81	1 919
1973	1 433	2.41	3 454
1974	2 161	2.36	5 100
Total:	5 643	Total:	14 571
Average:	1 129	Average:	2 914

Price ratio: $\frac{\text{fob Sabah}}{\text{spot NY}} = \frac{2\ 268}{2\ 914} = 0.778$

E. C O C O A B E A N S (continued)

	$/t
Adjusted price	
Average of annual fob prices, Sabah exports, 1970–74 1/	M$2 268
Average of spot prices, Ghanain beans, New York, 1970–74	US$1 129
Equivalent to	M$2 914
Price ratio: fob Sabah / spot NY	0.78
Projected spot price NY in 1985 in constant 1975 $	US$1 062
Equivalent fob price, Sarawak	(M$)1 062x.78x2.45
	= 2 030
(–) Handling charges, dock to ship	12
	2 018
(–) Exporter's margin (4%)	80
	1 938
(–) Transport to exporter	17
	1 921
(–) Kampong shopkeeper's margin	65
Adjusted producer price of cocoa beans	1 856

(Equivalent to M$112 per picul)

1/ No price data available for Sarawak; Sabah prices used instead.

CROP LABOUR REQUIREMENTS, COSTS AND RETURNS

Tables 2-12 which follow show the Mission's estimates of labour requirements for the various crops entering into the analysis and also the per ha estimates of yield, value of output and net returns to producers and to the economy as a whole. The difference between these last two values is that in the case of the latter a deduction is made to cover the opportunity cost of farm labour. Net return before charging for labour is used as the basis for estimating producers' incomes in the commercial analysis. Net return after charging for labour is the figure which enters into the social cost-benefit analysis.

A distinction is made between conditions under the present (traditional) farming system and expected performance under the improved husbandry likely to be associated with a development scheme. The data are broken down by season, where relevant, and lower yields are assumed in the early years of development compared to later years. The sources of unit price and cost data are explained in the preceding section on price derivation.

TABLE 2 Labour requirement in padi production, man-days/ha

Season	Improved system* Landas	Improved system* Off-season (irrigated)	Traditional system* Landas
Land preparation	-	-	25
Nursery preparation and maintenance	12	12	12
Transplanting	20	20	20
Maintenance of bunds and drains	12	12	6
Weeding	25	25	30
Fertiliser application and water control	6	12	3
Pest control	5	10	5
Harvesting and transporting	25	25	25
Threshing* drying and winnowing	15	15	25
Marketing	2	2	1
Totals	122	133	152
Opportunity cost (M$)	488	532	608

*Assumes use of mechanical padi thresher

Source: Based on Wageningen report, Vol. 4, p. 73 and Huntings, Supporting Report No. 2, Part IV, p. 145.

TABLE 3 Farm costs and returns in padi production, M$/ha

Season	Improved Landas		Improved Off-season (irrigated)		Traditional Landas
Yield/ha (kg)*	2 500	2 750	2 500	3 000	2 200
Price/kg (M$)	0.46	0.46	0.46	0.46	0.46
Value of output (M$)	1 150	1 265	1 150	1 380	1 012
Less costs					
Seed	15	15	15	15	15
Rotovation/	17	17	17	17	-
Labour	-	-	-	-	-
Fertilisers	80	80	80	80	-
Pump operating costs/	-	-	32	32	-
Chemicals	-	-	-	-	-
Miscellaneous	50	50	50	50	25
Net return	988	1 103	956	1 186	972
Net return expressed per man-day	8.1	9.0	7.2	8.9	6.4
Net return - opportunity cost of labour (for social cost-benefit analysis)	500	615	424	654	364

*The lower of the yield levels under "landas" and"offseason" refers to performance in the first five years of planting and the higher yield to every year following.

/Direct costs only.

TABLE 4 Labour requirements in maize production, man-days/ha

	Improved system
Land preparation	-
Sowing	5
Application of fertilisers and chemicals	6
Weeding	15
Water control	5
Harvesting and transporting	15
Drying and shelling	15
Marketing	2
Total	63
Opportunity cost (M$)	252

Source: Based on Wageningen report, Vol. 4, p. 73.

TABLE 5 Farm costs and returns in maize production, improved system, M$/ha

Yield/ha (kg)*	1 400	2 000
Price/kg (M$)	0.33	0.33
Value of output (M$)	462	660
Less costs/ha		
Seed	10	10
Rotovation	17	17
Labour	-	-
Fertilisers	178	178
Chemicals	25	25
Miscellaneous	15	15
Net return	217	415
Net return expressed per man-day	3.4	6.6
New return - opportunity cost of labour (for social cost-benefit analysis)	-35	163

*It is assumed that yield will be relatively low for the first 5 years (1 400 kg per ha) and rise to 2 000 kg per ha thereafter.

TABLE 6 Labour requirements in soya bean production, man-days/ha

	Improved system
Land preparation	-
Sowing	5
Application of fertilisers and chemicals	6
Weeding	15
Water control	5
Harvesting and transporting	20
Drying and threshing	20
Marketing	2
Total	73
Opportunity cost (M$)	292

Source: Based on Wageningan report, Vol. 4, p. 73.

TABLE 7 Farm cost and returns in soya bean production, improved systems M$/ha

Yield/ha (kg)*	1 000	1 250
Price/kg (M$)	0.79	0.79
Value of output	790	987
Less costs/ha		
Seed	36	36
Rotovation	17	17
Labour	-	-
Fertilisers	48	48
Chemicals	25	25
Miscellaneous	15	15
Net return	649	846
Net return, expressed per man-day	8.9	11.6
Net return-opportunity cost of labour (for social cost-benefit analysis)	357	554

*It is assumed that yield will be relatively low for the first 5 years (1 000 kg/ha) and rise to 1 250 kg on average thereafter.

TABLE 7 Labour requirements for coconut plantation establishment, and production of copra (man-days/ha)

	Establishment period Improved system					Production period (year 6 and onwards) Improved system	Traditional system
Year	1	2	3	4	5		
Planting, etc.	50	-	-	-	-		
Maintenance	-	40	40	40	40	15	5
Harvesting	-	-	-	-	-	9	6
Transporting	-	-	-	-	-	24	12
De-husking) Cutting) Drying)	-	-	-	-	-	50	30
Packing sacks	-	-	-	-	-	4	2
Total	50	40	40	40	40	102	55
Opportunity cost (M$)	200	160	160	160	160	408	220

*Samarahan area only. Yields are negligible in Sadong-Krang area.

Source: Establishment labour - based on Best and Esmawi, Table Co. 4.
Production labour - based on Wageningen report, p.135

TABLE 9 Cost of establishing new coconut plantations, M$/ha

Year	1	2	3	4	5
Planting material	100	10	10	-	-
Fertilisers	-	-	-	-	-
Labour	-	-	-	-	-
Miscellaneous	15	15	15	15	15
Net return	-115	-25	-25	-15	-15
Net return - opportunity cost of labour	-315	-185	-185	-175	-175

TABLE 10 Farm costs and returns from copra production, M$/ha

Type of plantation	Improved New		Improved Existing		Traditional Existing
Period (years) following engineering works	6-9	10-30	2-5	6-50	-
Yield of copra (kg/ha)	1 000	1 500	1 000	1 500	600
Price/kg	0.44	0.44	0.44	0.44	0.44
Value of output (M$)	440	660	440	660	264
Less costs					
Labour	-	-	-	-	-
Fertilisers	-	-	-	-	-
Pest control	25	25	25	25	15
Miscellaneous	15	15	15	15	15
Net return	400	620	400	620	234
Net return expressed per man-day	3.9	6.1	3.9	6.1	4.3
Net return - opportunity cost of labour*	80	212	80	212	14

*Labour requirement estimated to be only 80 man days ((M$) 320 in years 6-9 while yield is building up, and 102 man days thereafter.

TABLE 11 Labour requirements for cocoa plantation establishment and production, under mature coconut palms, man-days/ha

Year	1	2	3	4	5	6	.....	30
Planting etc.	50	5	5	-	-	-		
Maintenance	-	20	20	20	20	20		
Application of fertilisers and chemicals	10	10	10	10	10	10		
Collection, transporting, splitting, fermenting	-	-	20	25	30	30		
Marketing	-	-	2	2	2	2		
Total	60	35	57	57	62	62		
Opportunity cost (M$)	240	140	228	228	248	248		

Source: Based on Best and Wong, p.22

TABLE 12 Farm costs and returns from cocoa production, interplanted among coconuts, M$/ha

Year	1	2	3	4	5	6	......	30
Yield (dried bean equivalent) kg.	-	-	250	500	700	750		
Price per kg (M$)	1.9	1.9	1.9	1.9	1.9	1.9		
Value of output	-	-	475	950	1 330	1 425		
<u>Less</u> costs								
Planting material	30	3	3	-	-	-		
Labour	-	-	-	-	-	-		
Fertilisers	110	130	150	180	180	180		
Pest control	105	105	105	105	105	105		
Miscellaneous	25	250	25	25	25	25		
Net return	-270	-488	192	640	1 020	1 115		
Net return - opportunity cost of labour	-510	-628	-36	412	772	867		867

Net returns from combination of coconuts and cocoa at maturity (M$) = Per ha 1 735
Per man-day 10.6

SOCIAL COST-BENEFIT ANALYSIS

This section of Appendix 10 comprises the social cost-benefit analyses of the more important development schemes proposed for the study areas. The results of the analysis for the Lower Samarahan Scheme are in Tables 24 and 31 for Options I and II respectively, and those for the Empila Scheme are set out in Tables 39 and 45 for Alternatives A and B respectively. The other tables in this section incorporate the data on which the results of the analyses are based.

LOWER SAMARAHAN SCHEME: OPTION I

TABLE 13* Current land use and proposed land use following each stage of development, ha

	Current	Proposed		
		Stage I	Stage II	Total
Rubber	5	-	-	-
Forest	330	-	-	-
Coconut	139	24	47	71
Coconut/cocoa	-	74	140	214
Padi - cultivated	288	185	725	910
- fallow	433	-	-	-
Soyabeans (off-season)	-	140	540	680

TABLE 14* Details of land use conversion following each stage of development, ha

	Stage I	Stage II	Total
Converted to padi			
Rubber	5	-	5
Forest	46	226	272
Coconuts	28	42	70
	79	268	347
Remaining as padi land	106	457	563
Converted to coconuts, or coconuts with cocoa			
Forest	18	20	38
Padi land	52	126	178
	70	146	216
Remaining in coconuts, or coconuts with cocoa	28	41	69

*Note: The major bunding, draining and land preparation works to be spread over a 3 year period: Stage I of the works to be completed in year 0 and Stage II in years 1-2. The cost of acquiring land for bunds and drains is not entered in Table 15, being included as an opportunity cost in Table 20 (Item C). The life of the project is estimated at 30 years.

LOWER SAMARAHAN SCHEME: OPTION I

TABLE 15* Capital costs schedule, M $ 000 (Data source : Appendix 9, Tables 3-5)

	Year of scheme										
	0	1	2	3....10		11	12....20		21	22...30	
EARTHWORKS Perimeter bund - land clearing	5.4	6.0	5.7								
- excavation	72.0	78.0	78.0								
Internal bund - land clearing	4.1	1.6	1.6								
- excavation	40.5	16.0	15.5								
Main drain - land clearing	4.1	6.0	5.3								
- excavation	90.0	125.0	125.0								
Stream clearing - land clearing	0.8	3.8	3.0								
- excavation	5.0	22.5	22.5								
STRUCTURES (gates, bridges etc)	339.0	156.0	155.0								
Miscellaneous engineering costs	10.0	5.0	5.0								
EQUIPMENT (tractors etc)	421.0	304.0	-		421	304	-	421	304	-	-
LAND CLEARING: for rice	57.1	77.3	77.3								
" coconut/cocoa	5.4	3.0	3.0								
SECONDARY DRAINS - rice area	11.8	23.2	23.2								
- coconuts/cocoa area	12.8	12.0	12.0								
INITIAL LAND PREPARATION	11.9	22.1	22.1								
Subtotal	1090.9	861.5	554.2	-	421	304	-	421	304	-	-
(+) Contingencies (10%)	109.1	86.2	55.4								
TOTAL CAPITAL COSTS	1200.0	947.7	609.6	-	421	304	-	421	304	-	-
MAINTENANCE OF EARTHWORKS, STRUCTURES, ETC	-	-	-	83	83	83	83	83	83	83	83
TOTAL CAPITAL & MAINTENANCE	1200	948	610	83	504	387	83	504	387	83	83

*Note: The major bunding, draining and land preparation works to be spread over a 3 year period: Stage I of the works to be completed in year 0 and Stage II in years 1-2. The cost of acquiring land for bunds and drains is not entered in Table 15, being included as an opportunity cost in Table 20 (Item C). The life of the project is estimated at 30 years.

LOWER SAMARAHAN SCHEME: OPTION I

TABLE 16* Padi: area development schedule (ha) and net returns (M $ 000)

		Year of scheme										
		0	1	2	3	4	5	6	7	8	9	30
Stage I New Padi land, 79 ha	(ha)	W	40	40	40	40	40	40	40	40	40.....	40
	(M $ 000)	-	20.0	20.0	20.0	20.0	20.0	24.6	24.6	24.6	24.6	24.6
	(ha)	W	-	39	39	39	39	39	39	39	39	39
	(M $ 000)	-	-	19.5	19.5	19.5	19.5	19.5	24.0	24.0	24.0	24.0
Existing padi land, 106 ha	(ha)	W	106	106	106	106	106	106	106	106	106	106
	(M $ 000)	-	53.0	53.0	53.0	53.0	53.0	65.2	65.2	65.2	65.2	65.2
Stage II New padi land, 268 ha	(ha)	-	W	67	67	67	67	67	67	67	67	67
	(M $ 000)	-	-	33.5	33.5	33.5	33.5	33.5	41.2	41.2	41.2	41.2
	(ha)	-	W	-	67	67	67	67	67	67	67	67
	(M $ 000)	-	-	-	33.5	33.5	33.5	33.5	33.5	41.2	41.2	41.2
	(ha)	-	-	W	67	67	67	67	67	67	67	67
	(M $ 000)	-	-	-	33.5	33.5	33.5	33.5	33.5	41.2	41.2	41.2
	(ha)	-	-	W	-	67	67	67	67	67	67	67
	(M $ 000)	-	-	-	-	33.5	33.5	33.5	33.5	33.5	41.2	41.2
Existing padi land, 457 ha	(ha)	-	W	230	230	230	230	230	230	230	230	230
	(M $ 000)	-	-	115.0	115.0	115.0	115.0	115.0	141.5	141.5	141.5	141.5
	(ha)	-	-	W	227	227	227	227	227	227	227	227
	(M $ 000)	-	-	-	113.5	113.5	113.5	113.5	113.5	139.6	139.6	139.6
Total	(M $ 000)	-	73.0+	241	422	455	455	472	511	552	560....	560

"W" = Works in progress

+ It can be assumed that farmers will continue to plant 288 ha of their existing padi land in the first year when the area under the scheme is still low. Since 106 ha of existing padi land are incorporated into the scheme in year 1 this leaves 182 ha, which can earn a net return of M $ 66 200 (i.e. 182 ha x M $ 364). Net return in year 1 is therefore 73 + 66 = M $ (000) 139, and it is this figure which is used in Table 20. No padi is planted under the traditional system after year 1.

*Note: Half of the new padi land (i.e. land outside the existing padi production cycle) to be planted to padi in the year following completion of the works programme, and the remainder after an interval of one year. Existing padi land (i.e. land currently in the padi production cycle) to be fully utilised from the first year after completion of the works. Padi yields average 2 500 kg/ ha for the first 5 years and 2 750 kg/ ha thereafter. Data on net return per ha are taken from Table 3.

TABLE 17* Coconuts: area development schedule (ha) and net returns (M$ 000)

		Year of scheme															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	....	30
Stage I New coconut land	(ha)	W	(35)	(35)	(35)	(35)	(35)	35	35	35	35	35	35	35	35	35		35
70 ha	(M$ 000)		-11.0	- 6.5	- 6.5	- 6.1	- 6.1	2.8	2.8	2.8	2.8	7.4	7.4	7.4	7.4	7.4		7.4
	(ha)	W	-	(35)	(35)	(35)	(35)	(35)	35	35	35	35	35	35	35	35		35
	(M$ 000)		-	-11.0	- 6.5	- 6.5	- 6.1	- 6.1	2.8	2.8	2.8	2.8	7.4	7.4	7.4	7.4		7.4
Existing coconut land	(ha)	W	28	28	28	28	28	28	28	28	28	28	28	28	28	28		28
28 ha	(M$ 000)		-	2.2	2.2	2.2	2.2	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9		5.9
Stage II New coconut land	(ha)	-	W	(41)	(41)	(41)	(41)	(41)	41	41	41	41	41	41	41	41		41
146 ha	(M$ 000)			-12.9	- 7.6	- 7.6	- 7.2	- 7.2	3.3	3.3	3.3	3.3	8.7	8.7	8.7	8.7		8.7
	(ha)	-	W	-	(35)	(35)	(35)	(35)	(35)	35	35	35	35	35	35	35		35
	(M$ 000)	-			-11.0	- 6.5	- 6.5	- 6.1	-6.1	2.8	2.8	2.8	2.8	7.4	7.4	7.4		7.4
	(ha)	-	-	W	(35)	(35)	(35)	(35)	(35)	35	35	35	35	35	35	35		35
	(M$ 000)	-	-	-	-11.0	- 6.5	- 6.5	- 6.1	-6.1	2.8	2.8	2.8	2.8	7.4	7.4	7.4		7.4
	(ha)	-	-	W	-	(35)	(35)	(35)	(35)	(35)	35	35	35	35	35	35		35
	(M$ 000)	-	-	-	-	-11.0	- 6.5	- 6.5	-6.1	- 6.1	2.8	2.8	2.8	2.8	7.4	7.4		7.4
Existing coconut land	(ha)	-	W	21	21	21	21	21	21	21	21	21	21	21	21	21		21
41 ha	(M$ 000)	-	-	-	1.7	1.7	1.7	1.7	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5		4.5
	(ha)	-	-	W	20	20	20	20	20	20	20	20	20	20	20	20		20
	(M$ 000)	-	-	-	-	1.6	1.6	1.6	1.6	4.2	4.2	4.2	4.2	4.2	4.2	4.2		4.2
Total	(M$ 000)	-	-11.0	-28.2	-38.7	-38.7	-33.4	-20.0	2.6	23.0	31.9	36.5	46.5	55.7	60.3	60.3		60.3

"W" Works in progress

"( )" Data in brackets indicates area of immature coconuts

*Note Half of the area re-allocated to coconuts to be planted out in the year following the works programme and the remainder a year later. Data in parentheses indicates immature plantations. Yield averages 1 000 kg/ ha for years 6-9 after planting and 1 500 kg/ ha thereafter. Existing plantations improved by drainage average 1 000 kg/ ha for years 2-5 after completion of the works and 1 500 kg/ ha thereafter (For net returns per ha, see Tables 9 and 10).

LOWER SAMARAHAN SCHEME: OPTION I

TABLE 18* Interplanted cocoa: area development schedule (ha) and net returns (M $ 000)

		Year of scheme																			
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19..30
Stage I New coconut	(ha)	W	-	-	-	-	-	35	35	35	35	35	35	35	35	35	35	....			35
land 70 ha	(M $ 000)	-	-	-	-	-	-	-17.9	-22.0	- 1.3	14.4	27.0	30.3	30.3	30.3	30.3	30.3				30.3
	(ha)	W	-	-	-	-	-	-	35	35	35	35	35	35	35	35	35				35
	(M $ 000)	-	-	-	-	-	-	-	-17.9	-22.0	- 1.3	14.4	27.0	30.3	30.3	30.3	30.3				30.3
Existing coconut	(ha)	W	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28				28
land 28 ha	(M $ 000)	-	-14.3	-17.6	- 1.0	11.5	21.6	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3				24.3
Stage II New coconut	(ha)	-	W	-	-	-	-	-	41	41	41	41	41	41	41	41	41				41
land 146 ha	(M $ 000)	-	-	-	-	-	-	-	-20.9	-25.7	- 1.5	16.9	31.7	35.5	35.5	35.5	35.5				35.5
	(ha)	-	W	-	-	-	-	-	-	35	35	35	35	35	35	35	35				35
	(M $ 000)	-	-	-	-	-	-	-	-	-17.9	-22.0	- 1.3	14.4	27.0	30.3	30.3	30.3				30.3
	(ha)	-	-	W	-	-	-	-	-	35	35	35	35	35	35	35	35				35
	(M $ 000)	-	-	-	-	-	-	-	-	-17.9	-22.0	- 1.3	14.4	27.0	30.3	30.3	30.3				30.3
	(ha)	-	-	W	-	-	-	-	-	-	35	35	35	35	35	35	35				35
	(M $ 000)	-	-	-	-	-	-	-	-	-	-17.9	-22.0	- 1.3	14.4	27.0	30.3	30.3				30.3
Existing coconut	(ha)	-	W	21	21	21	21	21	21	21	21	21	21	21	21	21	21				21
land 41 ha	(M $ 000)	-	-	-10.7	-13.2	- 1.0	8.7	16.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2				18.2
	(ha)	-	-	W	20	20	20	20	20	20	20	20	20	20	20	20	20				20
	(M $ 000)	-	-	-	-10.2	-12.6	- 1.0	8.2	15.4	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3				17.3
Total	(M $ 000)	-	-14.3	-28.3	-24.4	- 2.1	29.3	30.8	- 2.9	-25.0	9.5	93.5	176.3	224.3	243.5	246.8	246.8				246.8

To aid in understanding the interplanting schedule, the relevant coconut area data from Table 17 are repeated in the above table, which thus implies a full cocoa planting regime. However, for purposes of the analysis it is assumed that cocoa is restricted to 75% of the coconut area and that planting is phased over a 5-year period at each site. On this basis total net returns are projected as follows:

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19..30
Total net returns from cocoa	(M $ 000)	-	- 2	- 7	-11	-12	- 7	-	4	4	6	16	38	72	113	148	170	181	184	184	184 184

"W" = Works in progress

*Note: Cocoa to be interplanted in allmature coconut stands up to a limit of 75% of the coconut area. Interplanting starts in the year following the engineering works in existing coconut plantations, and in the 6th year following coconut planting where new coconut plantations are being established; it is phased over a 5 year period. Yield builds up to 750 kg per ha in 5th year after planting. Figures used in the cost benefit analysis appear on the bottom line (For net returns per ha, see Table 12).

LOWER SAMARAHAN SCHEME: OPTION I

TABLE 19* Soyabeans: Area development schedule (ha) and net returns (M/$ 000)

		Year of scheme										
		0	1	2	3	4	5	6	7	8	9	30
Stage I	(ha)	W	40	70	100	130	140	140	140	140	140	140
	(M $ 000)	-	14.3	25.0	35.7	46.4	50.0	77.6	77.6	77.6	77.6	77.6
Stage II	(ha)	-	W	80	140	200	260	270	270	270	270	
	(M $ 000)	-	-	28.6	50.0	71.4	92.8	96.4	150.0	150.0	150.0	150.0
	(ha)	-	-	W	80	140	200	260	270	270	270	270
	(M $ 000)	-	-	-	28.6	50.0	71.4	92.8	96.4	150.0	150.0	150.0
Total	(M $ 000)	-	14.3	53.6	114.3	167.8	214.2	266.8	324	377.6	377.6	377.6

*Note: Adoption of soyabeans assumed to be phased over a 5-6 year period after completion of the works, up to a limit of 75% of the available area. Yield averages 1 000 kg/ ha in the first 5 years and 1 250/ ha over the remaining years of the project (for net returns per ha, see Table 7).

LOWER SAMARAHAN SCHEME: OPTION I

TABLE 20* Aggregate net returns from crop production, M $ 000

	Year of scheme																			
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19..... 30
A. Net returns from proposed cropping programme (Tables 16–19)																				
Padi	-	139	241	422	455	455	472	511	552	560	560	560	560	560	560	560	560	560		560
Coconuts	-	-11	-28	-39	-39	-33	-20	3	23	32	37	47	56	60	60	60	60	60		60
Cocoa	-	-2	-7	-11	-12	-7	-	4	4	6	16	38	72	113	148	170	181	184		184
Soyabeans	-	14	54	114	168	214	267	324	378	378	378	378	378	378	378	378	378	378		378
Subtotal	-	140	260	486	572	629	719	842	957	976	991	1 023	1 066	1 111	1 146	1 168	1 179	1 182		1 182
B.*Net returns foregone from existing crops within project area/																				
Padi	-	105	105	105	105															105
Coconuts	-	2	2	2	2															2
Subtotal	-	107	107	107	107	....														107
C. Value of crops foregone from land lost to earthworks	-	5	5	5	5															5
Net annual gain (A less B, C)	-	28	148	374	460	517	607	730	845	864	879	911	954	999	1 034	1 056	1 067	1 070	....	1 070

/Income from rubber is negligible and is ignored. Population (and area of existing padi cultivation) assumed to remain constant in the absence of a scheme.

*Note: Item B values are based on the assumption that existing areas and yields of rice and coconuts are maintained. This assumption is modified later in the analysis. The item C estimate covers loss of potential income from small areas of padi and coconut land lost in construction of earthworks. It is based on the net value of the crops which would otherwise have been produced off these areas.

LOWER SAMARAHAN SCHEME: OPTION I

TABLE 21 Staff, transport and housing requirements for preliminary studies, technical cooperation team and extension staff, and unit costs for each item.*

PRELIMINARY STUDIES

(Socioeconomic investigations into population, tenure, labour, credit and marketing)

Staff:	1 ex-patriate sociologist for 2 years, plus 2 Malaysian sociologists/land tenure specialists for 2 years and 1 year respectively. 1 Malaysian economist for 1 year. Any enumerators required to be drawn from existing junior staff complement.
	1 driver and 2 boatmen for 2 years
Transport:	1 motor vehicle 1 boat
Housing:	1 house for ex-patriate

SCHEME INITIATION

Staff:	3 expatriates for 3 years - 1 drainage and irrigation engineer, 1 agricultural engineer and 1 agronomist - plus Malaysian counterparts.
	3 drivers and 2 boatmen for 3 years
Transport:	3 motor vehicles 1 boat
Housing:	3 houses for the ex-patriates

EXTENSION

Staff:	1 agricultural officer and 2 assistant agricultural officers for life of the schemes
	1 driver and 2 boatmen
Transport:	1 motor vehicle 1 boat
Housing:	1 house for each officer.

The unit cost of the above items are assumed to be as follows (all costs are on a per annum basis except for capital costs of vehicles and boats):

Staff:	Ex-patriate staff	(equivalent to)	M$ 58 000/
	Malaysian counterparts, sociologists and economists		12 000
	Agricultural officer		12 000
	Assistant agricultural officer		7 200
	Drivers		3 000
	Boatmen		1 800
Transport:	Motor vehicles	(equivalent to)	16 000
	Boats		7 000
	Motor vehicle running costs		4 000
	Boat running costs		4 000
Housing rentals:	Kuching (ex-patriate)		9 000
	On scheme (extension)		4 000

*These are aggregate requirements for both study areas.
/Inclusive of passages, education allowances, etc.

LOWER SAMARAHAN SCHEME: OPTION I

TABLE 22 Cost of preliminary studies, technical cooperation team, and extension staff, M $ 000*

		Year of scheme				
	-1	0	1	2	3......	30
STAFF						
Preliminary studies						
Ex-patriate	58	58	-	-	-	-
Malaysian	36	12	-	-	-	-
Scheme initiation						
Expatriate	-	174	174	174	-	-
Malaysian	-	36	36	36	-	-
Extension	-	26	26	26	26	26
Drivers	3	15	12	12	3	3
Boatmen	4	11	7	7	4	4
TRANSPORT						
Motor vehicles: Capital/	16	64	-	-	-	-
: Running costs	4	20	16	16	4	4
Boats : Capital/	7	14	-	-	-	-
: Running costs	4	12	8	8	4	4
HOUSING						
Ex-patriates	9	36	27	27	-	-
Extension staff	-	12	12	12	12	12
Total	141	490	318	318	53	53
50% chargeable to Lower Samarahan Scheme	71	245	159	159	27	27

*These are aggregate costs for both study areas, chargeable as follows: Lower Samarahan Scheme - 50%, Empila Scheme - 15%, other sites - 35%.

/For simplicity no salvage values are shown against vehicles and boats required only over the years 0-3, nor is allowance made for the periodic replacement of the vehicle and boat used by extension staff. To some extent these omissions counter-balance each other.

LOWER SAMARAHAN SCHEME: OPTION I

TABLE 23 Benefit and cost flows, M $ 000

Year	(i) Net annual gain (T.20)	(ii) Capital and maintenance (T.15)	(iii) Preliminary studies and support staff (T.22)	(iv) = (ii) + (iii)	(v) = (i)-(iv) Net benefit
-1	-	-	71	71	-71
0	-	1 200	245	1 445	-1 445
1	28	948	159	1 107	-1 079
2	148	610	159	769	- 621
3	374	83	27	110	264
4	460	83	27	110	350
5	517	83	27	110	407
6	607	83	27	110	497
7	730	83	27	110	620
8	845	83	27	110	735
9	864	83	27	110	754
10	879	504	27	531	348
11	911	387	27	414	497
12	954	83	27	110	844
13	999	83	27	110	889
14	1 034	83	27	110	924
15	1 056	83	27	110	946
16	1 067	83	27	110	957
17	1 070	83	27	110	960
18	1 070	83	27	110	960
19	1 070	83	27	110	960
20	1 070	504	27	531	539
21	1 070	387	27	414	656
22	1 070	83	27	110	960
30	1 070	83	27	110	960

LOWER SAMARAHAN SCHEME: OPTION II

TABLE 27* Area development schedule (ha) and net returns≠ (M$ OOO)

		Year of scheme						
	0	1	2	3	4	5	6 ...	30
Padi (ha)	W	368	448	528	608	721	721	721
(M$ 000)	-	183	222	262	302	358	441	441
Soyabeans (ha)	W	40	80	120	160	216	216	216
(M$ 000)	-	14	28	42	57	76	119	119
Subtotal (M$ 000)	-	197	250	304	359	434	560	560
Less Net returns from existing padi crop (M$ 000)	-	105	105	105	105	105	105	105
Net annual gain (M$ 000)	-	92	145	199	254	329	455	455

"W" = Works in progress

*Note: The areas planted to padi and soyabeans increase to their maximum levels by year 5. Padi yields are 2 500 kg/ha in years 1-5 and 2 750 kg/ha thereafter. Soyabean yields average 1 000 kg/ha and 1 250 kg/ha, respectively, over the same periods. In the absence of the scheme it is assumed that the current level of rice production will be maintained. This assumption will be relaxed later.

≠Net returns per ha for padi and soyabeans are M$ 3 lower than the values shown in Tables 3 and 6 respectively to cover the higher running costs of pedestrian tractors compared to conventional tractors.

TABLE 28 Staff, transport and housing requirements for preliminary studies, technical cooperation and extension staff, and unit costs for each item**

PRELIMINARY STUDIES

As for Option I (See Table 21)

TECHNICAL COOPERATION

<u>Staff</u>: 1 expatriate agronomist for 3 years plus a Malaysian counterpart
1 driver and 2 boatmen for 3 years

<u>Transport</u>: 1 motor vehicle
1 boat

<u>Housing</u>: 1 house for expatriate

EXTENSION

As for Option I (See Table 21)

The unit costs of the above items are the same as those shown in Table 21.

**These are aggregate requirements for both study areas.

TABLE 29 Cost of preliminary studies, technical cooperation and extension staff, M$ OOO*

	Year of scheme					
	-1	0	1	2	3	30
STAFF						
Preliminary studies	94	70	-	-	-	-
Technical cooperation: Ex-patriates agronomist	-	58	58	58	-	-
: Malaysian agronomist	-	12	12	12	-	-
Extension	-	26	26	26	26	26
Drivers	3	9	6	6	3	3
Boatmen	4	11	7	7	4	4
TRANSPORT						
Motor vehicles: Capital/	16	32	-	-	-	-
: Running costs	4	12	8	8	4	4
Boats : Capital/	7	14	-	-	-	-
: Running costs	4	12	8	8	4	4
HOUSING						
Ex-patriates	9	18	9	9	-	-
Extension staff	-	12	12	12	12	12
	141	286	146	146	53	53
50% chargeable to Lower Samarahan Scheme	71	143	73	73	27	27

*These are aggregate costs for both study areas, chargeable as follows: Lower Samarahan Scheme - 50%, Empila Scheme - 15%; other sites-35%.

/Assumptions about replacement and salvage values as for Option I (See Table 22).

LOWER SAMARAHAN SCHEME: OPTION II

TABLE 30 Benefit and cost flows, M $ 000

Year	(i) Net annual gain (T.27)	(ii) Capital and maintenance (T.26)	(iii) Preliminary studies and support staff (T.29)	(iv) = (ii)+(iii)	(v) = (i)-(iv) Net benefit
-1	-	-	71	71	-71
0	-	407	143	550	-550
1	92	36	73	109	-17
2	145	61	73	134	11
3	199	36	27	63	136
4	254	85		112	142
5	329	11		38	291
6	455	209		236	219
7		36		63	392
8		61		88	367
9		36		63	392
10		85		112	343
11		11		38	417
12		209		236	219
13		36		63	392
14		61		88	367
15		36		63	392
16		85		112	343
17		11	ditto	38	417
18	ditto	209		236	219
19		36		63	392
20		61		88	367
21		36		63	392
22		85		112	343
23		11		38	417
24		209		236	219
25		36		63	392
26		61		88	367
27		36		63	392
28		85		112	343
29		11		38	417
30	455	11	27	38	417

LOWER SAMARAHAN SCHEME: OPTION II

TABLE 31 Results of the cost-benefit analysis, M$ 000

		M$ 000	
Net annual gain, years 6-30		455	
Discount rate	10%	20%	30%
Present value (PV) in year 5	4 130	2 251	1 515
PV in year 0	2 564	905	408
PV of net gain, years 1-5	731	548	426
subtotal	3 295	1 453	834
(-) PV of capital, maintenance, preliminary studies and support staff	1 586	1 149	972
NET PRESENT VALUE	1 709	304	-138
Internal rate of return		26% (approx)	

If the area planted to padi in the absence of the scheme increases at 2½% per year instead of remaining constant (as assumed in the above calculation) the Net Present Values and Internal Rate of Return derived above would change as follows (see Table 24):

Net Present Value (as above)	1 709	304	-138
Less	428	165	91
	1 281	139	-229
Internal rate of return		23% (approx)	

Sensitivity analysis: The assumed values of key variables associated with the scheme have to be reducedby the following amounts to bring NPV (=1281) to 0 at the 10% rate of discount: Padi area, 37%; padi price, 37%; padi yield, 17%.

EMPILA SCHEME, STAGES I and II: ALTERNATIVE A

TABLE 32* Current land use and proposed land use following each stage of development, ha (Data source : Appendix 9, Tables 8,9, 12).

	Current	Proposed		
		Stage I	Stage II	Total
Forest	26			-
Coconuts	34			-
Padi - fallow	59			-
- cultivated: landas	51	80	90	170
: off-season	-	60	70	130
Soyabeans: off-season	-	-	-	-

TABLE 33* Capital costs schedule (M$ OOO)

	Year of scheme										
	0	1	2...	10	11	12...	20	21	22...	30
EARTHWORKS										
Main canal - land clearing	1.3	1.4	-							
- excavation	9.8	8.0	-							
- trimming	2.2	2.6	-							
- turfing	2.8	3.2	-							
STRUCTURES										
Pump and pumphouse	27.0	12.0	-							
Headworks	60.0	-	-							
Other	52.0	14.0	-							
Miscellaneous engineering costs	15.0	10.0	-							
EQUIPMENT (tractors, etc)	108.0	44.0	-	108	44	-	108	44	-	-
LAND CLEARING	20.6	10.6	-							
SECONDARY CANALS AND DRAINS	3.5	5.5	-							
INITIAL LAND PREPARATION	5.5	4.7	-							
Sub-total	307.7	116.0	-							
(+) Contingencies (10%)	30.8	11.6	-							
TOTAL CAPITAL COSTS	338.5	127.6	-	108	44	-	108	44	-	-

Maintenance of earthworks, structures etc. costs M$ 14 000 annually from year 2 onwards.

*Note: The major irrigation, drainage and land preparation works to be spread over a 2 year period, Stage I in year 0 and Stage 2 in year 1. The cost of acquiring land for earthworks is not entered in T.33, being included as an opportunity cost in T.36 (item C). The life of the project is estimated at 30 years.

EMPILA SCHEME, STAGES I AND II: ALTERNATIVE A

TABLE 34 Details of land use conversions following each stage of development, ha

	Stage I	Stage II	Total
Converted to padi			
Forest	22	4	26
Coconuts	18	16	34
	40	20	60
Remaining as padi land	40	70	110

EMPILA SCHEME, STAGES I AND II: ALTERNATIVE A

TABLE 35* Padi area development schedule (ha) and net returns, (M $ 000)

		Year of scheme									
		0	1	2	3	4	5	6	7	8	9
Stage I New padi	(ha)†	W	20(5)	20(10)	20(15)	20(15)	20(15)	20(15)	20(15)	20(15)	20(15)
land 40 ha	(M $ 000)	-	10(2.1)	10(4.2)	10(6.4)	16.4	16.4	12.3(9.8)	22.1	22.1	22.1
	(ha)	W	-	20(5)	20(10)	20(15)	20(15)	20(15)	20(15)	20(15)	20(15)
	(M $ 000)	-	-	12.1	14.2	16.4	16.4	16.4	22.1	22.1	22.1
Existing padi	(ha)	W	20(5)	20(10)	20(15)	20(15)	20(15)	20(15)	20(15)	20(15)	20(15)
land 40 ha	(M $ 000)	-	12.1	14.2	16.4	16.4	16.4	22.1	22.1	22.1	22.1
	(ha)	W	-	20(5)	20(10)	20(15)	20(15)	20(15)	20(15)	20(15)	20(15)
	(M $ 000)	-	-	12.1	14.2	16.4	16.4	16.4	22.1	22.1	22.1
Stage II New padi	(ha)	-	W	10(3)	10(6)	10(8)	10(8)	10(8)	10(8)	10(8)	10(8)
land 20 ha	(M $ 000)		-	5(1.3)	5(2.5)	5(3.4)	8.4	8.4	6.2(5.2)	11.4	11.4
	(ha)	-	W	-	10(3)	10(6)	10(8)	10(8)	10(8)	10(8)	10(8)
	(M $ 000)	-	-	-	6.3	7.5	8.4	8.4	8.4	11.4	11.4
Existing padi	(ha)	-	W	35(8)	35(16)	35(26)	35(26)	35(26)	35(26)	35(26)	35(26)
land 70 ha	(M $ 000)	-	12.7††	17.5(3.4)	17.5(6.8)	17.5(11)	28.5	28.5	21.5(17)	38.5	38.5
	(ha)	-	W	-	35(8)	35(16)	35(26)	35(26)	35(26)	35(26)	35(26)
	(M $ 000)	-	-	-	20.9	24.3	28.5	28.5	28.5	38.5	38.5
Total	(M $ 000)	-	36.9	79.8	120.2	134.3	139.4	150.8	175.2	188.2	188.2
Net returns in off-season		-	4.2	17.3	35.2	49.3	54.4	61.2	75.8	83.6	83.6
" " " landas season		-	32.7	62.5	85.0	85.0	85.0	89.6	99.4	104.6	104.6

† Values outside brackets refer to landas season, and those inside to the off-season

†† Estimated net returns from 35 ha of padi grown under traditional system

"W" = Works in progress

*Note: Half of the land prepared for padi production to be planted out in the year following the works, and the remainder 1 year later. The area under off-season padi builds up gradually over a 3 year period until it reaches 75% of the landas season area. Yields of the irrigated landas season crop are 2 500 kg/ ha over the first 5 years and 2 750 kg/ ha thereafter. Off-season yields average 2 500 kg/ ha and 3 000 kg/ ha respectively over these same periods.

EMPILA SCHEME, STAGES I AND II: ALTERNATIVE A

TABLE 36* Aggregate net returns from crop production, M$ 000

	Year of scheme									
	0	1	2	3	4	5	6	7	8.......	30
A. Net returns from proposed cropping programme (T.28)	-	37	80	120	134	139	151	175	188	188
B.* Net value of existing crop production										
Padi	-	19	19	19	19	19	19	19	19	19
Coconuts/	-	-	-	-	-	-	-	-	-	-
C. Value of production foregone from land lost to earthworks	-	1	1	1	1	1	1	1	1	1
Net annual gain (A. less B, C.)	-	17	60	100	114	119	131	155	168	168

*Note: Item B values are based on the assumption that existing areas of rice and coconuts are maintained. This assumption is relaxed later in the analysis.

/The coconut palms in the project area are non-productive.

TABLE 37 Cost of preliminary studies, technical cooperation team and extension staff (M$ 000)

	Year of scheme					
	-1	0	1	2	3	30
Cost**	11	37	24	24	4	4

**Empila scheme assumed to account for 15% of total cost for both study areas - see Table 22, footnote/ of which about half can be allocated to Stages I and II.

EMPILA SCHEME, STAGES I AND II: ALTERNATIVE A

TABLE 38 Benefit and cost flows, M$ 000

Year	(i) Net annual gain (T.36)	(ii) Capital and maintenance (T.33)	(iii) Preliminary studies and supporting staff (T.37)	(iv) = (ii)+(iii)	(v) = (i)-(iv) Net benefit
-1	-	-	11	11	-11
0	-	339	37	376	-376
1	17	128	24	152	-135
2	60	14	24	38	22
3	100	14	4	18	82
4	114	14		18	96
5	119	14		18	101
6	131	14		18	113
7	155	14		18	137
8	168	14		18	150
9		14		18	150
10		122		126	42
11		58		62	106
12		14		18	150
13		14		18	150
14		14		18	150
15		14		18	150
16		14	ditto	18	150
17		14		18	150
18	ditto	14		18	150
19		14		18	150
20		122		126	42
21		58		62	106
22		14		18	150
23					
24					
25		ditto		ditto	ditto
26					
27					
28					
29					
30	168	14	4	18	150

EMPILA SCHEME, STAGES I AND II: ALTERNATIVE A

TABLE 39 Results of the cost-benefit analysis, M $ 000

	M $ 000	
Net annual gain, years 8-30	168	
Discount rate	10%	20%
Present value (PV) in year 7	1 492	827
Present value (PV) in year 0	766	231
PV of net gain, years 1-7	446	304
Subtotal	1 212	535
(-) PV pf capital, maintenance, preliminary studies and support staff	776	630
NET PRESENT VALUE	436	(-)95
Internal rate of return	18% (approx.)	

If the area planted to padi in the absence of the scheme increases at 2½% per year instead of remaining constant (as assumed in the above calculation) the Net Present Values and Internal Rate of Return would change as follows (see Table 24; in this case it is assumed that the increase in area planted is 10 ha in each of 6 successive 5-year periods compared to 55 ha in Table 24):

Net Present Value (as above)	436	-95
Less	78	30
	358	-125
Internal rate of return	17% (approx.)	

Sensitivity analysis: The assumed values of key variables associated with the scheme have to be reduced by the following amounts to bring NPV (=358) to 0 at the 10% rate of discount : padi area, 26%; padi price, 15%; padi yield, 12%.

EMPILA SCHEME, STAGES I AND II: ALTERNATIVE B

TABLE 40 Current land use and proposed land use following each stage of development, ha

	Current	Proposed		
		Stage I	Stage II	Total
Forest	26	-	-	-
Coconuts	34	-	-	-
Padi - fallow	59	-	-	-
- cultivated: landas	51	80	90	170
: off-season	-	-	-	-
Soyabeans (off-season)	-	60	70	130

TABLE 41* Capital costs schedule, M$ 000

	Year of scheme									
	0	1	2....	10	11	12....	20	21	22...	30
Drainage structures/	12	13.5	-	-	-	-	-	-	-	-
Drains	1.2	1.8	-	-	-	-	-	-	-	-
Equipment (tractors, etc)	108	44	-	108	44	-	108	44	-	-
Workshop	10	-	-	-	-	-	-	-	-	-
Land clearing	20.6	10.6	-	-	-	-	-	-	-	-
Initial land preparation	5.5	4.7	-	-	-	-	-	-	-	-
Subtotal	157.3	74.6	-	108	44	-	108	44	-	-
(+) Contingencies (10%)	15.7	7.5								
Total capital costs	173.0	82.1	-	108	44	-	108	44	-	-

*Note: Stages of development and land use conversions as for A, but with soyabeans substituting for off-season padi. No irrigation facilities.

/Costs of structure maintenance are very low and have been ignored in the analysis.

EMPILA SCHEME, STAGES I AND II: ALTERNATIVE B

TABLE 42 Area development schedule (ha) and net returns M $ 000

		Year of scheme									
		0	1	2	3	4	5	6	7	8.....30	
Soyabeans											
Stage I	(ha)	W	20	30	40	50	60	60	60	60	60
	(M $ 000)	-	7.1	10.7	14.3	17.9	21.4	33.2	33.2	33.2	33.2
Stage II	(ha)	-	W	20	35	50	65	70	70	70	70
	(M $ 000)	-	-	7.1	12.5	17.9	23.2	25	38.8	38.8	38.8
(i) Subtotal (M $ 000)		-	7.1	17.8	26.8	35.8	44.6	58.2	72.0	72.0	72.0
(ii) Padi (landas)/ (M $ 000)		W	32.7	62.5	85.0	85.0	85.0	89.6	99.4	104.6	104.6
Subtotal (i) & (ii) (M $ 000)		-	39.8	80.3	111.8	120.8	129.6	147.8	171.4	176.6	176.6
Less Net Value of existing padi (landas) (M $ 000)		-	19	19	19	19	19	19	19	19	19
Net annual gain (M $ 000)		-	21	61	93	102	111	129	152	158	158

"W" = Works in progress

/See last line Table 35.

*Note: The area planted to soyabeans builds up gradually following the works until it reaches 75% of the landas season padi area. Yields average 1 000 kg/ha over the first 5 years and 1 250 kg/ha thereafter.

TABLE 43 Cost of preliminary studies, technical cooperation team and extension staff

Assumed to be the same as for Alternative A (Table 37). In fact the cost will be a little lower since no irrigation expertise is required bu the difference is small enough to be ignored.

EMPILA SCHEME, STAGES I AND II: ALTERNATIVE B

TABLE 44 Benefit and cost flows, M$ 000

Year	(i) Net annual gain (T.42)	(ii) Capital and maintenance (T.41)	(iii) Preliminary studies and supporting staff (T.43)	(iv) = (ii)+(iii)	(v) = (i)−(iv) Net flow
-1	-	-	11	11	-11
0	-	173	37	210	-210
1	21	82	24	106	-85
2	61	_	24	24	37
3	93	-	4	4	89
4	102	-		4	98
5	111	-		4	107
6	129	-		4	125
7	152	-		4	148
8	158	-		4	154
9		-		4	154
10		108		112	46
11		44		48	110
12		-		4	154
13		-		4	154
14		-		4	154
15		-	ditto	4	154
16		-		4	154
17		-		4	154
18		-		4	154
19	ditto	-		4	154
20		108		112	46
21		44		48	110
22		-		4	154
23					
24					
25					
26		ditto		ditto	ditto
27					
28					
29					
30	158	-	4	4	154

EMPILA SCHEME, STAGES I AND II: ALTERNATIVE B

TABLE 45 Results of the cost-benefit analysis, M$ 000

		M$ 000	
Net annual gain, years 8-30		158	
Discount rate	10%	20%	30%
Present value (PV) in year 7	1 404	778	525
" " " " " 0	720	217	84
PV of net gain, years 1-7	429	292	211
Subtotal	1 149	509	295
(-) PV of capital, maintenance, preliminary studies and support staff	447	368	342
NET PRESENT VALUE	702	141	-47
Internal rate of return		27% (approx)	

If the area planted to padi in the absence of the scheme increases at 2½% per year instead of remaining constant (as assumed in the above calculation) the Net Present Values and Internal Rate of Return would change as follows (see Table 39):

Net Present Value (as above)	702	141	-47
Less	78	30	17
	624	111	64
Internal rate of return		26% (approx)	

Sensitivity analysis : The assumed values of key variables associated with the scheme have to be reduced by the following amounts to bring NPV (=624) to 0 at the 10% rate of discount: padi and soya beans area, 47%; padi and soya beans prices, 29%; padi and soya beans yields, 22%.

FINANCIAL AND COMMERCIAL ANALYSIS

Financial analysis

The financial analyses in this report are incomplete since the full extent of the financial burden on government cannot be estimated at present. A major part of the total is accounted for by the capital outlays associated with the proposed schemes comprising costs of construction and maintenance of the engineering works, initial purchases of tractors and associated equipment (but not replacements which will be the responsibility of the farmers themselves), land clearance and initial land preparation. Also included is the cost of land acquisition for earthworks, and the cost of support staff and preliminary studies (excluding ex-patriate staff costs). For ease of reference these can be termed Group I items.

In addition, Government is expected to be involved in buying and selling land and compensating farmers for loss of rights arising out of the proposed land redistribution. It may also wish to subsidise certain production inputs (for a time at least) and provide credit for the purchase of fertilisers and chemicals. Prior to land survey and a decision on redistribution it is not possible to estimate the funds required for land purchase and payment of compensation. Nor can an estimate be made of the cost to government of a subsidisation programme in the absence of an official policy statement on subsidisation. The cost to the government of these various outgoings, which can be referred to as Group II items, can only be estimated after completion of the preliminary studies.

The Mission has estimated the pattern of governmental expenditure over the lives of the various schemes for the Group I items and the respective sub-totals are presented in Table 46. These estimates do not include provision for any Group II items.

TABLE 46 Estimated governmental expenditure on Group I items for the development schemes ($ 000)

Year	Lower Samarahan Option I	Lower Samarahan Option II	Empila Alternative A	Empila Alternative B
-1	41	41	6	6
0	1 385	492	363	192
1	1 075	80	145	93
2	736	105	25	11
3	110	63	18	4
4	110	113	18	4
5	110	38	18	4
30	110	38	18	4

In each case the major part of the financial burden falls in the early years of the scheme. The Lower Samarahan Option I proposal is by far the most expensive of the four in terms of its requirements for public funds.

Assuming that tax collection continues to receive low priority, government will earn little revenue from the development schemes unless special charges are levied on participating farmers.

Commercial analysis

Producers' annual incomes under the schemes can be estimated by multiplying crop areas by the appropriate figure of "net return per ha" after downward adjustment of the latter to cover depreciation of tractors and equipment. The implicit assumption here is that farmers will meet in full all direct costs of production such as planting materials, fertilisers, chemicals, rotovation and pump operating costs, and that labour requirements will be met from within the household or through exchange amongst households. It is also assumed that farmers make no payments by way of rent or interest to other parties. These assumptions simplify the complexity of the real situation, but they are adequate for present purposes.

Projected levels of producers' incomes compared to present estimated levels are presented in Table 47. The projected levels refer to the periods after full development and the attainment of maximum yields.

TABLE 47 Producers' annual incomes under development schemes ($ 000)

Income	Lower Samarahan Option		Empila Alternative	
	I	II	A	B
Current incomes	312	312	50	50
Incomes under scheme	1 881	942	318	274
Year maximum income level attained	17	6	8	8

It would appear that producers' incomes in aggregate are likely to be substantially higher under the schemes than they are at present. Option I shows the highest income level, but has associated with it a relatively long build-up period before the maximum level is reached.

It is not possible to arrive at an estimate of average income per household under the schemes in advance of a decision on the pattern of land redistribution in the study areas.

PRELIMINARY STUDIES

It is recommended that studies should be undertaken in the following areas in advance of scheme implementation as a means of confirming, or otherwise, the results of the economic analyses:

Labour

The study will be aimed at assessing labour availability in relation to crop labour requirements under the proposed schemes and consideration will be given to removal of likely bottlenecks, if any.

Shortage of labour might limit expansion of crop production on the schemes to levels below those anticipated in the proposals, due to the demands of operations such as transplanting, weeding and harvesting of rice. Little is known at present about labour availability and the pattern of its utilisation over the agricultural year; this requires investigation.

Labour can be thought of as falling into one of several categories, for example: family members wholly employed in farm work or related activities (including exchange arrangements); family members partially or wholly employed in off-farm work; labour outside the area directly affected by the development proposals but available for employment on the schemes. There are also important qualititative divisions based on sex and age. The extent to which labour is likely to be available within each category and in aggregate will determine whether the manual labour components of the proposed crop production operations are realistic or not. If the latter, then the actual scale of crop production will fall short of projected levels (and this will have repercussions on the economics of the schemes) or else means will have to be found for dealing with the particular constraints that have been identified, and these might include, for example, the use of herbicides in place of manual weeding.

Marketing

The objectives of the marketing study are (a) to determine whether the existing marketing system can cope with the increased flows of inputs and outputs to be expected following the initiation of development and (b) to identify solutions to any problems likely to arise from development.

The data presented in Tables 1A, 1B and 1C indicated the quantities of rice, maize and soyabeans, respectively, being imported into Sarawak. Responses to local enquiries made by the Mission suggest that, provided quality requirements are met and production is on a large enough scale, local products could substitute for these imports and might also find export markets in Asia. These indications should be checked in the course of more systematic enquiries amongst traders and through discussions with the FAMA.

Even though there is a potential central market demand for particular commodities, production may be inhibited if local trading arrangements and facilities are inadequate. While existing arrangements may be adequate to handle the present relatively small volumes of produce moving out of the study areas they may not be able to cope with the rapid increase in flows which should accompany a vigorous development programme. This possibility requires investigation; solutions should be identified to any problems that seem likely to emerge as development proceeds. These might relate, for example, to the transportation of produce from local farms to the market, storage, quality of produce, or financing of traders. Again the FAMA should be able to assist in solving such problems.

Supply and distribution of inputs should also be considered in terms of the quantities and types of inputs required and the organisation of the supply and distribution of these inputs.

Credit

The objectives of the study are to assess credit needs under the schemes and consider how these needs can best be met.

Credit for production purposes does not seem to be an important element in the farm economy at present (Credit for consumption purposes is referred to Appendix 8) Development will, however, be accompanied by a rapidly increasing demand for resources other than family labour (e.g. fertilisers and chemicals) and these will have to be obtained from commercial sources. Producers may also need cash to meet the costs of mechanical cultivation and possibly hired labour before returns from crop sales are realised. The supply of inputs and the provision of credit are obviously closely related and it is desirable that credit requirements in terms of the purposes for which credit is needed, the amounts required, the time scales of loan requirements, and repayment possibilities should be appreciated well in advance of development.

Consideration should also be given to identifying alternative mechanisms for channelling credit and inputs to borrowers, and it is possible that the "Farmers' Organisations" currently being promoted in Sarawak could have a major role to play in this connection.

Producer response

This study will assess whether farmers are likely to support the developments conceived in this report along the lines and at the rates proposed.

The Mission's enquiries in the field suggest that, under existing conditions, farmers in the study areas do not engage in production of off-season annual crops for sale or, if so, only to a limited extent. The economics of the development schemes depend heavily on a favourable response from farmers to the idea of off-season cropping (both irrigated and rainfed) and also to the suggestions relating to improved tree crop production. If the pace of expansion of cropped area or the rate at which improved husbandry techniques are adopted fall short of those assumed in the analyses, the economics of the schemes will be adversely and perhaps seriously affected.

Although it is not easy to obtain reliable indications of how producers are likely to react to development opportunities, it is worthwhile making further enquiries amongst farmers, village heads, local administrators, extension staff and other knowledgeable persons in an attempt to predict reactions to the cropping proposals contained in this report. Study by analogy is also advocated, that is, by reference to comparable situations where similar programmes have been introduced in the past.

This response study should be undertaken in association with the socioloical study of administration and local leadership (Appendix 8).